Abstract (EN)

Thesis deals with an approximation of static moduli in wells from dynamic moduli determined by acoustic well logging using T-matrix model. Proposed approach makes possible to determine moduli values, which are close to values of static moduli, which would be determined by loading tests.

This approach is based on an idea, that an intact rock with sufficiently high compressional strength σ_c and sufficiently high value of static Young's modulus E_s, manifests more or less linear elastic behaviour. In such case, the values of static and dynamic moduli are identical. This fact has been experimentally verified for rocks with values of σ_c and E_s in order of higher tens of MPa and GPa respectively. In case of a rock damage presence in such rock, it's behaviour becomes nonlinearly elastic. The amount of nonlinearity is proportional to increasing amount of rock damage. This results in the difference between values of static and dynamic moduli.

T-matrix model is used to quantify this difference. This model is based on an anisotropic rock matrix with ellipsoidal inclusions. These inclusions can affect each other. The result of this model calculation is a group of values of elastic constants, which we call effective moduli. These effective moduli include the effect of porosity in the rock as well and they serve as an estimate of static moduli.

Input data for T-matrix model construction and calculation are based on several following parameters. Firstly it is acoustic well logging providing dynamic moduli. Secondly it is data from the set of other well logging methods which provide information about lithology and its changes along the borehole and porosity and density data of rocks in which the borehole is situated. Further on, static moduli determined by loading tests on selected core samples and acoustic scan of borehole wall from which presence of cracks is interpreted, are used.

Based on results of well logging data interpretation, the borehole profile is simplified and divided into quasihomogeneous layers. Within these layers, individual core samples are selected on which static moduli are determined by uniaxial static loading tests in laboratory. By combination of these static moduli and layered profile, the initial layered model is put together. Determined porosity of rock along the borehole is interpreted, in combination with detected cracks, into so called effective medium porosity.

Verification of proposed approach has been carried out on experimental well, drilled in Silurian limestones. Aside from core samples used for putting together the model and its calibration, a set of control samples has been taken. These served for model functionality evaluation only. Effective moduli values calculated in depths respective to control samples have been compared to static moduli values, determined on these samples in laboratory. The final comparison of dynamic and effective values of Young's modulus with static values showed significant mitigation of initial difference. For majority of control samples, the difference dropped from initial value of around 40 % of static modulus value, to less than 10 %.