ERROR ESTIMATES OF ELASTIC TENSOR COMPONENTS IN STRESS-DEPENDENT VTI MEDIA

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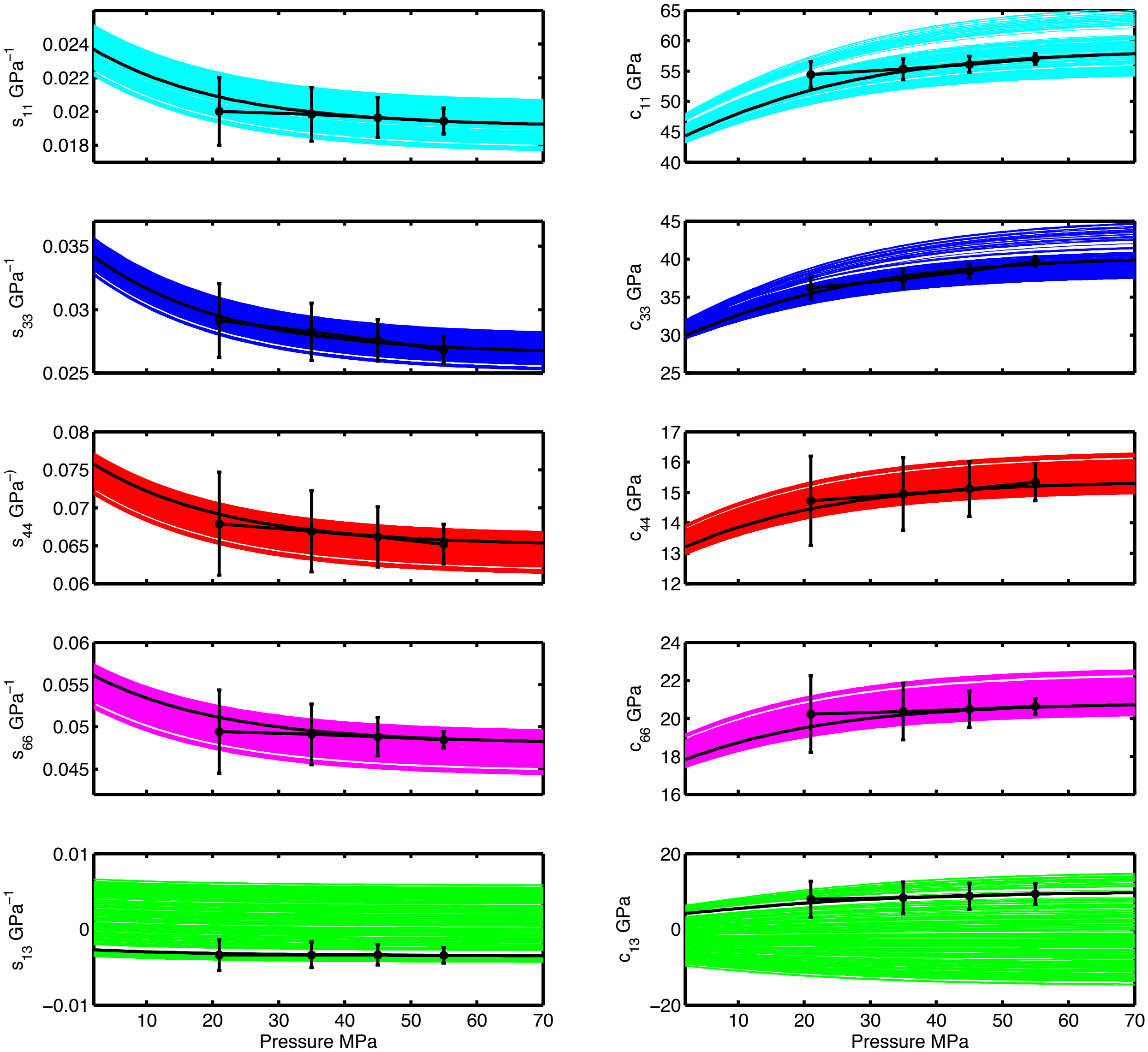
ABSTRACT

This work examines the range of physically acceptable VTI stress tensor components for a laboratory shale dataset. The importance of this work is to demonstrate the potential model-based variability and associated error of elastic compliance and stiffness components that are physically acceptable. 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, hard shale provide the basis for completing this work. In terms of a rock physics model, a pressure-dependent model was used to represent simultaneously five compliances at any given pressure from 20–70 MPa. This model requires specifying compliances at high pressure (5 independent parameters), plus four others. These four are a characteristic pressure, the ratio of tangential to normal compliance, the anisotropic crack orientation parameter, and the product of the tangential compliance and the specific surface area of cracks per unit volume. Prior distributions of the five compliance components and the rock physics model provided the parameter space. Acceptable solutions were constrained to several criteria including energy requirements, relative values of stiffness coefficients, and relative values of calculated anisotropic parameters. Multiple solutions were validated, and criterion relating compressional to shear waves was violated most frequently was an inequality relating shear and compressional stiffnesses. Differences between the models and data indicate error in the data or that the samples deviate away from a true VTI medium. These simulations provide a way to analyze the elastic tensor components, and they provide uncertainty estimates useful in seismic inversion and imaging techniques.



Solutions for the compliance components in the left column and stiffness components in the right column for a subset of the simulations. A total of 805 simulations over all pressures were considered, and 287 passed on the checks for energy requirements and other cut off criteria. Considering the overall fit of all models to the original model (in black), the 11 and 33 terms are likely the best fits, followed by the 44 and 66 terms. However, the 13 terms are skewed notably above (compliance) and below (stiffness) the original model and data. This suggests the sensitivity of this parameter. The inconsistent match of the range of models from one component to the next also suggests that more error is present in the 44, 66, and 13 data than in the 11 and 33 data components. An alternate scenario is that these samples are not absolutely VTI.