Pore-pressure and geomechanical parameters prediction based on elastic inversion results

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Predicting pore-pressures and geomechanical properties and developing of recommendations for further drilling are essential problems of geological exploration. It is a major concern to predict abnormal pressures and technological parameters before penetrating the target horizons. In this context, seismic exploration methods are particularly in demand. The latest seismic data processing and post-processing technologies could improve the accuracy of pore-pressure and geomechanical parameter definition. The latest seismic inversion methods also extend the abilities of seismic data to obtain P- and S-impedances and determine elastic constants such as Poisson`s ratio, Young`s modulus, etc. This in turn allows us to define the line of normal compaction much more precisely, calculate the rock and hydrostatic pressures and move on to predicting abnormal geofluid pressures. In the next step, fracture pressures can also be derived from the calculated pore pressures in conjunction with knowledge of Poisson`s ratios. The joint consideration of the determined pore pressure and fracture pressure values enables the prediction of the optimal mud density and windows of drilling schedule. These investigations on the pore pressure and geomechanical properties were carried out in the area of the NY-1 well of the Taimyr Peninsula, which belongs to the northern part of Western Siberia. The region is located in the southwestern part of the Taimyr Peninsula within the Yenisei-Khatanga Trough and consists of a thick sequence of Mesozoic-Cenozoic volcanogenic-terrigenous sediments, in which Upper Permian and Triassic deposits are also present. Petrophysical data from the NY-1 well was attracted for the study. P-wave velocity and two S-wave velocity log records were provided down to 3,694 m depth. Seismic stacking velocities from seismic line 21 were also used. The P- and S velocities were reconstructed in the missing intervals up to 6 km based on petro-elastic modelling. The reconstructed velocities helped to create a low-frequency model for the elastic inversion and to determine P- and S-impedance, Poisson's ratio and other characteristics. Analysis of the inverted P-impedance data at NY-1 well site allowed the normal compaction trend to be established and the overburden and hydrostatic pressures to be defined. Considering the presence of permafrost zone, the normal hydrostatic pressure was derived based on a reduced water density of 0.8 g/cm^3. The first observation of the abnormal pressure was recorded in the Aptian-Albian Yakovlevskaya Formation (1,100–1,200 m), with an anomaly coefficient (AC) of 1.12 to 1.14. The next zone of increased pressure was detected at the level of the Lower Cretaceous Sukhodudinskaya Formation and deeper (interval: 1,660–2,000 m), with corresponding AC of 1.04–1.06. At a depth of 4,900 m, AC reaches 1.23, and below 5,150 m, the pore-pressure AC becomes to 1.45–1.5 and continues to increase with further burial. The determined Poisson's ratio allowed us to determine the fracture pressures. Considering the obtained pore pressure and fracture pressure together in the seismic inverted data enables us to predict the optimal mud density and the drilling windows up to a depth of 6,000 m. The calculations were performed for all CDPs of seismic line 21. The accuracy of predicted mud density at the NY-1 well site was 95–96 %.