Joint Use of AVO and Multi-Component Seismic Attributes to Estimate Tight Gas Sand Probability in Mamm Creek Field, Piceance Basin, Colorado

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We present a workflow to estimate probabilities of thick sandstone bodies from attributes derived from inversion of seismic data calibrated with log data in the Mesaverde Group, Piceance Basin, Colorado. Our workflow starts by performing petrophysics, rock physics, and geological analysis which results in a set of lithofacies logs that are used jointly with seismic attributes to generate estimates of probabilities of thick sandstone bodies greater than 15 ft.

Most of the gas production in Mamm Creek field comes from fluvial sandstones in the Williams Fork formation, but marine sandstones in the Corcoran, Cozzette, and Rollins members of the Iles Formation and the middle and upper sandstones of the Williams Fork Formation also contribute. Mapping the distribution of sandtones is critical for early effective development of the field but, unfortunately, seismic data have not been used extensively for this purpose because elastic properties of sandstones and shales show large overlap in rock physics diagnostics. We address this problem of overlapping elastic properties by jointly analyzing, in a probabilistic sense, multidimensional crossplots of seismic derived attributes colored by the property of interest generated at log scale.

The data set used for this study consisted of log data from 107 wells, 3D pre-stack compressional seismic data, and two shearwave stacked volumes from a 3D multicomponent data set (PS fast and PS slow).

A summary of our workflow follows: 1) Petrophysical analysis and generation of facies flags based on lithology and thickness. 2) Log scale analysis of relations between petrophysical properties of target facies and attributes derived from AVO inversion and inversion of PS stacked data. 3) 3-term AVO inversion of PP pre-stack gathers and post stack inversion of 3D PS stacked data. The result of this step are volumes of Vp, Vs, density, pseudo S-impedance fast and pseudo S-impedance slow. 4) Analysis of relations between attributes at seismic scale vs. log scale facies. Selection of pay thickness that can be adequately mapped with seismic data. 5) Estimation of probabilities of thick sandstone bodies using the five attributes derived from inverting different types of seismic data. This step estimates the likelihood of different scenarios from crossplots of seismic attributes colored by the pay flag and accounts for overlap of the different scenarios.

Rock physics diagnostics indicated a good clustering of pay intervals greater than 15 ft in the crossplots of seismic attributes studied. Facies probability volumes created using different combinations of seismic attributes compare favorably with well data but the joint use of attributes from AVO inversion and multicomponent attributes was the combination that yielded the best correlation coefficients between well and seismic data. Our probabilistic approach proved to be successful in mapping thick, tight, gas-sandstone bodies in Mamm Creek field.