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Rheological double-porosity model for clayey rocks

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Abstract

We examine a unified mathematical model of rheological and transport properties of saturated deformable fractured rocks and clays. The foundation of the model is the unification of filtration consolidation theory and the theory of stability of lyophobic colloids for the case of clay's deformations, which is based on the concept of disjoining pressure as surplus in comparison with hydraulic pressure, caused by the surface capacities and existing in water films between clay particles. We analyzed the approximate solution about wringing the water out of the layer. The solution that we received demands us to introduce a concept of limit shear stress for clays. We investigate the peculiarities of the model, which are important for explaining some characteristic features of mass transport processes in deformable rocks (the existence of special filtration regime in fractured rocks) and transfer processes in clays (the existence of anomalous high pressures in not compressed clays, the flocculation at diffusion in clays, etc.). It is shown that the solutions that we have derived are in good agreement with results of experiments.

1. Introduction

Deformable fractured rocks and clays are traditional objects of intensive investigation for mechanics and geomechanics because of the functions that they perform and also the availability of some specific properties (non-linear filtration in deformable fractured rocks, ability for swelling and plasticity in moist condition in clays and others). So, low-permeable clayey rocks usually play the role of confining layer for water-bearing strata or oil pools, appearing as natural buffer in underground water pollution, and are used in building and others branches of industry. Deformable fractured rock mechanics plays an important role for hydrogeology and the oil industry.

Properties of deformable fractured rocks and clayey rocks, and also processes occurring in them, depend on a number of factors. This is because the mathematical simulation of these properties and processes, as one of the methods of their examination, is a difficult problem. Physically it is clear that the specific properties of these rocks (low permeability, plasticity in moist condition for clays) are caused by the existence of low permeable zones in deformable fractured rocks [1] and clay minerals in their composition in clayey rocks, and these properties are the display of surface capacities, which exist between particles of clay minerals, which are included in composition of clays [1].

The most productive concept of the activity of surface capacities is that of disjoining pressure between colloid particles [2]. In this work, we give a description of physical and mechanical clay properties and transfer processes in them. Also, we give a mechanical description of deformable fractured rock behavior. The description is based on methods of the theory of filtrational consolidation [3] and also on the theory of stability of lyophobic colloids (theory of Derjaguin, Landau, Verwey and Overbeeck; DLVO theory), which uses the concept of disjoining pressure.

2. Fractured rock mechanics

Before we proceed to the theoretical description of deformable fractured rocks properties we will describe

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