CO_2 efflux, soil temperature and carbon/helium isotope results from the Los Humeros geothermal field, Mexico

(http://doi.org/10.5880/GFZ.4.6.2020.001)

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1. Licence

2. Citation

When using the data please cite:

Jentsch, A., Jolie, E., Jones, D. G., Taylor-Curran, H., Peiffer, L., Zimmer, M., Lister, B. (2020): CO_2 efflux, soil temperature and carbon/helium isotope results from the Los Humeros geothermal field, Mexico. GFZ Data Services. http://doi.org/10.5880/GFZ.4.6.2020.001

The data are supplementary material to:

Jentsch, A., Jolie, E., Jones, D. G., Taylor-Curran, H., Peiffer, L., Zimmer, M., & Lister, B. (2020). Magmatic volatiles to assess permeable volcano-tectonic structures in the Los Humeros geothermal field, Mexico. *Journal of Volcanology and Geothermal Research*, 106820. https://doi.org/10.1016/j.jvolgeores.2020.106820

3. Data Description

Magmatic volatiles can be considered as the surface fingerprint of active volcanic systems, both during periods of quiescent and eruptive volcanic activity. The spatial variability of gas emissions at Earth's surface is a proxy for structural discontinuities in the subsurface of volcanic systems. We conducted extensive and regular spaced soil gas surveys within the Los Humeros geothermal field to improve the understanding of the structural control on fluid flow. Surveys at different scales were performed with the aim to identify areas of increased gas emissions on reservoir scale, their relation to unknown/knows volcano-tectonic structures on fault scale favoring fluid flow, and determine the origin of gas emissions. Herein, we show results from a carbon dioxide efflux scouting survey, which was performed across the main geothermal production zone together with soil temperature measurements. We identified five areas with increased carbon dioxide emissions, where further sampling was performed with denser sampling grids to understand the fault zone architecture and local variations in gas emissions. We show that a systematic sampling approach on reservoir scale is necessary for the identification and assessment of major permeable fault segments. The combined processing of CO_2 efflux and carbon/helium isotopes facilitated the detection of permeable structural segments with a connection to the deep, high-temperature geothermal reservoir, also in areas with low to intermediate carbon dioxide emissions. The results of this study complement existing geophysical datasets and define further promising areas for future exploration activities in the north- and southwestern sector of the production field.

3.1. Sampling method

CO_2 efflux was measured in-situ (60–120 s) by means of the accumulation chamber method. Due to expected anthropogenic disturbances no CO_2 efflux measurements were performed in Humeros village.

94 soil gas samples were collected for $\delta^{13}C_{CO_2}$ isotopic analyses (Table 1 & 2) from areas of low, intermediate and high CO_2 efflux to constrain the origin of CO_2 emissions by their isotopic signatures (biogenous, endogenous). A hollow metal probe was installed in 1 m depth for gas sampling. To avoid any contamination with ambient air, the metal probe was flushed five times with a 60 ml syringe before collecting a gas sample. The sample was injected into an evacuated 12 ml glass vial with a pierceable septum.

To further constrain the origin of gas emissions, six helium samples were taken from selected sites to determine the $^3He/^4He$ ratios. Samples were taken on steam vents to reduce the contribution of ^4He from ambient air by placing a funnel on the outlet of the steam vent, which was connected via a flexible tube to a 40 cm copper pipe. If steam flow was insufficient, gas was aspirated with a hand pump for about two minutes. Metal clamps were fixed to each end of the copper tube and tightly closed for a safe storage of the gas.

3.2. Analytical procedure:

CO_2 efflux measurements were performed with portable LICOR LI-820 infrared gas analyzers being connected through a closed loop to an accumulation chamber Type A (West Systems). Soil temperatures were measured at 50 cm depth with a Greisinger GMH 285-BNC thermometer (accuracy ± 0.1 °C) coupled to a 620 mm long stainless-steel probe. For the domain-based surveys a Hanna HI-93510® thermistor thermometer (accuracy ± 0.4 °C) fitted to a 500 mm temperature probe was used.

Carbon isotopic analyses were performed with a GC-C-IRMS system consisted of a GC (6890N, Agilent Technology, USA) connected to a GC-C/TC III combustion device coupled via open split to a MAT 253 mass spectrometer (ThermoFisher Scientific, Germany) under continuous flow. The quality of the carbon isotope measurements was checked by direct injection a CO_2-reference gas with known $\delta^{13}C$ into the mass spectrometer during each run as well as by daily measurements of n-alkane gas standard (n-C1 to n-C6). The standard deviation is < 0.5 ‰. Herein, all results are reported in the standard notation δ as per mille (‰) deviations relative to the PDB (Pee Dee Belemnite) standard.

Helium samples were analyzed with a VG-5400mass spectrometer. Results were normalized to the air ratio ($R/R_A = 1.386 \times 10^{-6}$).

3.3. Data processing

The statistical evaluation of CO2 efflux data was performed by the graphical statistical analysis (GSA) introduced by Sinclair (1974; Fig. 2). This method is commonly used to separate large datasets by plotting the logarithmic CO2 efflux values against the cumulative frequency and identifying major inflection points as a key indicator of different populations. By identifying multiple log-normal populations different gas sources and/or transport mechanisms can be inferred. A detailed description of the GSA method was compiled by Chiodini et al. (1998, 2008). Both datasets (scouting and domain-based CO2 surveys) have been merged for statistical analyses.

The interpolated maps of CO2 efflux and soil temperature were generated by means of sequential Gaussian simulations (sGs) using ESRI ArcGIS® 10.5 software. The sGs algorithm was introduced by Deutsch and Journel (1998), who emphasize that sGs respects original data without smoothing extreme values in order to preserve spatial variations. In total, 100 realizations were performed for the sGs based on a simple kriging model. The sGs procedure requires a gaussian distribution of data. Therefore, all data were normal score transformed and declustered to correct data distribution before the generation of omnidirectional variograms.

4. File description

The data are presented in 4 data tables (tab delimited text format) according to the measurement variable. The columns are defined in each data file.

- 2020-001_jentsch-et-al_3He-4He-ratios
- 2020-001_jentsch-et-al_carbon-isotopes
- 2020-001_jentsch-et-al_CO2-efflux
- 2020-001_jentsch-et-al_soil-temperatures

5. References

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