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Fluid transport by faults and fractures in the Hengill Volcano, Southwest Iceland

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The Holocene Hengill Volcanic System is situated in the active West Volcanic Zone in Southwest Iceland. It contains the Hengill Central Volcano, located south of lake Thingvallavatn and being one of the most active geothermal fields in Iceland. The current spreading rate in the West Volcanic Zone varies between 3-7 mm/a with a subsidence of 1 mm/a (Tryggvason, 1982; LaFemina et al., 2005). The Hengill Volcanic System is 60-70 km long and 5-10 km wide. Structurally, it is dominated by large NNE-striking normal faults.

The Hengill Volcano is located at a triple junction between the Reykjanes Peninsula, the Western Volcanic Zone, and the South Icelandic Seismic Zone. The plate-tectonic setting of the Hengill Volcano is one reason for its very high background seismicity. In the period between 1994 and 1998 more then 80,000 small earthquakes were recorded in the Hengill and its surroundings (Vogfjord et al., 2005). Some 50% of them had focal mechanisms consistent with normal and strike-slip faults related to plate movements in the area. The strike-slip faults form a conjugate system of NNE-striking dextral and ENE-striking sinistral faults. The remaining 50% of the earthquakes are concentrated in the high temperature areas of the area and exhibited non-double-couple mechanisms characteristics of extensional failure due to circulating fluids (Foulger, 1988).

The main purpose of this study is to improve our understanding of fracture development and fluid transport mechanisms in the Hengill area. This understanding is necessary for making realistic models and predictions as to fluid transport over the lifetimes of the individual geothermal fields in the area, as well as predictions for seismogenic faulting, since most earthquakes are triggered by overpressured fluid.

For this purpose, we measured more than 2000 joints, 1000 mineral veins, and 29 large-scale normal faults in the Hengill Volcano. The normal faults that form the main graben strike, on average, N30˚E. The cumulative throw of all the normal faults in the measured profile exceeds 1200 m. The joints belong to two main sets: one strikes perpendicular (NW-SE) and the other parallel (NE-SW) to the Hengill Volcanic System. NE-SW trending joints were avoured conductors for the circulating geothermal fluids and therefore occur currently mostly as mineral veins. These points were used by the water since they trend perpendicular to the time-averaged maximum principle tensile stress (the spreading vector). In addition to the NE-SW striking mineral-vein set, two subsets occur. One strikes E-W and one is subhorizontal. The E-W striking set developed probably in relation to the conjugate strike-slip faults. This set is likely to be related to the earthquake swarms in the Hengill Volcano.

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