Using Lidar to Characterize and Model Outcrop Analogs: Application to Aeolian and Shallow Marine Exposures, Wyoming

Mark Tomasso[1], Brian M. Reyes[1], Randi S. Martinsen[2], Lee F. Krystinik[3], and Adam R. Van Holland[4]

[1]Enhanced Oil Recovery Institute, The University of Wyoming, Laramie, WY.

[2]Department of Geology and Geophysics, The University of Wyoming, Laramie, WY.

[3]Fossil Creek Resources, LLC, Arlington, TX.

[4]BP Exploration Alaska Inc., Anchorage, AK.

Lidar (light-detection and ranging) technology provides an additional method to the field geologist's toolbox, and in the last seven years or so has produced a step-change in the way geologists deal with outcrop analogs and apply them to subsurface reservoirs. The technique, which involves laser scanning of outcrop surfaces to generate cm-resolution digitalsurface models, enables exposures with high amounts of rugosity or three-dimensionality to be captured and analyzed with accurate 3-D registration. When these data are combined with traditional outcrop-characterization techniques, including mapping, photopanel interpretation, and paleocurrent measurements, analysis of such things as facies variability and dimensionality can take place in three dimensions instead of using pseudo 2-D panels.

We present two examples. The first, from the Pennsylvanian- Permian Casper Sandstone of SE Wyoming, examines a highly rugose outcrop of aeolian sandstones with dolomite-dominated interdunal ponds, analogous to individual reservoirs of the Minnelusa Sandstone in the Powder River Basin. The second, from the Chimney Rock Member of the Upper Cretaceous Rock Springs Formation in SW Wyoming, examines an incised valley complex, analogous to some of the Muddy Sandstone reservoirs in Wyoming.

For each example, a high-resolution geological interpretation is generated using the traditional field data transposed into the digital domain. Three-dimensional mapping allows complex stratigraphic relationships to be revealed. Stratigraphic logs are incorporated as pseudo-wells along the exposure profile to constrain a three-dimensional facies model that honors the outcrop data. These high-resolution models can be interrogated to provide additional input information for "real-world" reservoir models.

To bridge the gap in scale between the high-resolution outcrop and lower-resolution subsurface data, a static reservoir model using parameters from producing analog reservoirs is generated from the facies model. From this reservoir model, seismic forward models at varying resolutions are generated allowing a comparison of the architectures observed in the outcrop to those observed on seismic in the subsurface. This style of workflow aims to provide a rigorous method to apply knowledge gained from outcrop directly to analog producing reservoirs.