Time variations of the temperature depth profile in a scientific-drilling borehole penetrated through the Futagawa Fault, Japan

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A scientific vertical borehole (borehole FDB) was rapidly drilled down to 691.7 m during September 2017 – March 2018 after the Mw 7.0 Kumamoto earthquake (mainshock), Japan occurred on 16th April 2016. This borehole penetrated the seismogenic fault called Futagawa Fault which ruptured during the mainshock. Temperature measurements across a newly ruptured fault enable us to detect the frictional heat induced by the high-speed fault slipping, and then to estimate the fault frictional resistance which controls earthquake dynamics. To investigate the frictional heat of its coseismic rupturing, we started temperature measurements in the borehole FDB from May 2018, i.e. two years after the mainshock. We are still repeating the temperature measurements once per two or three months; and have conducted seven times of the measurements until the end of November 2019.

At the drilling site located at Mashiki town, Kumamoto Pref, a ~2.5 m dextral strike-slip coseismic displacement which is the largest displacement of the mainshock was observed on the surface rupture in this area. The borehole FDB consists of a cased interval from the surface down to a depth of ~300 m, and an open hole interval below that, down to the bottom of the borehole. In this borehole, the groundwater level is ~42 m, we measure the water temperature below the groundwater level and assume that the water temperature is the same as that of the formation after they became an equilibrium state after several months after the drilling operation. We measured the temperature and pressure while putting down and pulling up high resolution temperature and pressure sensors at an approximately constant rate of 3 m/min. A positive temperature peak around a fault where resistivity and P-wave velocity obtained from borehole logging abruptly dropped. The temperature depth profile showed time variation possibly including dissipation of the coseismic frictional heat caused by the fault rupturing and the other natural reasons e.g. groundwater flow.