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Ground-based hyperspectral imaging for the mapping of geological outcrop composition

Tobias Kurz (1), Simon Buckley (1), Danilo Schneider (2), and John Howell (1)

(1) Centre for Integrated Petroleum Research, University of Bergen, Postboks 7800, N-5020 Bergen, Norway (simon.buckley@uni.no), (2) Institute of Photogrammetry and Remote Sensing, Technische Universität Dresden, D-01062 Dresden, Germany (danilo.scheider@tu-dresden.de)

The use of high resolution surveying techniques has increased dramatically in earth science applications over the last decade. New products, software solutions and an increased attention to "usability" have made terrestrial laser scanning (lidar) and digital photogrammetry popular methods for obtaining more detailed geometric data for many applications. Geology, especially the study of outcrops, is one such application area where the introduction of laser scanning in particular has benefitted, by allowing an increasingly quantitative approach at a variety of scales. Despite this, most of the contribution of modern surveying techniques has been related to the capture of topographic detail – the shape and form of outcrops – while the remote mapping of outcrop lithology has yet to be satisfactorily addressed.

Ground-based spectral imaging offers new possibilities for an improved understanding of outcrop composition, by mapping lithology and the distribution of mineralogy with high resolution and increased automation. Advances in airborne and spaceborne multispectral and hyperspectral sensors have been successful for mineral prospecting and the regional mapping of rock types. However, because of the nadir viewing angle of the sensor, such a configuration is of limited value for near-vertical cliff sections. A new generation of close range hyperspectral imagers is now becoming available, with capabilities of measuring in the short-wave infra-red (SWIR) part of the electromagnetic spectrum suitable for detecting absorption features exhibited by many minerals found in sedimentary rocks.

This research uses a ground-based hyperspectral sensor to acquire spectral images of geological outcrops, with the aim of remotely determining the distribution of lithologies. The method was applied to case studies from carbonate and siliciclastic rocks. The images were processed to obtain spectral classification maps of the distribution of representative rock types. To increase the quantitative approach, the spectral data were integrated with photorealistic 3D models derived from terrestrial laser scanning and conventional image acquisition. Because the push-broom hyperspectral sensor recorded panoramic rather than planar images, the integration was performed using a cylindrical camera model. Using this approach, it was possible to relate the pixels of the spectral images to a real-world coordinate system, aiding analysis and validation. In addition, the spectral images could be superimposed on the lidar-derived photorealistic models, allowing a simultaneous visualisation of multiple thematic results together with the conventional digital camera imagery. For the case studies used, encouraging results were produced, allowing the mapping of features that were not easily visible in conventional images. It is therefore concluded that ground-based hyperspectral imaging is an important method that may be applicable to many earth science applications.