MODELING THE ANISOTROPIC ELASTIC PROPERTIES OF THE EAGLE FORD SHALE WITH COMPLEX MICRO-SCALE FABRIC

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ABSTRACT
Micro-scale fabric influences the elastic properties of rock formations. The influence is most significant on complex rocks such as shale. The complexity of the micro-scale fabric of shale results from composition, platy clay minerals, kerogen, and their preferred orientation patterns. This micro-scale fabric also increases the rock elastic anisotropy. In this paper, we present a comprehensive three-step rock-physics approach to model the anisotropic elastic properties of the Upper Eagle Ford Shale. We start with anisotropic differential effective media modeling, followed by an orientation correction and then a pressure adjustment. This method accounted for the micro-fabric of the rock in terms of the complex composition, shape and alignment of clay minerals, pore space, and kerogen. In addition, the different pressure-dependent behaviors of P-waves and S-waves are included. The modeling results match log measurements relatively well. The clay content, kerogen content and porosity decrease the rock stiffness. The anisotropy increases with kerogen content, but the influence from clay content is more complex. Clay content increases the anisotropy at small concentration; however, the anisotropy stays nearly constant, or slightly decreases, as clay content continuously increases. This result suggests that the preferred orientations of clay clusters are preserved at relatively low clay concentrations at the core scale. However, the preferred orientations can vanish at high clay concentrations at the same scale. This method could also be applied to other shales with carefully chosen parameters.
Crossplot of \((C_{33} - 2C_{44})\rho\) and \(C_{44}\rho\). The lines represent stiffness models with different volumes of clay. The scattered points are calculated from log measurements, in color of clay volume. From upper right to lower left, both the measured points and models show the trend of increasing clay volume. Each model line covers a range of porosity plus kerogen volume from 4% to 16% from the top of each line to the bottom.