Geothermal waters in Geysir area. Mixing, boiling, water-rock interaction and conceptual model

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Most of the geothermal activity of the Geysir geothermal area occurs in an area only few hundred meters across. Outside the main geothermal area warm springs and drill holes are spread over a larger area which is elongated southwest to northeast or along the main tectonic fractures of the area. Samples of geothermal and cold water were sampled in the Geysir geothermal area and its surroundings and analyzed for major elemental composition. The purpose of the work was to assess fluid flow, boiling and mixing processes of the deep geothermal waters with cold ground waters using the water chemistry. The composition of geothermal waters are controlled by composition of the source water, magmatic degassing, rock leaching, secondary mineral formation as well as conductive cooling, boiling and mixing with shallow cold waters as the geothermal reservoir waters ascend to the surface.

According to a Na-K-Mg equilibrium diagram the waters within the Geysir geothermal area are fully equilibrated and are considered to represent the deep water reservoir water composition with the exception that they are depleted in CO_2 (<150 ppm) due to boiling in the upper parts of the system. However, the waters outside the area are either immature, partially equilibrated or mixed and are characterized by high CO_2 concentration (>300 ppm).

The composition of the geothermal waters at Geysir are dominantly controlled by three processes: 1) attainment of equilibrium with secondary minerals in the hot reservoir fluids at temperatures between 200 and 250°C, 2) Boiling and CO_2 loss in the upper parts of the system and 3) mixing between the geothermal water and cold ground water. Chlorine (Cl), boron (B) behave as mobile elements in geothermal waters meaning they are not incorporated into any secondary minerals. Linear trend between the two and linear trends between boron, sulfate (SO_4) and fluorine (F) for the fresh ground water and the geothermal water indicates mixing between the two and they act as mobile during the mixing process. Spatial distribution of temperature, CO_2 and Cl concentrations demonstrate that the upwelling geothermal waters are dominantly below the main geothermal area and then moves along the main tectonic fractures (SW-NE) where it mixes with cold ground waters. Depleted CO_2 levels of the geothermal waters within the main geothermal area indicate boiling in the upper parts of the system (<400 m based on reservoir fluid of 200-250°C and boiling curve with depth) and elevated CO_2 levels of the mixed waters outside the field clearly show mixing prior to boiling.