

Comprehensive study of stress effect on filtration-capacitance properties of underground gas storage reservoirs using geomechanical and CT-based approach

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The system of underground gas storage facilities (UGSF) is an integral part of the Russian gas supply infrastructure, providing stability in the presence of large climatic differences and significant length of the country's territory [1]. UGSF are created in depleted gas, gas condensate fields, aquifers or caverns eroded for them in salt formations. Reservoirs suitable for UGSF must be formed by rocks with high porosity and permeability, they have low strength characteristics often. One of the main problems in the operation of underground gas storage facilities, sand production, is related to this. The destruction of the reservoir rock and the production of sand into the well leads to wear of underground and surface equipment, clogging of filtration channels in the bottom-hole zone, and the formation of sand plugs [2]. In addition, the specific feature of UGSF operation is cyclic gas injection and extraction, which affects changes in reservoir pressure and stress-strain state in the vicinity of the wells. These factors can also negatively affect well quality creating a reduced permeability area in the bottom hole zone, which deteriorates the hydrodynamic connection between the well and the reservoir.

In order to justify the optimal regimes of well operation, as well as to find effective methods of construction and impact on the bottom hole zone of wells, it is necessary to conduct preliminary comprehensive studies of reservoir rocks.

This work presents the results of multidisciplinary experimental study of filtration-capacitance characteristics of highly porous reservoir rocks of an UGS aquifer. The geomechanical part of the research included the study of the dependence of rock permeability on the stress-strain state, which changes in the vicinity of the well during well operation, and physical modeling of the implementation of the directional unloading of the reservoir (DUR) method [3]. The tests were carried out on the unique Triaxial Independent Load Test System (TILTS) of the Ishlinsky Institute for Problems in Mechanics RAS [3]. The digital part of the research included non-destructive computed tomography-based analysis of the internal structure, pore space and filtration characteristics before and after tests. The study of changes in the internal structure of specimens was performed using a high-resolution X-ray micro-CT scanner ProCon X-Ray CT-MINI [4]. Numerical modeling of filtration flow on 3D models of rocks was carried out using GeoDict software modules.

The porosity, geodesic tortuosity and permeability values of rocks were obtained in the results of digital studies and numerical modeling. High homogeneity and cohesion of rock pore space was revealed on the basis of analysis of pressure field, pore size distribution and flow velocity field. The reasons of weak transversal anisotropy of permeability are revealed. The destruction character of specimens after tests on TILTS were analyzed. The results obtained by digital method are in good agreement with the results of laboratory measurements.

Physical modeling on specimens of the DUR method implementation confirmed the efficiency of the method for the conditions of the studied reservoir. Necessary parameters of its application were calculated: an optimal stage of operation, bottom hole design, and pressure drawdown.

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Reference list

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