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The Application of Ground-Based Lidar to Conduct Multiscale, Outcrop Structural Evaluation with examples from the Anadarko Basin and the Colorado Plateau

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The application of ground-based lidar for creating digital outcrops for stratigraphic evaluation has been an important advancement in field-based analysis of lithofacies and sedimentary cycling during deposition. Entire escarpments can be scanned and combined with digital photography and used to generate high-resolution digital outcrops for detailed laboratory evaluation. Combined with traditional transect analysis, geologic variables can be applied to this data, which can then be used to conduct a wide range of modeling exercises that incorporate the detail captured by these remote sensing techniques. To date, much less work has been completed that attempts to use these same data to evaluate outcrop-scale structural fabrics. In particular, lidar-based imagery is useful in collecting robust geospatial data sets on planar structural fabrics (joints, foliation). Although not entirely useful for kinematic evaluation, such data can be useful in understanding and modeling the impact of fracture porosity on reservoir quality and potentially the impact of these fractures on seismic velocities.

Three examples of lidar-based fracture studies are presented here. The first two examples are from gas-producing Mississippian-Pennsylvanian rocks. First, scan data collected in quarries in the Devonian-Mississippian Woodford shale successfully identified two key fracture trends, at 45° and 85°, both of which were verified using FMI, core analysis completed in the nearby subsurface, and scan lines across thec quarry floor. Fracture trends at 67°, 112°, and 315° were documented in scans of quarry walls within Pennsylvanian Jackfork Group turbidite sandstones. These results, in both cases, have significant tectonic implications as they indicate a reorientation of the principle stress directions during the Carboniferous for this area.

In an unrelated study, lidar data were collected over a maximum horizontal range for the instrument, because scanner resolution is a function of range, this type of data allows us to compare lidar-based derived fracture sets as a function of sampling scale. This can in turn provide a more clear understanding of how we should construct digital fracture frameworks for modeling reservoir-fracture porosity by allowing us to recognize the key differences in scale between primary and secondary joint sets found on the outcrop.

All three studies demonstrate the utility of combining outcrop based studies with lidar to rapidly collect large, statistically significant data sets for use in structural studies.