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Explicit simulation of seismic waves in fluid-filled fractured porous media

Tuesday, 1 June 2021 10:00 (1 hour)

Oil and gas deposits are still the largest energy sources among all over the world. The most common and reliable method of their prospecting and exploration is the seismic survey process. It is based on the propagation of seismic waves in geological media and their interaction with heterogeneities (reflection, diffraction, attenuation). Recently, a lot of migration and inversion algorithms were developed: full-waveform inversion, petrophysical inversion, stochastic inversion, etc. All of them are based on the numerical solution of the direct wave problem. That is why, the investigation of accurate and effective methods of the computer simulation is an important scientific task.

Previously, the usage of sophisticated mechanical-mathematical models for describing the dynamic behavior of geological media was strictly limited by the performance of available computers. In the last century, several models describing wave propagation in porous fluid-saturated media were proposed. Initially, the Gassmann model [Gassmann, 1951] has become widespread. Further, the Biot model [Biot, 1956], has grown more popular, since it describes the porous medium more accurately. For example, the Biot model considers two velocities of longitudinal waves that can be observed and measured experimentally [Winkler et al., 1989]. In 1989, V.N. Dorovsky proposed a non-linear continual theory of filtration [1989]. The theory was expanded in the work [Blokhin and Dorovsky, 1995], and the two-velocity linearized model, known now as the Dorovsky model, was presented. The comparison of the continuum filtration theory with the Biot-Johnson theory was done at [Dorovsky et al., 2012]. Both models show excellent agreement with each other. Another physical model of the multiphase medium was suggested in [Romensi et al., 2019]. Its governing equations form a hyperbolic system of PDEs that significantly differs from the Biot system [Biot, 1956] because of the different stress-strain relationships; however, the authors state that "the features of wavefields are qualitatively similar in both models, and in some cases, they are quantitatively close by a corresponding choice of the material parameters"[Romenski et al., 2019].

In this work we extended our novel approach for the simulation of seismic waves in hydrocarbon deposits [Golubev et al., 2020] to the case of fractured fluid-saturated medium described by the Dorovsky model. We relied on the method of incorporating fractures into the computation process presented in [Khokhlov et al., 2020] for isotropic elastic media, which replaces an inclined fracture with a number of small fractures tied to the mesh points and duplicates the corresponding nodes (containing the unknown functions). The feature of the method is the possibility to perform calculations on a structural computational grid, that avoids the construction of unstructured grids and drastically decreases computational costs. Physically correct internal contact conditions were derived for the two sides of the fracture, that eliminates the meshing process inside the crack volume. The presented approach allows us not only to simulate precisely the stress-strain state, but also to estimate the pore pressure inside the reservoir.

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Time Block Preference

Time Block A (09:00-12:00 CET)

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Primary authors: GOLUBEV, Vasily (Moscow Institute of Physics and Technology); Mr SHEVCHENKO, Alexey (Moscow Institute of Physics and Technology)

Presenter: GOLUBEV, Vasily (Moscow Institute of Physics and Technology)

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