NUMERICAL ANALYSIS OF LAYER THICKNESS EFFECTS ON ACOUSTIC SONIC LOG VELOCITIES

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ABSTRACT
I have simulated borehole sonic waveforms and processed them with waveform coherence stacking using semblance in order to quantify the relative effect of layer thickness on the P-wave slowness estimates. The simulations were done for four different models containing interspersed layers of sand and shale. Three of the models have constant sand and shale velocities, and the fourth model accounts for some vertical heterogeneity from laminated sand and shale plays by using distributions of velocities for the sand and shale. The synthetic sonic waveforms were computed using a high order finite-difference code and processed with slowness-time-coherence to detect the P-wave mode and estimate the slowness. The results from the four velocity models indicate that the effective properties found are contained in between the sand and shale end members. At bed boundaries the tool measures an average velocity as soon as one of the receivers is located in the adjacent layer. For very thin layers, the effective velocity can be estimated by effective medium theory. However, effective medium theory does not completely represent the picked sonic velocities for the heterogeneous model. This study show that one has to be careful when using acoustic sonic log velocities in relatively thinly laminated sand and shale plays. The smoothing of velocities that results from thin layers gives a false sense of homogeneity, and these errors propagates into the estimations of slowness. Any use of the incorrect velocities in rock-physics analysis should account for these errors.
Synthetic sonic log for Vp created for velocity model 4. The red line corresponds to numerically calculated slownesses estimated from STC, and the blue line is the input model. The numerically calculated slownesses predict a smoother version of the input model.