Effective Confining Pressure Dependency for Fluid Flow Properties of Young Sedimentary Rocks from TCDP

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Abstract

Accurate measurement of the stress-dependent fluid flow properties is essential to explore the process of fluid percolation in crust. This study utilized an integrated permeability/porosity measurement system to determine the confining pressure-dependent permeability/porosity of sedimentary rock cores from a 2 km borehole in Taiwan. The measured permeabilities of sandstone and siltstone/shale are 10^{-13}~10^{-14}m^2 and 10^{-16}~10^{-19}m^2 under confining pressure of 3~120 MPa. The Klinkenberg effect is considered to evaluate the difference between the gas- and water- derived permeability of core samples. The permeability of siltstone and shale is more sensitive to effective confining pressure than that of sandstone. Meanwhile, different rock types have almost identical pressure-sensitivity of porosity. The measured porosities of sandstone, siltstone and shale under confining pressure of 3~120 MPa are 15%~24%, 8%~11% and 13%~14%, respectively. Based on laboratory work, a power law describing the pressure-dependency of permeability/porosity appears superior to an exponential relation for fresh, young sedimentary rocks (Late Miocene to Pliocene) in the Western Foothills of Taiwan. Consequently, a power law describing the pressure-dependency of porosity is suggested to derive the specific storage of tested rocks. The calibrated porosity sensitivity exponent α ranges form 3.26 to 5.47 (loading) and ranges form 2.34 to 3.08 (unloading) for tested sandstones using a power law for describing the pressure-dependency of permeability/porosity. Specific storages of tested sandstone and siltstone/shale are 0.2~2.0×10^{-3} MPa-1 and 0.07~0.7×10^{-3} MPa^{-1}, respectively, under confining pressure of 3~120 MPa. With the adoption of a power law, a representative relation between specific storage and effective confining pressure was derived for tested rock samples. The suggested pressure-dependent specific storage and the pressure-dependent permeability/porosity were incorporated into one

dimensional consolidation simulation to demonstrate the influence of pressure-dependency fluid flow properties on overpressure development.