URTEC-198221-MS

Improving Wellbore Placement Accuracy Using Stratigraphic Misfit Heatmaps

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Abstract

Accurate wellbore placement is of key importance in producing and developing unconventional resources. For cost reasons, unconventional wells areusually drilled with gamma radiation data as the only downhole geophysical sensor. This creates significant challenges for geosteering, in which sensor measurements are correlated with reference offset well data to identify vertical depth within the stratigraphic column. Distinguishing among multiple possible interpretations can be difficult with the standard manual gamma radiation correlation technique. We have therefore developed a new visually-guided approach based on stratigraphic misfit heatmaps. This technique enables reliable identification of all possible stratigraphic interpretations consistent with the measured data.

Downhole measurements of the natural gamma radiation in the subject well are transmitted in real-time to the surface for correlation with a reference type log, derived from previously drilled offset wells in the area. In standard geosteering, the subject gamma log is divided into sections, each of which is stretched and compressed to find a good match with a corresponding section of the type log. This stretching, compressing and matching corresponds to adjusting the dip, thickness and displacement of the geological formation in the subject wellbore. To find the correct interpretation of the data, all possibilities must be identified and evaluated. As a novel visual aid, we plot the difference between subject and reference gamma as a stratigraphic misfit heatmap. All possible stratigraphic interpretations can then easily be identified as valleys of low misfit in the heatmap, as demonstrated on example wells from North American unconventional plays.

The stratigraphic misfit heatmap brings out important features in striking clarity. Formation boundaries manifest themselves as linear features, while anomalies in the gamma measurements appear as disturbed vertical scan lines. Viable stratigraphic interpretations can be identified and traced as valleys in the heatmap, enabling the implementation of efficient and reliable geosteering processes and reducing the danger of misinterpretation.

To our knowledge, heatmaps have not previously been used for stratigraphic correlation.

Standard geosteering uses a tedious stretch-compress-and-match technique, whereas our holistic heatmaps facilitate a more intuitive visually-guided process. For backward compatibility, any heatmap-derived interpretation can still be transformed for display as a traditional correlation plot. Enhanced visualization of the solution space is key to developing reliable and repeatable geosteering processes with expert geologic oversight. Displaying geosteering solutions on stratigraphic misfit heatmaps gives confidence in landing the wellbore accurately in the target formation and helping to keep it in the pay zone.