13.21: Comparing Three Methods of Estimating Least Horizontal Stress in Mudrocks using UT GeoFluids Correlations

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ABSTRACT

Mudrock strength parameters are required to improve prediction of fracture gradient during drilling in poorly consolidated formations. Accounting for the influence that mineral composition and consolidation stress have on the mechanical properties of mudrocks aids in safe well design. Small changes in mudrock clay content are shown to have significant effects on the lateral stress ratio at rest, K_0, and critical state effective friction angle, φ'_{cs}. A laboratory testing program, using quartz silt and Gulf of Mexico clay mixtures, measured the effects of mudrock clay content on K_0 and φ'_{cs} at two stress levels: 1 MPa and 10 MPa. The values were obtained by subjecting specimens to drained uniaxial vertical strain (K_0 compression) followed by undrained triaxial compression. The results provide a consistent and systematic increase of K_0 and decrease of φ'_{cs} with increases in clay content at both stress levels. Stress dependence is observed through increases of K_0 and decreases of the φ'_{cs} with increases in stress level.

Three methods of predicting σ_h in normally consolidated mudrocks, as a function of clay content and effective stress are used to calculate the fracture gradient (least horizontal stress) profile at the Macondo well. The estimated fracture gradients illustrate the effects of clay content and consolidation stress on safe mud weight design.

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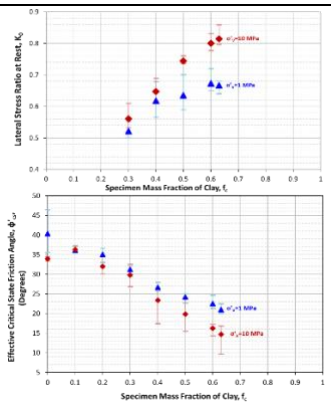


Fig 1: Top: average and range of lateral stress ratio (K_0) measured at 1 MPa and 10 MPa during consolidation of resedimented Gulf of Mexico Eugene Island Clay and quartz silt mixed specimens. Bottom: average and range of effective critical state friction angle measured at 1 MPa and 10 MPa during undrained shearing.

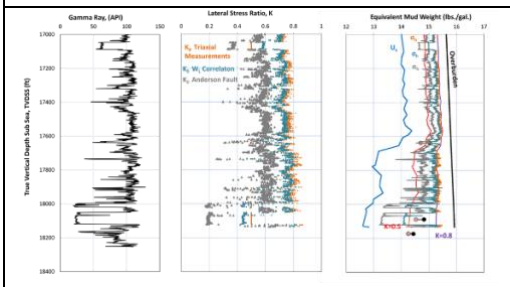
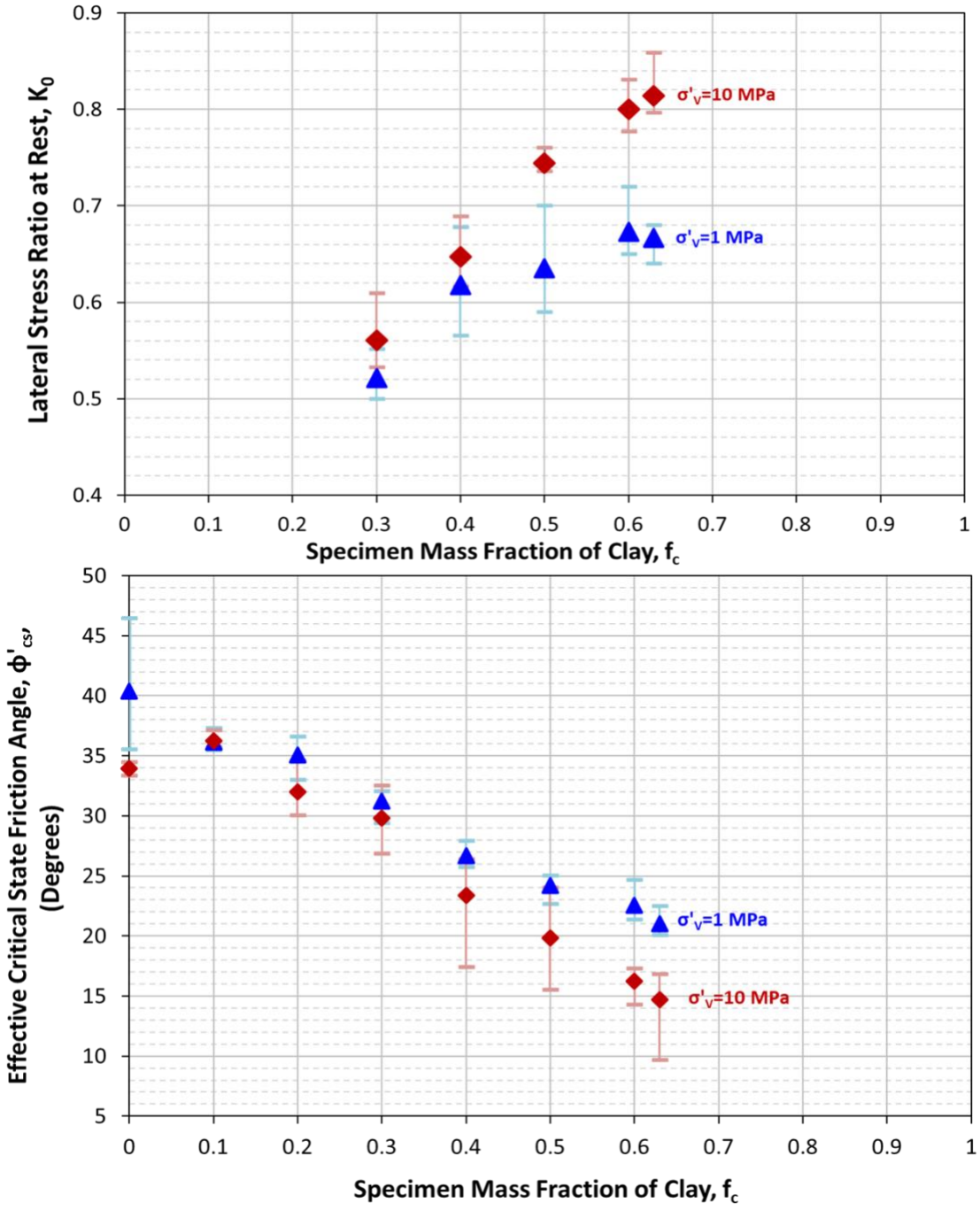


Fig 2: Left: gamma ray log for bottom 1,400 feet of Macondo well. Middle: estimated lateral stress ratio from the three estimation methods: Method 1 (orange points) models K_0 directly from triaxial tests; Method 2 (teal points) correlates K_0 from UT GeoFluids liquid limit correlation; Method 3 (grey points) models φ'_{cs} from triaxial tests and calculates horizontal stress in accordance with Anderson Faulting theory. Right: pressure and stress gradients in pounds per gallon for bottom 1,400 feet of the Macondo well. Estimated pore pressure from sonic log (blue line) and overburden stress (black line). σ_h gradient corresponding to the estimation method colors, or static values of 0.5 (red line) and 0.8 (purple line), and mud loss events. The lower bound of the mud loss event indicates last stable pressure prior to event and the upper limit represents the highest pressure measured during the event.



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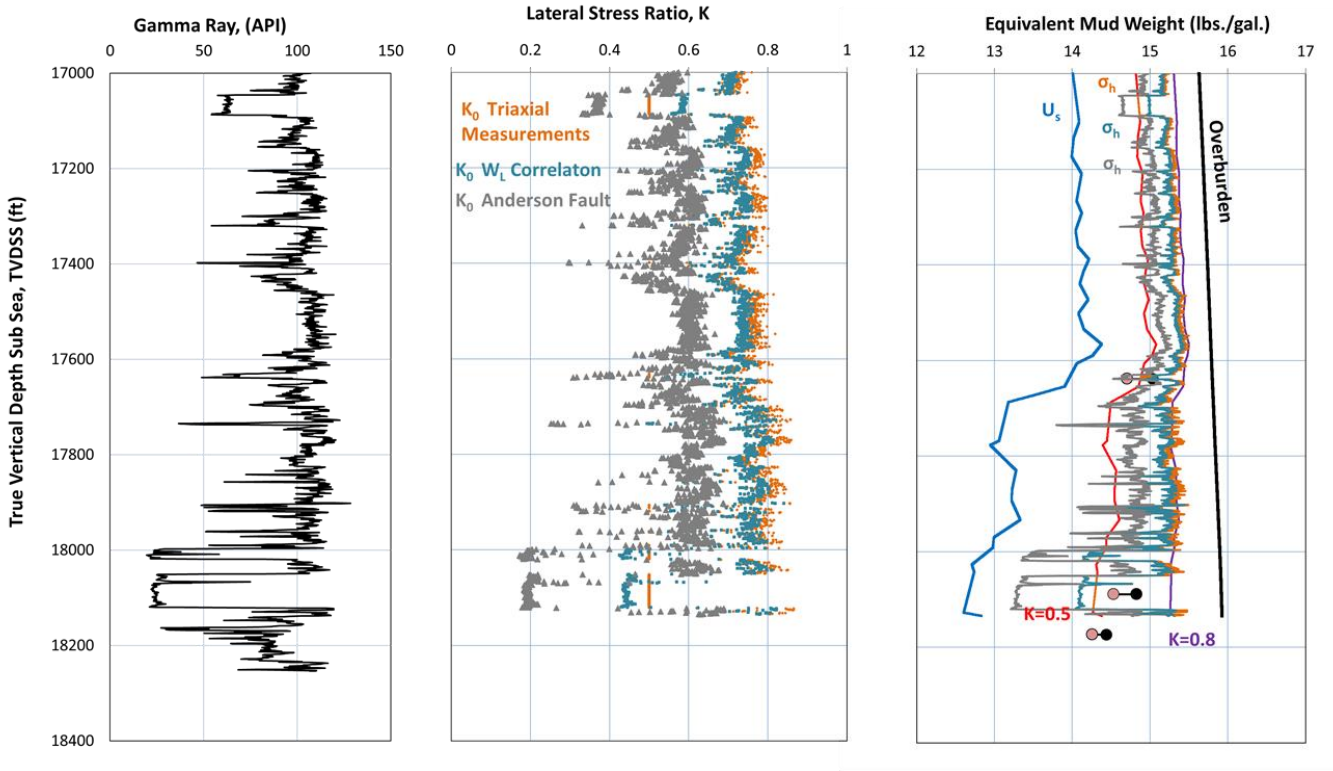
Back



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Back