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Numerical Simulation of a Non-volcanic Hydrothermal System Caused by Formation of a High Permeability Fracture Zone

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Because in the Japanese islands the earth crust activity is very active, a disposal stratum for high-level radioactive waste produced by reprocessing the spent nuclear fuel from nuclear power plants will be selected in the tectonically stable areas in which the waste can be disposed underground safely for a long term and there is no influence of earthquakes, seismic activities, volcanic activities, upheaval, sedimentation, erosion, climate and global sea level change and so on, which causes the risk of the inflow of the groundwater to destroy the disposal site or the outflow to the ground surface. However, even if the disposal stratum in such condition will be chosen, in case that a new high permeability fracture zone is formed by the earthquake, and a new hydrothermal system may be formed for a long term (thousands or millions years) and the system may affect the disposal site. Therefore, we have to understand the feature of the non-volcanic hydrothermal system through the high permeability fracture zone. We estimated such influence by using HYDROTHERM Ver2.2 (Hayba & Ingebritsen, 1994), which is a three-dimensional numerical reservoir simulator. The model field is the northwestern part of Kego Fault, which was formed by a series of earthquakes called “the 2005 Fukuoka Prefecture Western Offshore Earthquakes” (the main shock of Mjma 7.0 on 20 March 2005) in Kyushu, Japan.

The results of the numerical simulations show the development of a low temperature hydrothermal system as a new fracture zone is formed, in case that there is no volcanic heat source. The results of the simulations up to 100,000 years after formation of the fracture zone show that the higher heat flow and the wider and more permeable fracture zone accelerate the development of the hydrothermal system in the fracture zone. As a result of calculation of up to10 million years, we clarified the evolutional process of the non-volcanic hydrothermal system through the high permeability fracture zone. At the beginning, convection occurs in the fracture zone when the fracture zone is formed. Then, the convection reaches to the quasi-steady state in the fracture zone. At the end, the larger convection evolves widely and slowly outside of the fracture zone. Therefore, it is inferred that a non-volcanic hydrothermal system will be formed after formation of a permeable fracture zone and the distributions of underground temperature and groundwater flow will change in the long term, even if no hydrothermal feature appears just after the seismic events.