Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

STT07-07 Room:421 Time:April 29 11:00-11:15

Fluid-physical simulation of silicate scale formation using lattice Boltzmann method

MIZUSHIMA, Akihiro[1*] ; MIKADA, Hitoshi[1] ; GOTO, Tada-nori[1] ; TAKEKAWA, Junichi[1]

[1]Graduate School of Engineering, Kyoto University

Scaling behavior has an important role in various geosciences fields. For example, precipitation of silica can cling to pipes and wells, and prevent the geothermal power generation. Silica precipitation strongly affects the circulation of hydrothermal systems by changing the permeability structure, which is related to the nucleation of seafloor massive sulphide. Self-sealing is of importance in the understanding of long-term radionuclide mobility and the safety of deep geological repositories of radioactive waste.

The deposition of amorphous silica is controlled probably by many processes. There have been a number of experimental studies made on the chemical kinetics of silica deposition as a function of the degree of super-saturation. However scaling estimated by the simple chemical precipitations cannot explain the measured features in laboratory and field experiments. On the other hand, a high rate of deposition could be found where fluid flow stagnates. Although it has been empirically observed that the fluid flow structure can influence silica scaling, relatively little research have been conducted to investigate hydrodynamic effect on silica scaling. The aim of this work is to evaluate the importance of both chemical kinetic and hydrodynamic effects on silica scale growth with a method of numerical simulation.

Here using the lattice Boltzmann method, we calculated velocity, temperature and concentration of dissolved silica in the 2D parallel plate channel and predicted the silica deposition of both chemical kinetic and hydrodynamic deposition processes. The laboratory results by Hosoi and Imai (1982) can be as the reference. We also predicted the silica deposition along the channel with sudden expansion of width. For the latter case, the similar field example in the production pipes of the geothermal well was reported (Mercado et al., 1989).

In our numerical simulations, the silica deposition predicted by the kinetic process has the magnitude extremely lower than the amount of laboratory experiment, but shows the similar magnitude if the hydrodynamic process is considered for scaling. In addition, at the another channel model with the sudden expansion scaling predicted by the hydrodynamic process can explain the observed feature at the geothermal well.

It is found that consideration of the simple kinetics process solely is not sufficient for explanation of the real silica deposition. Therefore, we emphasize the importance of hydrodynamic effect on silica scaling. To predict the silica deposition more quantitatively, an advanced-simulation including behaviors of colloid silica particles in flow.

Keywords: scale prediction, silica scaling, kinetics, hydrodynamics, the lattice Boltzmann method