Poroelastic parameters of water-saturated Kimachi sandstone under confining pressure

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Abstract

In the geological storage of carbon dioxide (CO_2), a long-term monitoring of CO_2 in a reservoir is required. An inversion technique utilizing tilt data of the ground surface, which is based on the poroelastic theory, may be a promising for the requirement. Since the inversion technique is based on the poroelastic theory, poroelastic parameters of reservoir rocks (e.g., sandstone) should be well understood at a wide range of reservoir conditions. For this purpose, laboratory experiments were conducted to determine poroelastic parameters of water-saturated sandstone at various combinations of confining pressure (7-40 MPa) and pore pressure (5-25 MPa), namely various Terzaghi's effective stresses of 2-35 MPa. Sandstone specimens (29 mm in diameter, 62 mm in length) were prepared from Kimachi sandstone (Shimane prefecture, Japan). The sandsone had effective porosity of approximately 20%, Young's modulus of approximately 11 GPa, and Poisson's ratio of approximately 0.2, at the atmospheric pressure. Drained and undrained triaxial compressive tests were conducted to determine Young's modulus and Poisson's ratio. Under undrained condition, B-test, in which volumetric strain and pore pressure changed with confining pressure, was conducted to determine Skempton's coefficient B and undrained bulk modulus. Moreover, under drained condition, P-test and H-test, in which volumetric strain changed with confining pressure, and pore pressure, respectively, were conducted to determine drained bulk modulus, and poroelastic expansion coefficient, respectively. These tests and some calculations using poroelastic parameters from the tests provided a full set of poroelastic constants. As a result, it has been revealed that any poroelastic parameter (y) may be described by a simple function of Terzaghi's effective stress (σ_{eff}),$y = a + b \cdot e^{-\sigma_{eff}/10}$, in which a and b are constants.