The Relationship between Natural Fracture Distribution and Elastic Mechanical Properties in the Subsurface: Measurement and Calibration

R.A. Nelson, Broken N Consulting, Cat Spring, Texas

Natural and completion-related fractures are very important in production of oil and gas reservoirs around the world. The development of both types of fractures is the result of applied forces and the mechanical properties of the reservoir rock materials as measured statically or dynamically, per Figure 1.

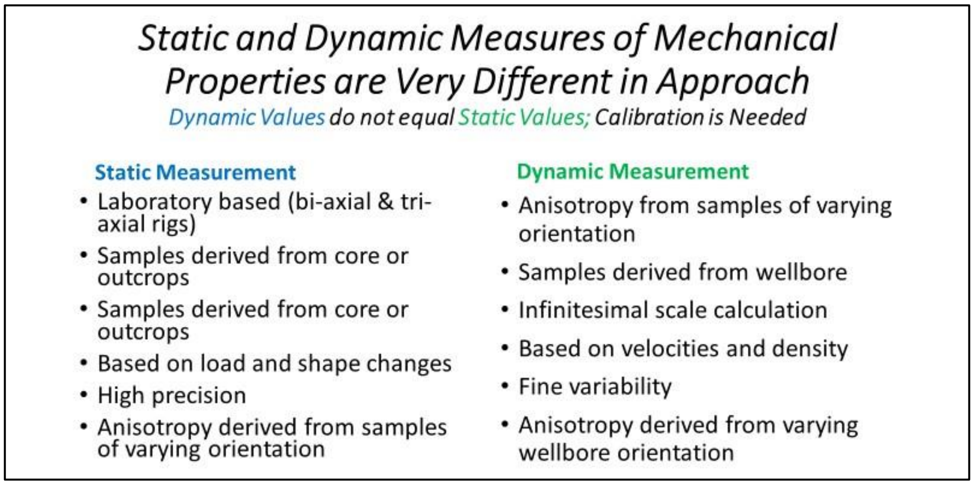

Figure 1. Rock mechanic properties are measured in the laboratory (Static) or in the subsurface via shear logs (Dynamic). The two methods result in different values which are appropriately applied in different situations.

Material properties of the rocks such as Young's Modulus (E), Poisson's Ratio (γ), and a combined version called Rigidity or Shear Modulus (G), have been used to define the mechanical stratigraphy of the reservoir section, Figure 2.

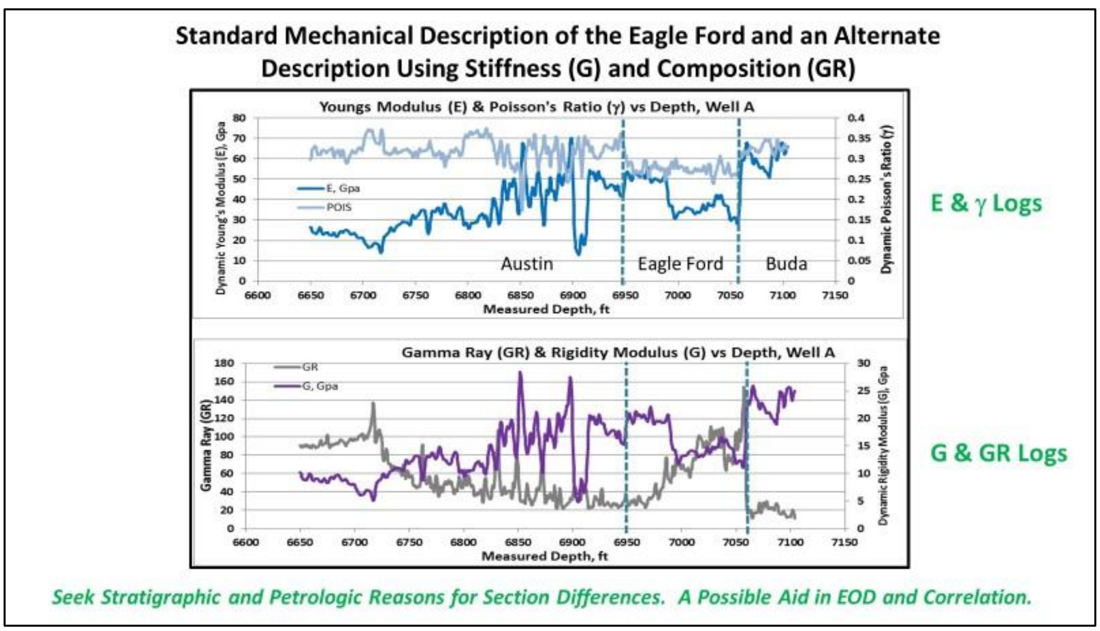

Figure 2. Shown is an example of use of dynamically obtained mechanical data to define the mechanical stratigraphy of a reservoir section.

Quantitative work on many reservoirs around the world has highlighted this relation with different classes of relations for different rock types. The presentation will show these relations and attempt to quantify the relationship and how it might vary with gross rock type and scale of observation.

In general, natural fracture intensity or fracture density increases with decreasing Poisson's Ratio and increasing Young's Modulus and, alternately, Rigidity Modulus at the time of fracturing, Figure 3.

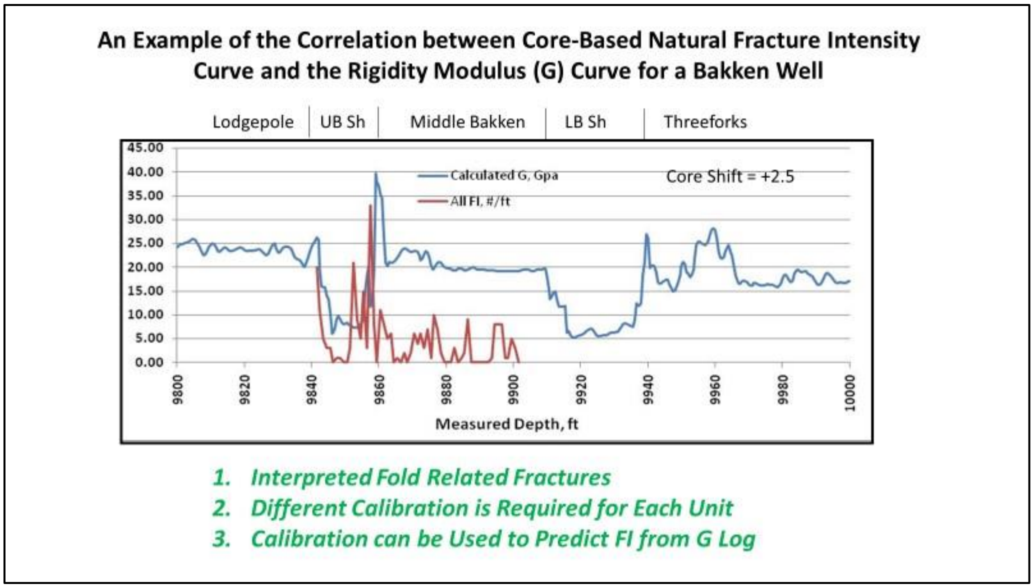

Figure 3. Shown is an example of the relationship between core-based Natural Fracture Intensity (FI) and Rigidity Modulus (G) in a Bakken well. Relatively higher G equates to relatively higher FI.

Multiple periods of natural fracturing may have been related with varying mechanical properties due to diagenetic alteration of the reservoir occurring between fracturing periods. The same mechanical property control occurs for hydraulic fracture completions in low permeability reservoirs, especially for the initiation of hydraulic fractures, fracture propagation, as well as hydraulic fracture containment

This presentation will focus on how subsurface natural fracture distributions are properly quantified from core observations and analysis of interpreted Borehole Image Logs. In addition, these same sections are quantified mechanically using mechanical properties logs (eg. shear sonic logs). Lastly, the predictability of natural fracture distributions directly from mechanical properties logs will be discussed.