A 3D photorealistic approach to the analysis of the depositional elements of the Pennsylvanian deltaic Breathitt Group, Pikeville, Kentucky

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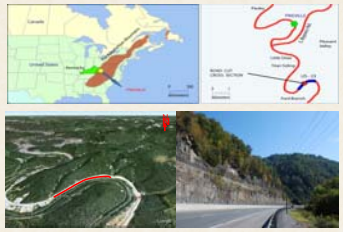
Abstract #166479

Three Dimensional digital mapping of outcrops provide a robust and flexible dataset that can be saved and archived to be re-interpreted multiple times subsequent to data collection. Specific digital analysis tools have been developed mainly for structural geology to analyze 3D photorealistic models of geology created at UTD. Three dimensional extraction tools for digital outcrop models of sedimentary features are being developed and tested on a site in the western Kentucky Appalachians, the Pennsylvanian deltaic outcrop of Breathitt Group, on an ArcGIS platform with the University of South Carolina to extract individual architecture elements in 3D from sedimentary outcrops for a more effective interpretation. This Appalachian road-cut shows a wide variation of facies and a multitude of heterogeneities represented within channel complex systems, which is a challenge to map and analyze quantitatively in only 2D. At least 30 channels and associated facies of different scales have been identified. The crescent (arc) shaped outcrop is about 1.5 km in length and 20 m in thickness which can lend itself to 3D digital analysis at small and large scales. The outcrop's small thickness relative to its length makes it difficult to manually correlate the architecture and facies through the entire outcrop and it is a dilemma as to how to display the features at scales from centimeters to kilometers. Hypotheses have been formulated which cannot be effectively tested without 3D quantitative information. Much of the outcrop has now been preliminarily captured by a UTD/USC team using integrated GPS, laser scanning 10 sites, 118 and 231 digital photographs with 24 and 105 mm lenses respectively. The high quality and resolution 3D model is being built and analyzed with our standalone 'graphic tools' on an ArcGIS platform to identify the various architectural elements used in the interpretation of the sedimentary depositional settings. Centimeter to kilometer scale features are being defined, digitized, extracted and analyzed as 3D models consisting of the photorealistic terrain surfaces bounded with geometries consisting of surfaces fit to the data. Therefore the various elements can then be placed in a lateral, vertical, and time context.

Study Area

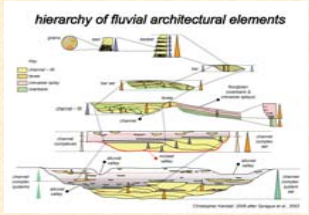
Pikeville, along US 23, Southeastern Kentucky



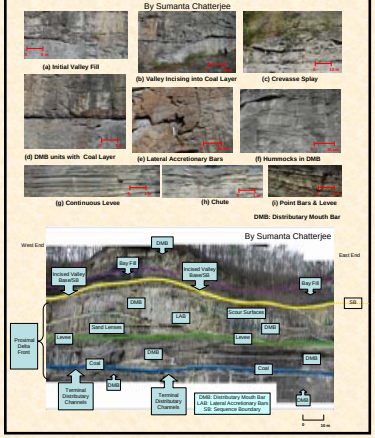
Regional setting

The sediments of this road-cut is in Breathitt Group, middle age of Pennsylvanian, along the Appalachian Mountain of eastern Kentucky, including about 30 channels and associated facies of different scales. The arc shaped outcrop is 1.5km long and 20m thick. It provides suitable constraints for laser scanned capture and subsequent incorporation into 3-D reconstruction of the geology and sequence stratigraphic framework of the outcrop, suggested by Chris Kendall and Sumanta Chatterjee from University of South Carolina.

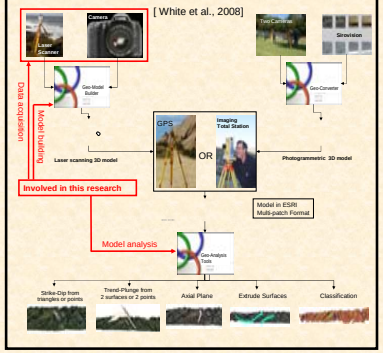
Feature of interests



Different Litho-facies and Depositional Settings at Pikeville



3D Photorealistic Model Workflow

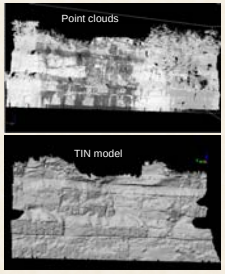


Field Work

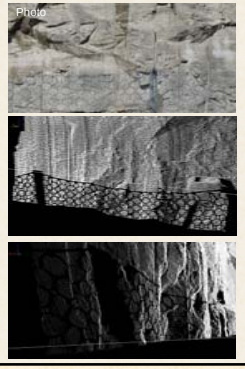
* Scan Outcrop by Terrestrial Laser Scanner (TLS)
* GPS RTK Geo-reference Scanner and Controls (assure centimeter level accuracy)
* Image Total Station provides tie-points
* Photograph Outcrop

Construction of the 3D Model

Scanner Point Cloud is converted into TIN model

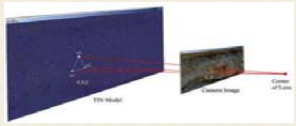


Point clouds by scanning through fences



Mapping Photo to Model

The vertices in the TIN model are mapped to corresponding pixels in the photographs according to the position of the controls.



Transform from UV coordinates to XYZ coordinates by collinearity equation.

Innovative approach to define control points from natural features [White et al., 2008]

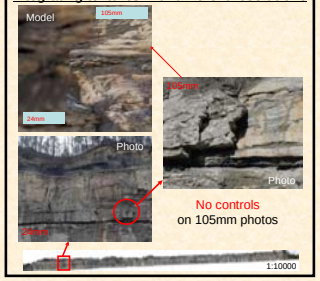
Image matching

Spatial image matching method.

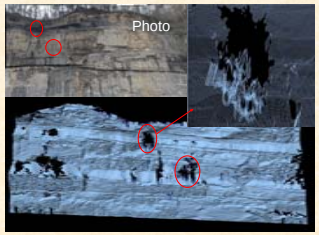
Note accurate location of matched smaller lower resolution images onto main photos.

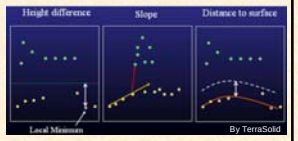
Control point is accurately located in the small image.

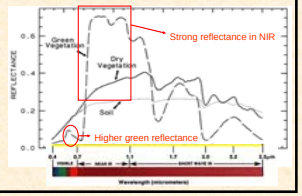
Integrating textures with different resolutions



Issue with vegetations

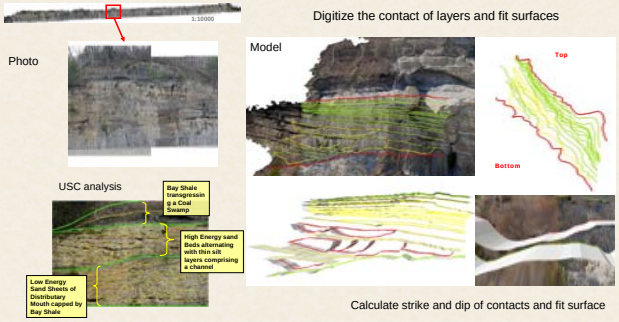






Vegetation causes discontinuous surfaces and slow construction and editing of the TIN mesh resulting in gaps. Vegetation filter can be applied based on geometric and spectral characteristics.

Geometric Analysis of Outcrop



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