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Numerical simulations to study the geodynamic origin of Los Humeros Volcanic Field in Mexico

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Los Humeros Volcanic Field (LHVF) represents one of the key volcanic calderas in Mexico. Nowadays, LHVF is the third largest geothermal field in Mexico in terms of energy output, with an installed capacity of 94 MWe. The caldera is about 21 by 15 km wide and is located in the Serdán Oriental basin, east of the Trans- Mexican Volcanic Belt in the central-eastern part of the country, roughly 440 km away from the Middle American Trench. In this study we show results of numerical simulations of magma intrusion in order to better understand the deep origin of the caldera. For this purpose, we used high-resolution two-dimensional coupled petrological-thermomechanical numerical simulations of magma intrusion where an initial thermal anomaly was placed in the asthenosphere just below the lithospheric mantle. We performed a parametric study where we investigated the influence of several parameters such as the diameter of the thermal anomaly, the excess temperature and the regional tectonic regime. These 2D simulations were carried out using the finite difference method coupled with the cell marker technique and employing the multigrid method. The physical parameters used for the Earth's layers (asthenosphere, lithospheric mantle, lower crust and upper crust) and for the composition of the magmatic intrusion were taken from literature and previously established models. In addition, we considered a viscoelastoplastic rheology and the simulations included erosion and surface sediment transport. Modeling results showed that only under certain conditions of temperature excess, initial diameter of the deep thermal anomalies that come in a specific chain-type sequence, it is possible to form a volcanic caldera similar with the dimensions of the LHVF. The temperature excess (ΔT = ~150K) suggested a deep origin for the thermal anomaly with an approximate depth of ~380 km, where currently the surface of the Cocos slab is located below the North American Plate. Additionally, we found that several magmatic pulses can reach the surface only if we consider in our models a small horizontal extension rate consistent with the extensional tectonic regime in the region.