Anomalous changes in groundwater and hot spring water after the 2016 Kumamoto earthquake

*Tsutomu Sato[1], Hiroshi A Takahashi[1], Kuniyo Kawabata[2], Masaaki Takahashi[1], Yuki Tosaki[1], Akinobu Miyakoshi[1], Akihiko Inamura[1], Hiroko Handa[1], Norio Matsumoto[1], Kohei Kazahaya[1]

1. Geological Survey of Japan, AIST, 2. Kagoshima University

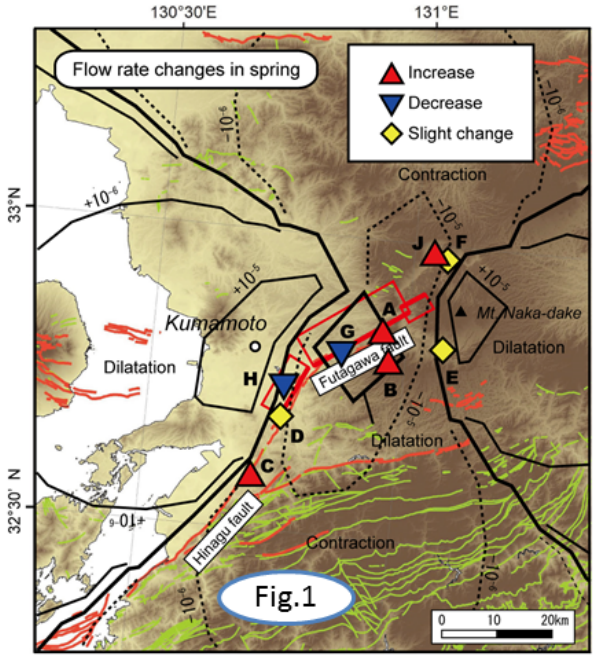
We have investigated the groundwater at the 8 springs (A-H in Fig.1) to clarify the changes associated with the 2016 Kumamoto earthquake. We also conducted inquiring survey at the 21 hot springs and investigated spring water newly generated in Aso area (J in Fig.1).
Six of the eight springs (A-D, G, H) were the places where the measurement of flow rate and sampling was done from 6th to 10th March 2016 one month before the earthquake. The same survey was carried out in 2014 for the remaining two springs (E, F) as well. Such pre-earthquake survey revealed the changes in flow rate and major chemical concentration due to the 2016 Kumamoto earthquake.
The flow rate increased more than twice that of before the earthquake at the three springs (A-C) and decreased less than half at the two springs (G, H) (Fig.2). At the other springs (D-F), changes of the flow rate was less than 30 %. The former five springs are located within 7 km form the Futagawa and Hinagu faults that caused the 2016 Kumamoto earthquake.
To compare the flow rate changes and crustal deformation which might occur at the time of earthquake, we calculated the crustal strain changes based on the fault model by Geospatial Information Authority of Japan (2016) using MICAP-G (Okada, 1992, Naito and Yoshikawa, 1999). Spatial distributions of the flow rate changes and the crustal strain changes did not show a clear relationship (Fig.1).
As for the major chemical composition, there were clear changes only in the nitrate ion concentration (Fig.3). The pattern of change was the same for the all springs as follows. The nitrate ion concentration peaked in May 2016 and decreased until September 2016 than before the earthquake.
As the result of our inquiring survey at the hot spring facilities, it became obvious that there were hot spring wells and areas where self-discharge occurred or the amount of self-discharge was markedly increased. A good relationship in the spatial distribution between the changes and the calculated crustal strain changes was found.

References

Geospatial Information Authority of Japan (2016) Rep. Coord. Comit. Earthq. Predict. Japan, 96, 557-589.
Okada (1992) Bull. Seism. Soc. AM., 82, 1018-1040.
Naito and Yoshikawa (1999) J. Seis. Soc. Japan, 2nd ver., 52, 101-103.

Fig.1 Spatial distribution of the flow rate changes of the springs in relation to the 2016 Kumamoto earthquake
Fig.2 Relative changes of flow rate of the springs
Fig.3 Relative changes of nitrate ion concentration of the springs

Keywords: The 2016 Kumamoto earthquake, groundwater, flow rate, nitrate ion, crustal strain changes, hot spring



The fault model by Geospatial Information Authority of Japan (2016)