Fluid flow patterns in fluid injection into swelling gel particles

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Frequency of slow slip events varies by pore-fluid pressure, and further, pore-fluid pressure varies by permeability change caused by silica dissolution [1]. It is important for comprehensive understanding of earthquake mechanism to understand not only how permeability change in various situations but also how fluid flows with such variation of permeability. For this purpose, we explore the fluid flow in varying permeability by an analogue injection experiment.

In this study, we tried to imitate a fluid flow in thin fracture. Thus, we used a thin 2-dimensiohnal cell made of two acrylic plates. The gap between the plates was set as 1 mm to imitate fracture. We initially filled the gap with samples, gel particle, made of sodium polyacrylate. This gel particle is so called ionic gel, and can swell to be 1000 times in its volume when pure water is added. Furthermore, we can tune the swelling rate, as well as final swelled volume by changing the salinity of water [2]. We used the gel particle whose typical radius 350 μm in dry condition. After we filled the cell with the sample, we tapped 10 times so as to have particle packed well [3]. We then injected an aqueous phase, an aqueous solution of sodium chloride, into the cell from the bottom of the 2-dimensional cell. As a control parameter, we have changed the concentration of sodium chloride Cs, and injection rate Q. The schematic illustration of experimental setup is shown in Fig. 1.

Fig.2 is the obtained phase diagram. In the diagram, particles are displaced by fluid flow in white areas, and fluid penetrates in deep black areas. At high Q and C_s, the gel particle did not swell significantly, and the injection front steadily expanded circularly without the interruption of fluid flow. On the other hand, at low Q and C_s, due to the swelling of gel particles, fluid flow was blocked, and the injection front branched. These behavior, the transition from branching to circular injection front, can be considered with a simple mathematical model.

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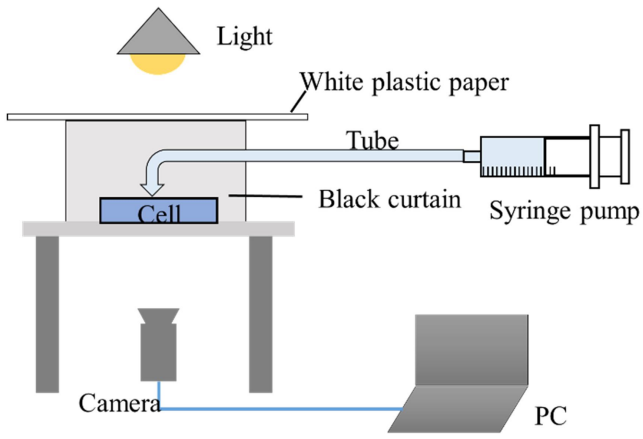

Fig.1 Schematic representation of experiment setup

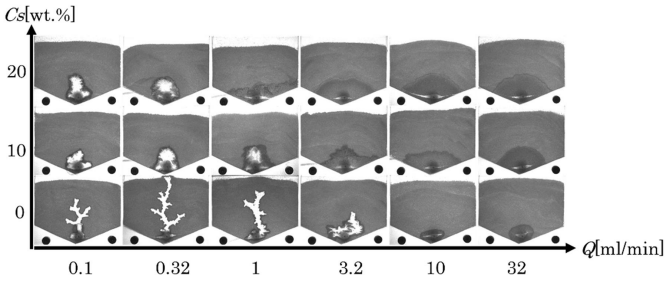

Fig.2 Phase diagram of injection behavior

