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Gas Driven Fracture during Gas Production using HeleShaw Cell

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Methane hydrate is considered a potential energy source, with worldwide reserves on the order of 500-10,000 Gt of carbon. The production of Methane from hydratebearing sediments requires hydrate dissociation for releasing mobile methane gas in sediments prior to gas production operation. Existence of even a small fraction of fines can greatly decrease the permeability of sandy sediments, which will affect the gas recovery process. Fines can migrate through or clog the pores of sandy sediments depending on geometric constraints such as the ratio of the size of the pore throat to the size of the fine particle. In multiphase flow, clogging of fines at the pores causes a change in pressure gradient which affects the flow of gas through the pores and might induce gas driven fracture. In the literature, there is a major knowledge gap that needs to be resolved to develop technical and economically viable methane production strategies from gas hydrate reservoirs. A comprehensive understanding of the underlying physical processes such as fines migration, clogging, and gas-driven fracture during gas production in hydrate bearing sediments is needed. Effects of fines migration and clogging on gas flow path and gas driven fracture were studied for Carbon Dioxide (CO2). This was achieved by conducting multiphase flow experiments on brine saturated sand-kaolinite mixtures using 2D Hele-Shaw cell; a common analogous model that has been used to investigate particle displacement process in sediments and has the unique advantage in allowing real-time visualization. The cell consists of two transparent acrylic sheets that are separated by a small gap. The gap between the two sheets is maintained using filter sheets that have a thickness of 1/16 in. (1.6 mm) at the boundaries. Fluids flow radially between the sheets through a port in the middle of the bottom sheet. Multiphase flow experiments are conducted on samples of brine saturated uniform F75 sand mixed with kaolinite at different percentages by weight (0% to 20%). Pressure volume actuator (flow pump) is used to

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inject brine into the sample for saturation. Following saturation, CO_2 is applied to the cell at a constant pressure (2 kPa, 5kPa, and 10 kPa). Variation of gas pressure is monitored using a pressure sensor that is attached near the port of the cell. The injection processes are recorder using a high resolution digital camera mounted above the cell. Gas pressure was found to increase with increasing fines content, which indicates the clogging of pores by kaolinite particles. Particle image velocimetry (PIV) analysis was conducted using PIVLAB code on MatLab. Velocity vector field and density plots of velocity field were generated to track particles displacements. Particles near the fracture tip were moving at the highest velocity. The results showed three different regimes of gas flow through sediments. For low concentration of fines, the gas percolates through the pores with no major host particles displacement. For a high concentration of fines, major particle displacement occurs and gas driven fractures are created. Gas solely flows through those generated cracks with no observed percolation. Finally, a combination of the two regimes takes place for intermediate fines content.