ERROR ESTIMATES OF ELASTIC COMPONENTS IN STRESS-DEPENDENT VTI MEDIA

Kyle T. Spikes

Department of Geological Sciences
The University of Texas at Austin

ABSTRACT

This work examines the range of physically acceptable VTI elastic compliance and stiffness components for a laboratory shale dataset. The importance of this work is to demonstrate that multiple constrained models explain independently calculated measurement error bars. Laboratory data and a statistical rock-physics approach provide the basis for this study. Velocity measurements, made as a function of pressure on a low porosity, brine-saturated hard shale, comprise the data. Error bars were computed for each elastic constant as a function of pressure. The rock physics model is pressure dependent and represents simultaneously five elastic compliances for a VTI medium. A non-linear least squares fitting routine established a best-fit model to the five compliances at each pressure. Distributions of the five compliances, based on the best-fit model, provided the simulation parameter space independent of error bars. Strain-energy requirements, inequalities for stiffness coefficients and anisotropy parameters, maximum thresholds, and local slopes determined which models were physically acceptable. Sixteen separate criteria were considered, and a criterion relating a compressional to shear stiffness was violated most frequently. Differences between the accepted models and data and error bars indicate systematic error in the data and/or that the samples are not a homogeneous VTI medium. However, these two interpretations cannot be separated and verified within the presented technique. The ranges of acceptable values and uncertainty estimates could be incorporated into seismic inversion, imaging, and numerical modeling.
Distributions of pressure-dependent stiffness components for a VTI medium. In each plot, pressure is on the x-axis, and the five independent stiffness components are on the y-axis. Color corresponds to the count for each distribution. Relatively narrow ranges of P-wave stiffness values occur frequently, but wider ranges are present for the other three stiffness terms. Even though anisotropy should decrease with pressure, the allowable ranges of all the components becomes wider as pressure increases.