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DEVELOPMENT OF ANALYSIS TECHNIQUES OF CLOSE RANGE 3-D PHOTOREALISTIC AND MULTISPECTRAL MAPPING WITH APPLICATION TO BIG ROCK QUARRY, ARKANSAS

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ABSTRACT

In this study remote sensing techniques are integrated with 3-D unique digital mapping to create a 3-D photorealistic multi-spectral model of the outcrop and the potential improvements over classical 2-D methods evaluated. The 3-D virtual outcrop facilitates interpretation and reconstruction of bed architecture, making possible further correlations of strata exposed on distinct sides of the quarry. Large, continuous exposures such as Big Rock Quarry provide an opportunity for collecting lateral and vertical attributes of strata and their bounding surfaces using the photorealistic method. Examination of the virtual model of the outcrop allows extraction of accurate 3-D qualitative (lithology), as well as, quantitative (bed thickness) geometric information.

The integration of close-range oblique remote sensing data and a 3-D digital model of the outcrop allows the capture of the three dimensional spatial distribution of lithological units. This is fundamentally important for understanding the internal architecture of erosional and depositional features, in this case channelized features.

Compared to previous attempts of reconstruction our 3-D virtual model is more realistic and because the model has accurate measurable real dimensions it can be used to calibrate the simulation of processes in deep water environments.

PROJECT DESCRIPTION

Orbital and sub-orbital multi-spectral remote sensing have been successfully used for lithologic mapping in geological studies for over forty years, but in this study it is applied to digital photography acquired obliquely from the ground, to test the possibility of automatic, digital detailed outcrop mapping. Multi-spectral imaging is applied to map detail lithology at outcrop scale and at wavelengths that can't be used to remotely sense spectra through the Earth's atmosphere due to the presence of absorption bands along the electromagnetic spectrum (Clark, 1999). However these spectral regions can be used when photographing outcrop since the atmospheric path lengths are thousands of times smaller.

Analyses of the spectral features of rock samples within the visible-far infrared (0.7-20μm) portion of the electromagnetic spectrum can effectively help in the identification of the lithology when the difference is not obvious on the outcrop. In the visible-near infrared region, until the wavelength of 3μm, the spectral signature represents reflected solar radiation. However, in the wavelengths beyond 3μm, the spectral signature is related to self-emitted radiation from the rock surface. The thermal properties may be considered as additional factors for discrimination of the lithological units. Since the spectral signature of rocks is directly related to their distinct mineralogical composition a chemical/mineralogical analysis of the rocks should be carried out.

Multi-spectral images have to be acquired using a digital camera having different narrow band pass filters whose wavelengths have been selected where diagnostic spectral features were identified in the spectral curves of the main rocks present at the outcrop. Individual bands are co-registered and displayed in Red-Green-Blue **(RGB)** color space to create false color images that are useful for highlighting lithologic variation of the outcrop. False-color images are further texture mapped onto the three-dimensional digital model of the outcrop built from terrain data collected using a combination of **RTK-GPS** and laser scanners. Digital photorealistic mapping techniques were developed as a new tool for outcrop studies (Xu , 2000; Xu *et al.*, 2000) and now faster high-density scanners with the accuracy of millimeters are used and virtual 3-D models can be built within days.

For this study, the turbidite deposits of the Jackfork Formation at Big Rock Quarry, Arkansas, are used as a test site. Excellent cliff faces exposed in this quarry were interpreted as proximal deep-water fans within slope channel canyons (Douglas *et al.*, 1993), but the geometry of these deposits is still difficult to interpret due to highly variable bed thicknesses and lateral discontinuities.

Deposits exposed at Big Rock Quarry are represented by massive to parallel-laminated, fine-grained sandstone, shale intraclast breccia having a sandy matrix, shale intraclast breccia having a shale matrix, and finely laminated shale (Link and Stone, 1986; Bouma, and Cook, 1994).

The three logs taken at this site illustrate potential problems in well log correlations of laterally discontinuous strata. When compared, the information from well logs (Jordan *et al.*, 1991) and a core drilled behind the outcrop face (Link and Stone, 1986), it is obvious that some of the thinner beds could not be identified on the gamma-ray profiles since they are too thin to be detected by the logging tool. Cores provide the necessary resolution for distinguishing these features, but unfortunately there was only one core taken at this site. Also, 2-D photomosaic interpretations are not effective tools in correlation of strata with a complicated 3-D geometry. Despite the horseshoe shape of the quarry no attempt has been made to correlate the strata from one side of the quarry to the other.

Large outcrops provide geologists with potential useful data, but without a proper methodology it is difficult to extract all data necessary to enhance reservoir management. The described methodologies applied to high heterogeneity turbidite systems enhance 3-D geologic mapping of outcrops especially deep water reservoirs with channelized features.

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