Drone-based VNIR–SWIR Hyperspectral Imaging for Mapping and Monitoring Environmental Conditions in Legacy Mine Sites

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While mining is essential for sourcing the materials needed for the energy transition, there are widespread negative environmental impacts associated with its activities. Legacy mine sites, in particular, are a major environmental concern which have attracted international attention. The scope and complexity of this challenge requires effective solutions that can reliably map and monitor changes in the environment. Drone-mounted hyperspectral imaging (HSI) is an emergent technique that senses, at centimetre-spatial resolution, infrared radiation across many narrow, contiguous spectral bands for each pixel in an image. We explore the capabilities of drone-mounted HSI for mapping surface patterns related to contamination dispersal in the former Mary Kathleen U-REE mine site, in Queensland, Australia. Hyperspectral data across the visible to near-infrared (VNIR) and short-wave infrared (SWIR) wavelength ranges (400–2500 nm) were collected over selected areas of the site. Analyses were performed using data-driven (Spectral Angle Mapper; SAM) and knowledge-based (Band Ratios; BRs) spectral processing techniques. The SAM technique identifies contamination dispersion patterns linked to the precipitation of sulphate-rich evaporative sediments, and differentiates mineral compositions within visually similar areas. The BR technique highlights reactive surfaces and clay mixtures, reinforcing key patterns identified by SAM. The results indicate that drone-based HSI can capture and distinguish complex surface trends, demonstrating its potential to enhance the monitoring and rehabilitation efforts at legacy sites. It also shows that by mounting HSI cameras on drones, the spatial resolution of the data is significantly improved compared to other platforms (e.g., centimetre-scale versus decimetre-scale for satellite and manned aircraft), enhancing the ability to detect subtle mineral and surface variations.