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Understanding the geologic structure of superhot geothermal systems, case study of Los Humeros caldera complex, Mexico

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Superhot geothermal systems (SHGS) are a particular type of geothermal reservoirs that are characterized by temperatures higher than 350-380º C. Even though SHGS become ideal candidates for geothermal energy, they include aggressive fluids that complicate the fluid extraction. There is still a lot of work to do in order to understand how these systems work. Los Humeros in the eastern sector of the Mexican Volcanic Belt is an excellent example of a SHGS. It is currently exploited producing ca. 90 MW, being the third most important geothermal field in Mexico. Los Humeros is associated to the development of a caldera complex that reveals a very complicated evolution that still needs to be unraveled. A revised volcano-tectonic structure is proposed, comprising the formation of multiple trap-door collapse calderas, related to the development of weakness areas and new structures derived from both the construction of contemporaneous scoria cones and a recent episode of resurgence, characterized by the emplacement of silicic domes in the caldera′s central zone. The older and larger caldera (Los Humeros) was formed at 160 ka, much younger than previously reported (460 ky), this provides more favorable thermal conditions with presumably longer longevity of the magmatic and geothermal system. While resurgent silicic volcanism occurred in the central part of the caldera promoting the formation of structures that provide the main paths of the geothermal fluids to the surface, most recent basaltic andesite volcanism (Holocene), controlled by the ring-fracture to the south, caused a partial sealing of the geothermal fluids. The complexity of the subsurface geology of the geothermal reservoir is mostly due to a very irregular paleotopographic configuration of the highly deformed metasedimentary calcareous basement rocks, which were filled by a thick pile of andesitic lavas hosting the geothermal reservoir. Permeability is mainly controlled by fractures but an important contribution is provided by microporosity within the volcanic rocks. Also, the heterogeneous variations in lithofacies mainly due to welding of the so-called cap layer (Xaltipan ignimbrite) provides also lateral variations in permeability, causing petrophysical heterogeneity of the geothermal reservoir. The periodic injection of magmas seems to be a recurrent process until the Holocene showing the heterogeneity of the magmatic sources and the dynamic interaction with the geothermal system.