

# LateralScience<sup>SM</sup> Wells Compare Favorably with Sonic in the Marcellus Shale

## Strong Alignment Between MSE and Sonic-Based UCS Data Demonstrates the Reliability of Drilling Data and the LateralScience Method

### Application of Sonic Geomechanics for Engineered Completions in Unconventional Reservoirs

As operators gain more experience producing unconventional reservoirs, many have come to realize that lateral heterogeneity within the formation should not be ignored. Variability in the stress profile along the lateral impacts the completion design and, if unaccounted for, can lead to significant inefficiency in the completion and the resulting production.

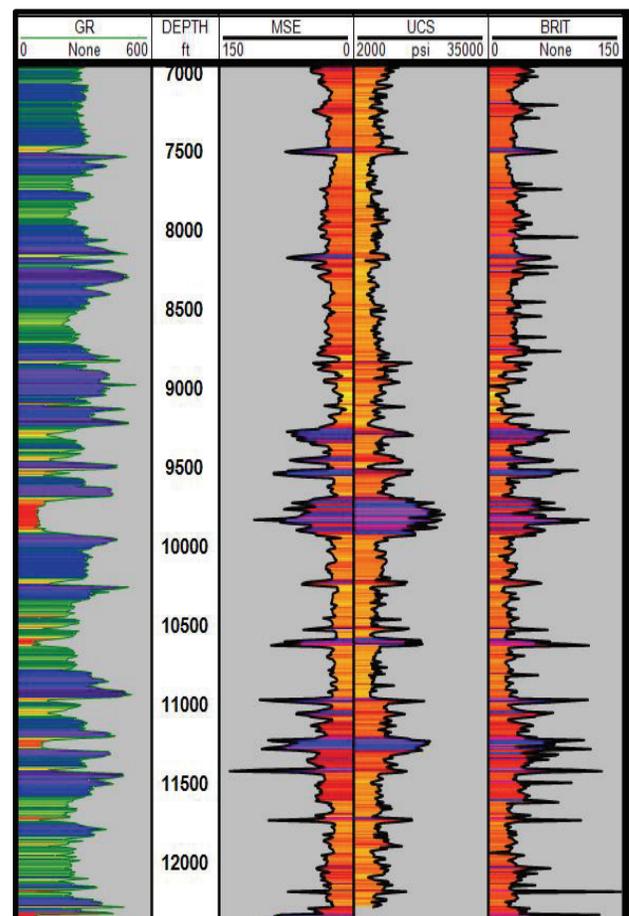
The current best-in-class approach to mitigating this problem is to estimate the stress profile using wireline tools that make full-waveform sonic measurements. These measurements are used as inputs to a sonic geomechanics workflow to estimate properties such as unconfined compressive strength (UCS), stress profile and brittleness index. These results are then used to guide the engineered completion to help ensure that perforation clusters are placed in "like rock," which effectively mitigates the negative impact of the heterogeneity.

### Engineered Completions for Every Well

The cost and inconvenience of acquiring wireline data in the horizontal section means that engineered completions are done on a very small percentage of the wells being drilled. The LateralScience method was developed to enable operators to realize the value of engineered completions easily, and at little cost, on every well by leveraging the drilling data which is gathered during the drilling process. To validate the LateralScience method, the next step is to confirm that the answers derived from drilling data are of comparable quality to those delivered by the best wireline-derived data.

### Comparison of UCS and Brittleness Index to Mechanical Specific Energy (MSE)

On the subject well, a full-waveform sonic tool was run and subsequently analyzed using a sonic geomechanics workflow. Two of the outputs of the analysis are UCS and brittleness index, shown in Tracks 3 and 4 in the adjacent logplot. Track 2 shows the MSE curve derived from the LateralScience workflow. This plot demonstrates, at a macro level, the excellent correlation between these three parameters, along with gamma ray (GR) shown in Track 1. The more detailed stage-level analysis that follows reveals that MSE is a highly reliable input to a robust engineered completion workflow.



Logplot from the subject well comparing MSE (Track 2) to sonic UCS (Track 3) and the brittleness index (Track 4)

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## Stage-Level Analysis

### Stage A:

The sonic geomechanics results suggest that Intervals B and D are in a common facies with higher UCS values and a higher brittleness index. The GR reads lower in both of these intervals. The MSE values agree that this facies is much tougher to drill (blue and magenta facies).

Intervals C and E are in a common facies according to the sonic UCS and brittleness index, in alignment with the LWD GR. The MSE concurs, as both intervals are in the red facies (easier to drill than blue and magenta).

Interval A is shown by MSE to be the easiest to drill (orange facies), and this is corroborated by the outputs of the UCS and brittleness index.

### Stage B:

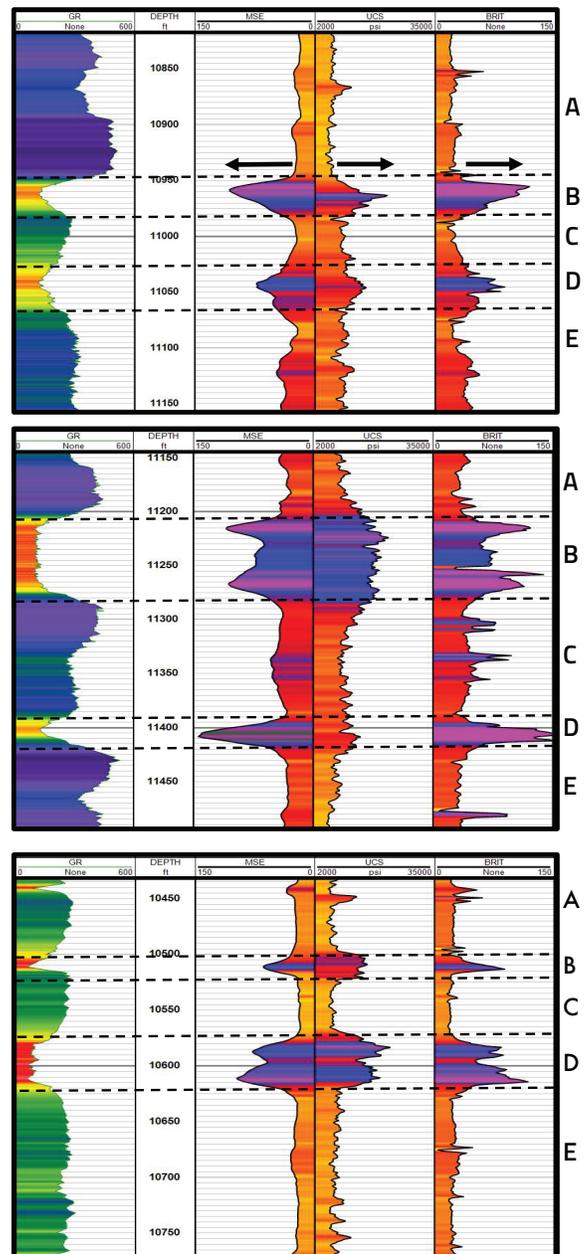
In this interval, the GR clearly identifies two intervals (B and D) that are much cleaner than the rest of this stage. The MSE agrees, showing them to be much more difficult to drill (blue and magenta facies). In Interval B, both the UCS and brittleness are in excellent agreement. In Interval D, the brittleness picks up the facies change while the UCS does not. This is a rarity, and in this case, it is the UCS that disagrees with the other three parameters.

Intervals A, C, and E all have higher GR readings that suggest these are like facies. The MSE and brittleness index are in perfect agreement, with Interval C looking slightly tougher than the other two, but very similar overall. The UCS value is also quite consistent across all three, with Interval E having a slightly lower UCS value than the other two. Overall, the match between MSE, UCS and brittleness is very good in this stage.

### Stage C:

Intervals A, C and E in Stage C all have GR values that are lower than the section in Stages A and B with the highest shale content. This suggests these intervals would be stronger rock (tougher to drill and frac) than the shales in the other two stages. However, the UCS, MSE and brittleness index all agree that this facies is much weaker (orange facies). This demonstrates that, while there is often a good correlation between MSE/UCS and GR, this relationship isn't always perfectly linear.

As with the other two stages, the GR, UCS, MSE and brittleness index all agree that Intervals B and D are in the same facies.



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NEX-19-287

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