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Multiscale fracture analysis of the Vallès fault zone in La Garriga-Samalús geothermal system

Gemma Mitjanas et al. ▶

La Garriga-Samalús geothermal system is located in the Catalan Coastal Ranges (CCR) (NE Spain). The CCR is a NE-SW horst and graben system with two lifted mountain chains, the Precoastal (PR) and Coastal ranges (CR), separated by the Vallès basin. An Hercynian highly fractured granodiorite thrusts the Paleozoic metamorphic units in the northern part of the PR. Towards the south, the intrusive unit is in contact with the Miocene rocks of the Vallès basin by a major Neogene normal fault, the Vallès fault.

Previous works in this area showed that the fractured zone associated to the Vallès normal fault, located in the Hercynian granodiorite, could act as the geothermal reservoir as well as the fast-ascending path for the hot fluids. Although some geophysical prospections and exploration boreholes have been made in La Garriga-Samalús area, it is still necessary to understand and model the fracture network.

This study presents a multiscale fracture analysis of the granodiorite from outcrops and boreholes samples. This multiscale analysis combines satellite pictures, field studies and laboratory measurements of both field and borehole samples.

The fracture data collection has allowed the identification of 3 major fracture sets related to the main tectonic events of the CCR, in addition to 7 other minor fracture groups. Through the variation of fracture density in the footwall, a 10 meters fault core, and an asymmetric damage zone of approximately 300 m, have been identified. The damage zone shows an increasing fracture density towards the northern and southern limits of the granodiorite, which are an alpine thrust and the Vallès fault, respectively. In the fault core, the presence of cemented rocks like cataclasites with hydrothermal sealed fractures result in low porosity and permeability. Contrary, the damage zone consists of minor faults and related fractures which may enhance fault permeability with respect the core and its protolith.

In order to characterize fractures in depth, the borehole samples have been digitized via photogrammetry method. The study of the point cloud related to this samples have allowed the identification and characterization of some of the fractures sets at greater depths. The permeability differences between the fault core and the damage zone can be also identified in the borehole samples. The presence of centimetric open fractures, cavities, and hydrothermal minerals, confirm the circulation of thermal fluids. Meanwhile, other samples within the fault trace are compact rocks, with slickensides and high-pressure alteration minerals.

These fracture results have been also correlated with a previous 2D magnetotelluric (MT) model which shows the Vallès fault zone as a low resistivity unit. The fault zone may give a low resistivity value only if it is permeable and water saturated. Therefore, our results identify the damage zone of the Vallès fault as the potential reservoir of La Garriga-Samalús geothermal system.

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