Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SMP44-01 Room:102B Time:May 25 09:15-09:30

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

SAISHU, Hanae[1*] ; OKAMOTO, Atsushi[2] ; TSUCHIYA, Noriyoshi[2]

[1]AIST, [2]Tohoku University

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.

References) Doi, N., Kato, O., Ikeuchi, K., Komatsu, R., Miyazaki, S., Akaku, K., and Uchida, T., 1998, Geothermics, 27, 663-690.; Fournier, R.O., 1991. Geophys. Res. Lett., 18, 955-958.; Ingebritsen, S.E. and Manning, C.E., 2010, Geofluids, 10, 193-205.; Saishu, H., Okamoto, A., Tsuchiya, N., 2014, Terra Nova, 26, 253-259.; Scholz, C.H., 2002, 2nd edn. Cambridge University Press, Cambridge.

Keywords: silica solubility, precipitation, deep drilling, geothermal field, permeable-impermeable boundary

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SMP44-02 Room:102B Time:May 25 09:30-09:45

Electromagnetic imaging of fluids under the brittle crust

OGAWA, Yasuo[1*]

[1]Volcanic Fluid Research Center, Tokyo Institute of Technology

This paper presents a 3D inversion result of the magnetotelluric soundings over the caldera regions in the central part of NE Japan arc. The 181 MT stations in total were located around the Naruko volcano with ˜3km grid covering the area of 40km (EW) x 80km (NS). We have used the full tensor components of impedance tensors at representative eight periods (0.4˜1300s). The inversion code of WSINV3DMT was used. The initial model had a uniform earth of 100 ohmm with surrounding oceans (0.25 ohmm). The final model gave rms of 2.5 with error floor of 10%. Significant features of the model are the thick resistive upper crust in the caldera regions and sub-vertical conductors arising from the lower crust to the geothermal manifestations. The top of such sub-vertical conductor coincides with the cutoff depth of the shallow seismicity. In particular, the sub-vertical conductor at Naruko volcano has a deep root in the mid-to-lower crust underneath the Mukaimachi Caldera, which is located 20km west of the Naruko volcano. The supply of the high salinity fluid may be originated sideways and may imply the path of the fluids, which is presumably blocked by the impermeable consolidated volcanic rocks directly above the lower crustal conductor. The resistivity of the mid-to-lower crustal conductors is significantly low at the Naruko volcano, compared with those at Sanzugawa caldera to the north. The difference may be due to the salinity as well as the porosity of the fluid, because seismic tomography result does not show such differences. A helium isotope anomaly at Naruko volcano may support that the flux from the upper mantle is large.

Keywords: fluids, brittle crust, resistivity, electromagnetic induction, magnetotelluric method