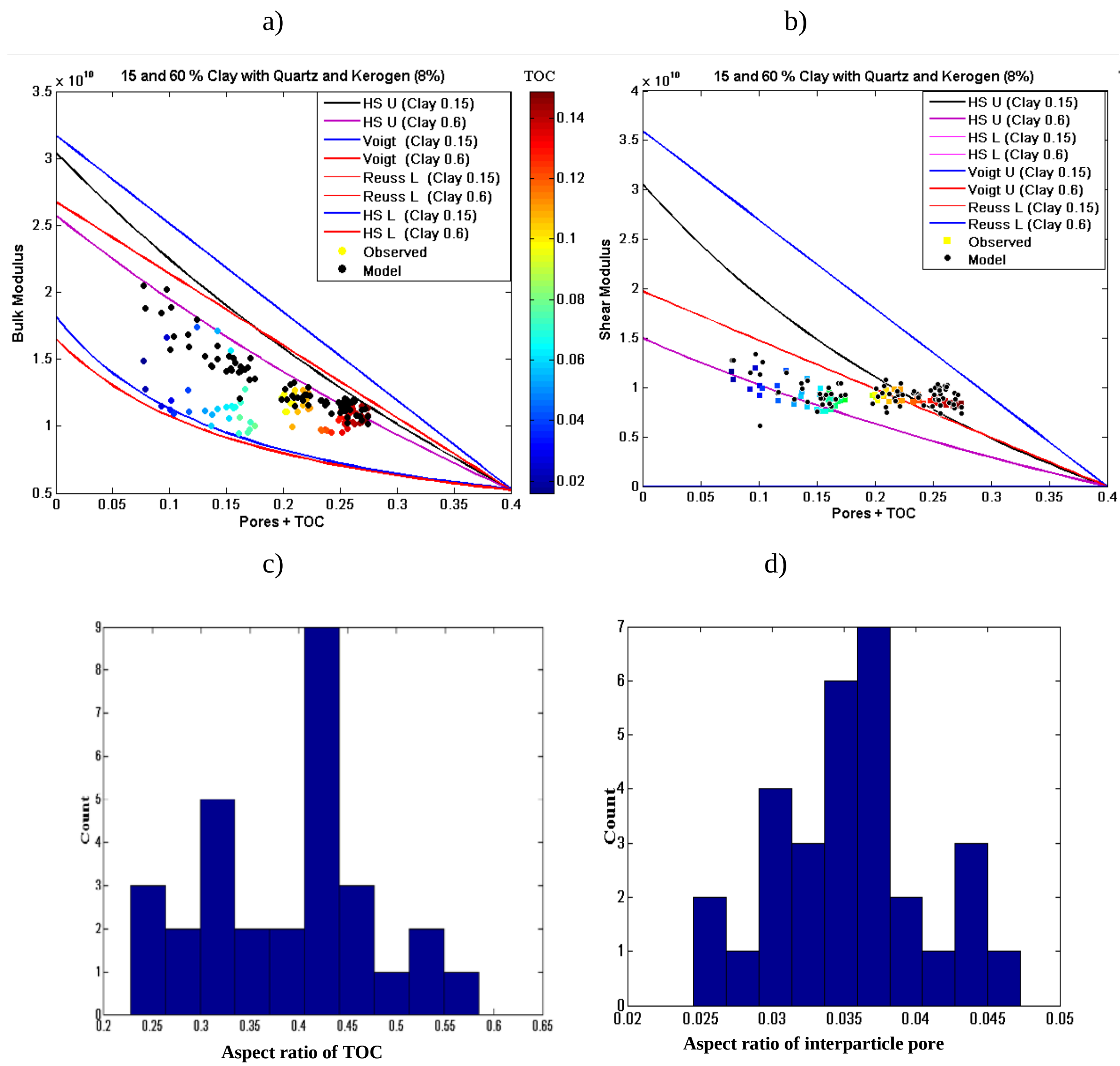
ROCK PHYSICS MODELING TO CONSTRAIN PETROPHYSICAL PROPERTIES IN THE PRODUCTIVE ZONE OF THE MARCELLUS SHALE, WV FROM WIRELINE LOG DATA

Sharif M. Morshed

Department of Geological Sciences
The University of Texas at Austin

ABSTRACT

A rock physics characterization based on wireline log data is proposed for constraining the petrophysical properties of the productive interval in the Marcellus Shale. The method involves two parts, 1) petrophysical interpretation of organic shale from conventional wireline log data, and 2) rock physics modeling utilizing the interpreted data. A petrophysical interpretation of the more radioactive interval of log data suggests that higher TOC is associated with lower clay content. This interpretation also showed that upper the part of the Marcellus Shale is clay dominated whereas the lower part is quartz dominated. The interval of interest did not contain significant amount of pyrite or carbonate minerals. Following the petrophysically interpreted data, the rock physics modeling was performed using differential effective medium (DEM) scheme in an inclusion based model to estimate the effective elastic moduli of the composites. The elastic moduli of the matrix phase in the DEM were provided with the Voigt-Reuss-Hill average for a composition of quartz and clay. Imbedded inclusions were assumed. Three types of inclusion phases were considered; a dry pore (i.e. equant pores or ellipsoidal pores), a water-wet clay pore and kerogen. Dry pores were saturated with pore fluids simulating reservoir situations with the low frequency Gassmann equations. Rock physics modeling reveals that the elastic properties of the Marcellus Shale were controlled by the interplay of clay content, kerogen content and low aspect ratio pores. Low aspect ratio pores (~1/40) also comprise the dominant pore types in the Marcellus Shale and these pores are more common in the lower part of the formation. This proposed rock physics scheme constrains the dominant petrophysical properties to be applied for surface seismic data interpretation.



Bulk Moduli (a) and Shear Moduli (b) of the observed data and the DEM modeled data are plotted as a function of pores plus TOC. Theoretical bounding lines are also plotted for two cases; 15% clay and 8% TOC with Quartz, and 60% Clay and 8% TOC with Quartz. The Hashin-Strikman lower bound overlaps with the Reuss lower bounds. The observed data are color coded by TOC content. Both observed and model data seems to fall within the theoretical bounds. Figure c and d shows the histograms of the aspect ratios of TOC and interparticle pores considered in the DEM modeling.