Aquifer and Reservoir Analog Heterogeneity for Petroleum and Groundwater Modeling from Lidar Imaging of Outcrops

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Preserving the influence of heterogeneity at varying scales is vital for modeling petroleum reservoirs and solute dispersion in groundwater. In order to characterize heterogeneity at the 2-3 m scale, a series of high-resolution (millimeter-scale) terrestrial lidar scans were taken of sediments located in braided-stream exposures west of Albuquerque, New Mexico, and from a site near Hanford, Washington. Lidar collects the intensity of the reflected infrared laser light from coordinates on the surface of the sediments. The lidar data are represented as a point cloud of intensity values with an x, y, and z coordinate system. We created a 3D characterization of the heterogeneity by successively scraping and scanning the outcrop in approximately 2 cm intervals at the New Mexico site. Successive slices were aligned and a 3D point cloud was obtained for the exposed volume. Because most segmentation approaches have been developed for 2D data, we previously segmented sand from gravel from each 2D slice of the outcrop.

Combining these segmented slices we developed a 3D grid that delineated the regions of sand versus gravel. We are currently developing means to interpolate the point clouds into a regular 3D grid and segment facies from this grid. Segmented facies from lidar data will be transformed into a grid for groundwater simulations. At present, the high resolution of our data results is in too many nodes to model practically. Therefore, upscaling techniques will be explored to facilitate modeling with our fieldbased representation of heterogeneity. 2D simulations at both sites showed that flow and solute transport are focused by crossbedding into the coarser-grained units and a non-Fickian breakthrough character. We expect the 3D simulations to show similar results. Additionally, we are developing simple reactive-transport models using the Hanford area 2D scan in order to evaluate the influence this fine-scaled heterogeneity has on transport.