Geostatistical approaches to the prediction of sandy reservoir facies based on the analysis of elastic inversion results

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The distinction between oil and gas reservoirs and non-reservoirs is one of the most important problems in petroleum exploration. Prediction of reservoir properties based on seismic data offers benefits for further exploration and development of hydrocarbon-saturated reservoirs. Analytical and numerical mathematical methods can be used to delineate reservoir properties based on elastic inversion results. The application of an integrated approach of joint analysis of petrophysical and seismic parameters allows to predict the optimal distribution of desired reservoir properties. The study was done based on the data from the southwestern Ural Foreland. The studied terrigenous formation consists of medium and fine-grained sandstones, siltstones, mudstones. A small amount of carbonate minerals occurs as pore cement. The studied TK formation belongs to the terrigenous deposits of the Lower Carboniferous and overlies a limestone sequence with interlayers of marls and mudstones. The applied approach to delineate reservoir properties is based on the analysis of elastic parameters of the seismic inversion. In the paper, an integrated approach for the analysis of petrophysical and seismic inverted data is considered, the results of which allow to predict the optimal distribution of the studied reservoir properties. Analytical and numerical solutions for predicting net pay thickness distributions, based on the elastic characteristic discrimination, are proposed. Numerical methods have higher accuracy, but the use of analytical approaches allows the calculations to be simplified and the algorithms to be more flexible for a wider range of programmes, while maintaining high reliability of the results. A 3D seismic cube and 12 wells with petrophysical data were used for this study. Missed P- and S velocities were reconstructed by applying petro-elastic modelling methods. Prestack seismic data were used to define elastic attributes such as P-impedance, S-impedance, Vp/Vs-ratio, Poisson's ratio and porosity. Analytical and numerical geostatistical approaches were used to separate the reservoir sand facies. Cross-plot analysis of PR = f (AI) was used to separate the desirable sand facies of the reservoir part, where PR is Poisson's ratio, AI is P-wave impedance. Initially, the distribution of the area of interest was defined on the cross-plot of PR = f (AI) and referred to as the Field of Initial Events (FIE). Then, in an iterative process, the optimal net pay thickness was calculated until the best correlation with the petrophysical data was established. The finally determined data set was called the Field of Resulting Events (FRE). Both the analytical and numerical approaches demonstrated good correlation with actual net pay thickness – 0.65 and 0.68, respectively. The defined sand reservoir facies were associated with the deltaic-fluvial bars. It was inferred that the fluvial sandy facies prograded from northeast and east to the paleo-shoreline. Tectonic movement of platform blocks in the Early Carboniferous and marine regressions led to the generation of clinoform strata, which are also well traced on the seismic data. Recommendations for further exploration were made and a specific well was proposed.