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Upscaled model for steady slip flow fluid structure coupling in shale system

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Shale is a highly heterogeneous porous material rich in organic matter. Injecting fluid into a porous material can expand the pore space, distorting the solid skeleton. The detailed flow and mechanics of this solid deformation has not yet been systematically investigated. This work reports on modelling steady liquid flow in shale system, considering the slip effect and fluid-structure wall deformation. A microscale (pore level) fluid structure interaction (FSI) problem is formulated in terms of incompressible Newtonian fluid and a linearized elastic solid. The slip effect is adopted means of a Navier-type boundary condition. Combining different mechanical properties of organic and inorganic matter, an asymptotic solution to the FSI problem is derived for a certain geometry. A nonlinear Darcy-type upscaled equation for the averaged pressure is obtained, as well as introducing an apparent permeability dependent on interface position and slip coefficient. Based on the obtained results, relevant results for more general situations are obtained through extended analysis. The accuracy of the result is assessed by comparisons with numerical simulations. Our results may be useful for a better understanding of shale oil rocks at the micrometer scale, studying the large squeezing deformation of carbonaceous shale in practical situation or studying the deformation of other porous media.

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Primary authors: SUN, Yurou (China University of Petroleum(East China)); SUN, Hai (China University of Petroleum (East China)); YAN, Xia (China University of Petroleum (East China)); FAN, Dongyan (China University of Petroleum (East China)); ZHANG, Lei (China University of Petroleum); FU, Shuaishi (China University of Petroleum (East China)); YAO, Jun (China University of Petroleum (East China))

Presenter: FAN, Dongyan (China University of Petroleum (East China))

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