Numerical modeling of the effect of borehole stress concentration on sonic logging measurements in shale formations

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In oil or gas exploration, sonic logging is a routine approach for formation evaluation. The drilling-induced stress redistribution around the wellbore can cause changes in the elastic properties of the near wellbore formations. This can make the sonic logging measurements deviate from the response of the virgin formations. The influence of borehole stress concentration on sandstones has been investigated by a number of researchers, we extend the study of this problem to anisotropic shale formations. To model the effect of borehole stress concentration on the elastic properties of shales, we need to first calculate the borehole stress distribution and then construct a rock physics modeling workflow to compute the changes in elastic properties under given stress conditions. We assume that shale formation is a transversely isotropic medium and its symmetric axis can be in an arbitrary direction with respect to the borehole axis. In our simulation, we first use the borehole stress solution of Amadei to calculate the stress distribution around the borehole, and then the elastic properties of the formation at each position around the wellbore is modified based on the local stress tensor by using a micro-crack rock physics model. The adopted rock physics model considers the influence of both intrinsic anisotropy and stress-induced anisotropy. This results in an inhomogeneous anisotropic borehole model that can reflect the effect of borehole stress concentration on near wellbore shale formations. Based on the proposed modeling workflow, we create a number of different scenarios that correspond to different shale formations and in-situ stress conditions, and then study the characteristics of the compressional and shear wave velocity variations in these situations.

Keywords: Sonic logging, borehole stress concentration, shale, rock physics modeling, in-situ stress

