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# Characteristics of silica solubility in the geothermal fields presented by the deep drilling data

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Permeability is one of the important parameters for geological events and the development of geothermal systems. Water-Rock Interaction has a role for spatial and temporal change of permeability in the Earth's crust, although geophysical properties have been mainly focused on. Especially silica is one of the dominant components in the Earth's crust, thus dissolution-precipitation of silica minerals is an important geochemical reaction in the crust. The permeable-impermeable boundary is regarded to consist of the brittle-ductile transition (BPT) at around 300-450 degree C (Scholz, 2002). The depth of the boundary is typically at 10 to 20 km depth (Ingebritsen and Manning, 2010), which is too deep and too strict to be observed by drilling. Therefore, the structure of the Earth's crust has been studied by indirect geophysical measurements and experiments, not by geological observation and geochemical analysis.

In the geothermal field, however, some deep drilling wells are expected to reach the permeable-impermeable boundary at around 3 km depth because of high temperature gradient. The deep drilling wells in Italy, Iceland, and U.S.A. recorded higher pressure than hydrostatic pressure at the bottom of these wells (Fournier, 1991). The deep drilling well WD-1a at the Kakkonda geothermal field, Japan, is the only well in the world to penetrate the boundary between the hydrothermal-convection zone and the heat-conduction zone (permeable-impermeable boundary) at 3.1 km depth, in 24 MPa and 380 degree C (Doi et al., 1998), which is in the supercritical conditions of water. The Kakkonda granite at $>$2.9 km depth is the heat source of the hydrothermal system of the Kakkonda geothermal field. Saishu et al. (2014) calculated quartz solubility along the well WD-1a, and revealed that the local minimum of quartz solubility consists of the permeable-impermeable boundary at 3.1 km, indicating the possibility that a large amount of quartz precipitate induce fracture sealing, blocking the downflow to the impermeable zone, and control the depth of the permeable-impermeable boundary.

In this study, quartz solubility is calculated to reveal the relationship between the permeability and dissolution-precipitation of silica minerals in the 4 deep drilling wells recorded overpressure at the bottom: (1)San Pompeo 2, Italy, (2)the well NJ-11, Iceland, (3) Wilson No. 1, U.S.A., and (4) San Vito 1, Italy. In the geothermal fields, including the Kakkonda geothermal field, the condition at the permeable-impermeable boundary is in or near the supercritical conditions of water, and quartz solubility decreases and increases drastically in hydrostatic and lithostatic pressure, respectively. If fracturing occurs at the boundary, downward fluid from the shallower part would dissolve large amount of silica and enhance quartz precipitation due to decrease of quartz solubility in deeper part. In addition, upward fluid of high quartz solubility from the over pressure zone would also trigger precipitation of quartz because of pressure decrease. Thus, in the geothermal field, the permeable-impermeable boundary would be controlled by precipitation of silica minerals.

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