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Kinetic evaluation of pH and temperature effects on silica polymerization in Mg, Al and Fe coexisting systems

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Silica scale formation is a serious concern in an operation of geothermal power plants because it can cause an obstruction in a pipe. Although a lot of countermeasures were adopted in geothermal wells, no ultimate solution for preventing the silica scale formation have been provided. In this study, therefore, we experimentally evaluated the effect of pH (3, 6, 9), temperature (298 - 353 K), and coexisting of other elements (Mg, Al, and Fe) on the silica polymerization and discussed about an effective countermeasure for preventing the silica scale formation.

In our experiments, the behavior of silica and coexisting elements varies greatly depending on pH and temperature. Under the acidic condition (pH 3), silica polymerization and decrease of coexisting metal elements were not confirmed. On the other hand, a silica polymerization proceeded at pH 6 and pH 9. The silica concentration decreased significantly during nucleus growth, and the rate was lower at pH 6 than at pH 9. In addition, the nucleus growth rate observed in the experiments with coexisting elements was higher than that of the experiments without coexisting elements. Furthermore, an induction period, in which the silica concentration dose not decrease, was not observed in the coexisting system. Increase of the rate constant and the absence of induction period indicated that the coexisting metal elements promote the nucleation and growth of silica scale.

Based on the above-mentioned results, we propose a new countermeasure that is to reduce the time from pumping to re-injection at pH 6 in which the nucleus growth rate was relatively slow and the rapid decrease in silica concentration was not observed. For example, if the fluid is re-injected at 353 K, we can confine the decrease of silica concentration to less than 100 ppm by returning the geothermal water within 4 hours.