Saturation dependency of Bishop’s effective stress coefficient strongly affects strain behavior of rocks under two-phase flow condition

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Understanding the strain behavior of rocks under two-phase flow condition is important to discuss a variety of subsurface processes including geological sequestration of carbon dioxide. Bishop’s effective stress coefficient (χ) is a parameter which defines “equivalent” fluid pressure in the stress-strain-fluid pressure relationships for porous media in two-phase fluid system (Coussy, 2007), and is commonly expressed as a function of the wetting-phase saturation. In this study, laboratory experiments and numerical simulations were conducted to investigate the effects of saturation dependency of χ on the strain behavior of rocks. In the experiment, compressed air was injected into a water-saturated cylindrical Berea sandstone sample from the bottom under hydrostatic external stress condition. During the experiment, confining pressure, air pressure at the bottom, and water pressure at the top were kept constant at 0.55, 0.35, 0.20 MPa, respectively, and axial and circumferential strains at half the height of the sample were monitored. Numerical simulation was conducted to reproduce the measured data by using a simulator which can solve coupled two-phase flow and deformation in porous media (Aichi, 2010). The measured strain behaviors before air breakthrough were reproduced well by assuming χ to be equal to water saturation, while those after the breakthrough was not. Non-linear relationships between χ and wetting-phase saturation explained both the measured strain behaviors before and after the breakthrough. It is concluded that saturation dependency of χ is an important parameter for understanding the strain behavior of rocks in two-phase fluid system.

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