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A High-Resolution Geological and Petrophysical Model Based on the Book Cliffs (Utah, USA) and its Full Elastic Seismic Responses

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A previously developed geological and petrophysical model of the fluviodeltaic Book Cliff outcrops contained 8 lithotypes (Tetyukhina et al., 2014). Each of these lithotypes grouped a number of lithologies typical for the particular depositional environment. For example, the characteristic of the offshore transition zone is very heterolithic, with shales, muddy siltstone and fine grained sandstone interbedded with each other in a variety of combinations and thicknesses. From a reservoir-geological point-of-view, however, such a model is too coarse as it contains reservoir and non-reservoir lithologies in the same lithotype.

For this reason, a new and more detailed geological model has been developed which is higher in resolution than the previous one and puts more emphasis on the reservoir-quality lithologies. Sequence stratigraphic concepts have been used in order to divide the lithological successions into smaller units. These units were then assigned rock physical properties based on the dataset obtained by Stanford University over the last few decades. Since many lithologies contain at least some amounts of clay, a sand-clay mixture model has been used in which the clay content affects the rock properties in two ways: If the clay content is lower than the porosity of clean sand, the compressional velocity increases with the clay content, while the porosity decreases. If, on the contrary, the clay content is higher than the porosity of clean sand, the change in compressional velocity decreases with increasing clay content, while the porosity increases. The model contains 11 lithologies with layers down to 1 meter in thickness. It can serve to model full elastic seismic responses, for which we present the first results here, and which may serve as a basis for non-linear full-waveform inversion. The very high resolution of this model is a basis to test the resolution limits of these inversions. Furthermore, the model can be populated with various fluid saturations in order to test 4-D elastic inversion.