



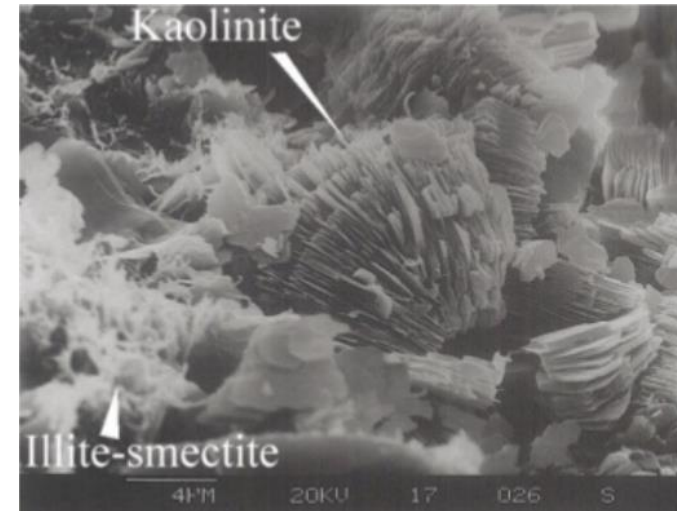
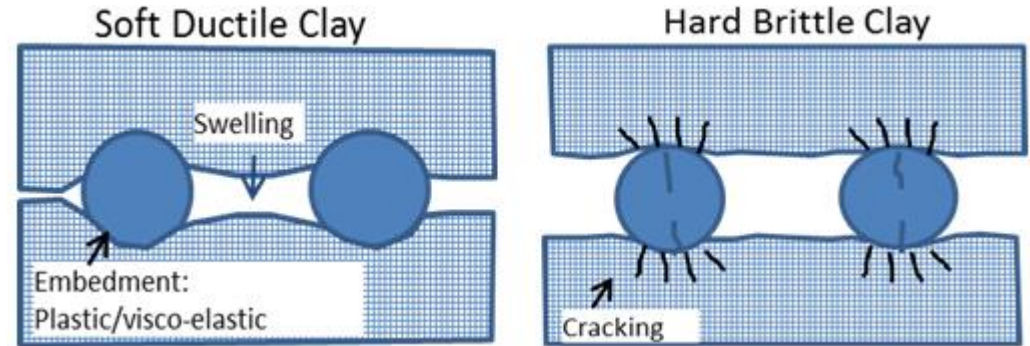
Clay Sensitivity Testing & Additive Selection

Liberty Engineering Solution



Analyzing Formation Clays

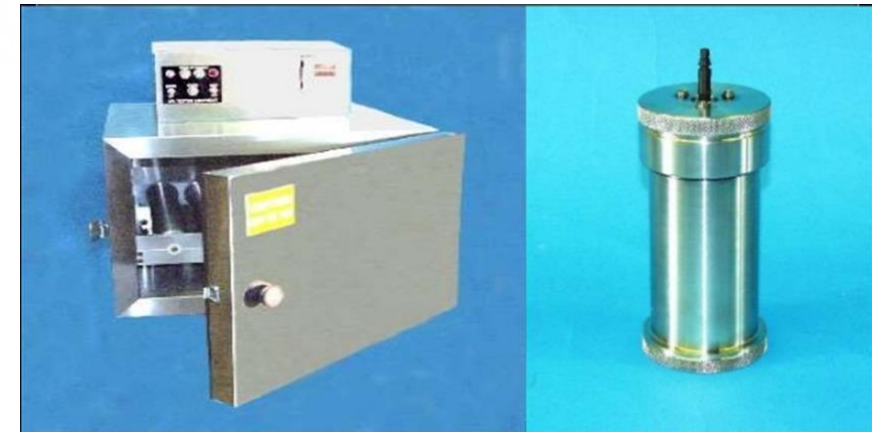
- What types of clay are present?
- How is clay affected by frac fluid?
- How much clay is there?



| Well ID | Sample Depth (ft) | TECTOSILICATES | | | CARBONATES | | | | PHYLLOSILICATES | | | | | ADDITIONAL | | TOTAL | | | |
|---------|-------------------|----------------|--------|-------|------------|----------|----------------|----------|-----------------|-----------|-------------|--------|---------------|------------|--------|----------------|------------|-----------------|------------|
| | | Quartz | K-spar | Plag. | Calcite | Dolomite | Dolomite Fe/Ca | Siderite | Chlorite | Kaolinite | Illite/Mica | Mx I/S | Expandability | Pyrite | Barite | TECTOSILICATES | CARBONATES | PHYLLOSILICATES | ADDITIONAL |
| Sample | | 61.7 | Tr | 18.9 | 1.2 | 0.9 | Tr | 0.0 | 0.8 | 0.7 | 13.5 | 1.7 | 15 | 0.6 | 0.0 | 80.6 | 2.1 | 16.70 | 0.6 |

Testing Clay Sensitivity

- Capillary Suction Testing (CST)
 - Slurry of ground cuttings, water, and clay additive are added to the cylinder
 - Timer measures how long it takes for the fluid to go from one ring to the second
- Roller Oven Testing
 - Mixture of cuttings and fluid is added to an ageing cell
 - The cell rolls continuously at temperature
 - Mixture is sieved



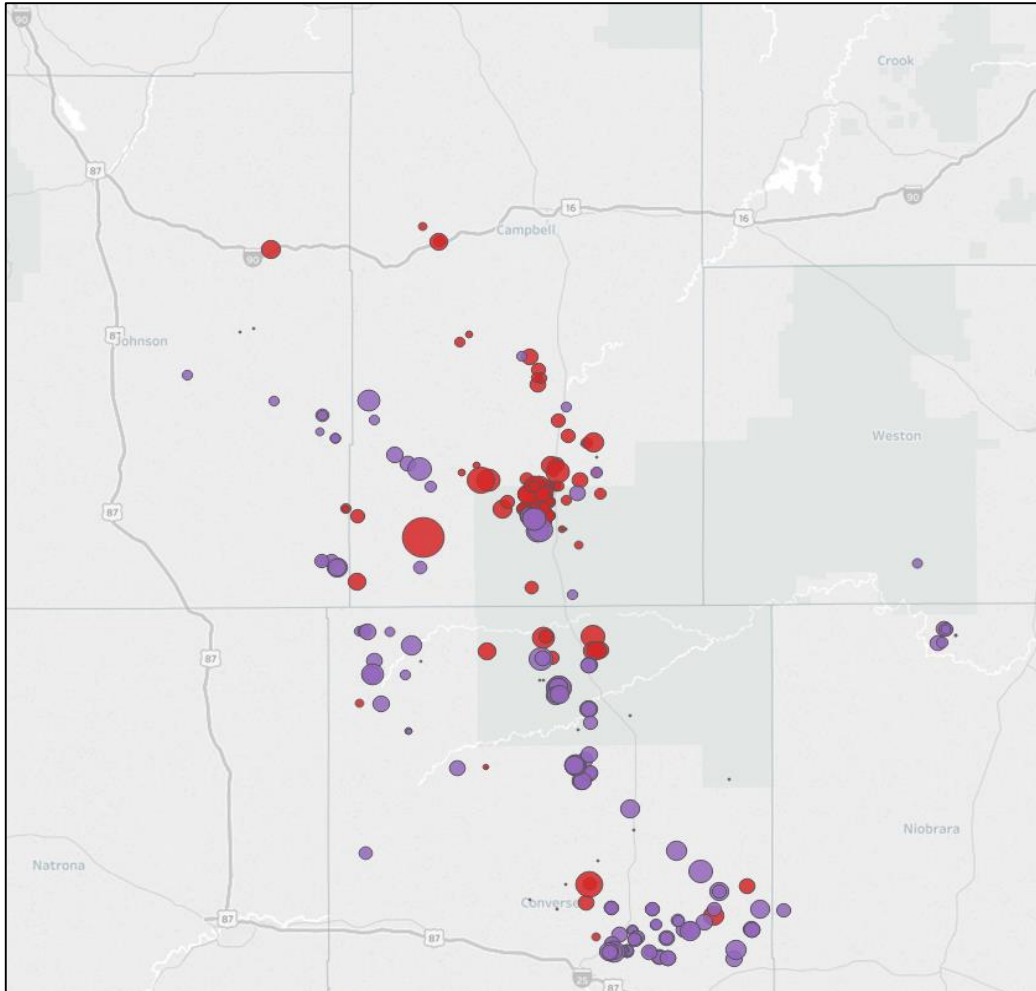
Testing Clay Sensitivity (continued)

- Bulk Hardness Tester
 - Similar ageing process as in Roller Oven Test
 - Cuttings are extruded through cylinder and torque is measured
 - Evaluates hardness after exposure to fluids

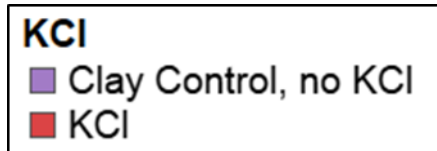
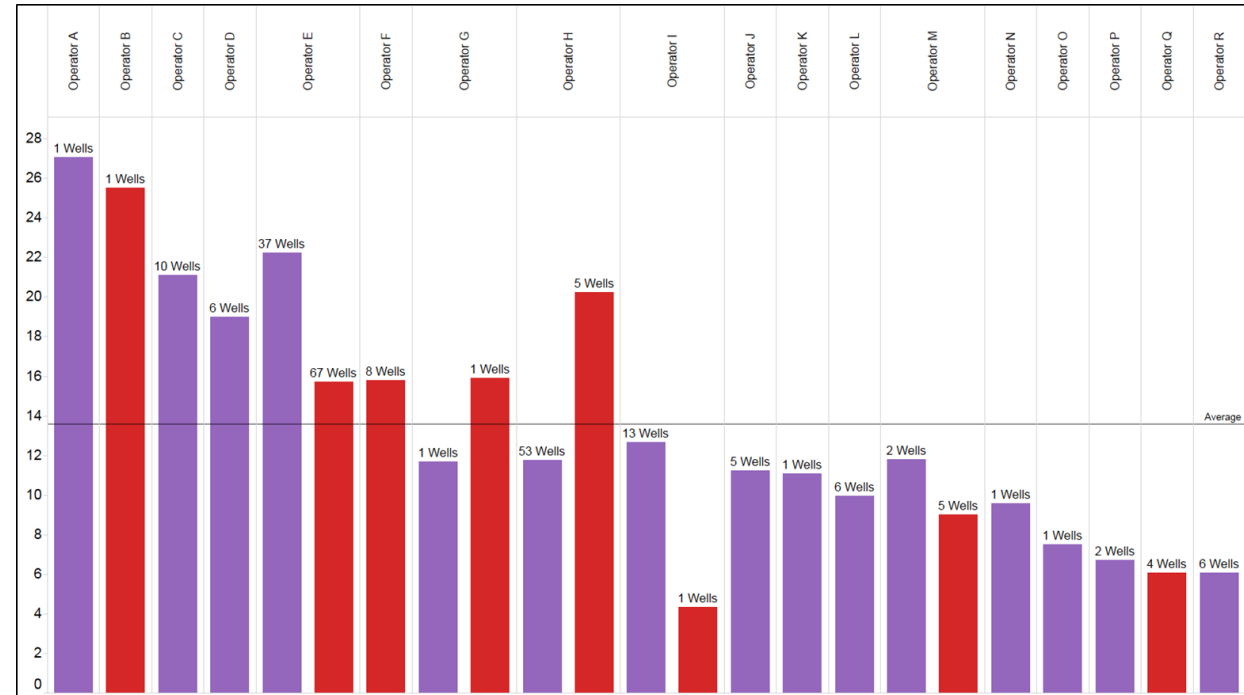


Basin Analysis

Powder River Basin



Normalized 365 Oil/Lat (bbl/ft) by Operator



Summary

- Different clays present different challenges
- Liberty has multiple in-house testing methods
- FracTrends database can be utilized for comparisons



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