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Thermal modeling in active poly-phased calderas: case study of Los Humeros, Mexico

Paromita Deb¹, Guido Giordano², Xiangyun Shi¹, Federico Lucci², Christoph Clauser¹, and Philippe Calcagno³

¹Institute for Applied Geophysics and Geothermal Energy, RWTH Aachen, Germany (pdeb@eonerc.rwth-aachen.de)

²Dipartimento di Scienze, Università Roma Tre, Roma, Italy

³Georesources Division, BRGM, Orléans, France

The Los Humeros Volcanic Complex (LHVC) is an active Quaternary caldera system in the Trans Mexican Volcanic Belt, characterized by two major caldera-forming events, Los Humeros (164 000 years ago) and Los Potreros (69 000 years ago). This site is also subjected to numerous episodes of post-caldera bi-modal volcanism during Holocene period (8 000 years – 3 000 years old). The volcanic complex hosts an active geothermal field which has been under commercial exploitation for the last 30 years. Latest geochemical, petrological and geochronological investigations consider the geothermal activity in the LHVC to be the result of an underlying complex magma plumbing system, characterized by numerous short-lived, shallow magma storage zones. Geothermal wells in the LHVC have encountered variable temperatures within depths of 2000 m, ranging from 170 °C at some areas to above 350 °C in the neighboring areas. To explain this anomalous temperature distribution and evaluate the thermal footprint of different volcanic episodes, we reconstructed the thermal history of the LHVC for a period of 182 000 years considering the spatially and temporally-varying nature of the heat sources. Our numerical model is constrained by information of depths, ages and volumes of the magma reservoirs, obtained from the geochemical and thermo-barometric modeling of the erupted material. The simulated present-day temperature state agrees well with the measured temperature data in the Los Humeros geothermal wells and can be used for identifying locations with anomalous temperature distribution. This integrated modeling approach, whereby numerical model is constrained by field-based geochemical information is essential in exploration geothermal fields, where limited borehole data is available, and promising for identifying potential locations of super-hot geothermal fluids.