CHARACTERIZATION OF THE CANA-WOODFORD SHALE USING A FRACTAL-BASED, VERY FAST SIMULATED ANNEALING ALGORITHM

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ABSTRACT

In order to develop a better 2D acoustic impedance model for the Cana-Woodford shale in west-central Oklahoma, we implement a fractal-based, very fast simulated annealing algorithm for seismic inversion. The fractal-based approach seeks to generate a starting model using the fractal characteristics (power-law behavior) often seen in well-log data. This method allows us to provide the inversion algorithm with a starting model close to the global minimum, thereby improving computational efficiency. The fractional Gaussian noise (fGn) generated from the re-scaled range analysis of the log data honors the statistics of the log, such as the mean, covariance, and the Hurst coefficient. Adding this fGn to the observed impedance gives us a starting model that includes the low-frequency content not present in the seismic data. It also includes some higher-frequency content not seen in the amplitude spectrum of the well-log data. The very fast simulated annealing (VFSA) algorithm provides an efficient means of searching for the global minimum of the objective function—the misfit between observed and synthetic seismic traces. The method seeks to avoid becoming trapped in local minima by allowing some small probability that increase in the objective function might be accepted. We carry out the inversion on a 30-trace line around the location of the Brooks 1-14H well, located in the central part of our study area. Our data set includes log data from 7 wells, as well as a 2D seismic line passing through 6 well locations. The inverted impedance results at the Brooks location match very well with the observed data. The synthetic seismic trace shows relatively high correlation with most of the peaks and troughs, with some issues near the base of the Woodford. Overall, the algorithm returns modeled impedances along a 30-trace 2D line that capture high-frequency variations within the Woodford, while honoring the low-frequency content seen in the wells.
An inverted impedance line of 30 traces around the Brooks 1-14H well. The overlying and underlying carbonate formations are seen in warm colors (high Zp values). The inverted model captures some high-frequency variations within the Woodford Shale. The magenta lines represent the Woodford horizon (top) and the Hunton horizon (bottom).