

### **Innovative Remote Sensing and GIS-Based Approach for the Identification and Mineralogical Characterization of Mine Tailings in South Africa**

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Mine tailings are widely distributed across Southern Africa, reflecting the region's rich mining history. Recently, a comprehensive geospatial inventory detailing the precise location and extent of tailings in South Africa was developed by the University of Cape Town. However, this database excluded some abandoned tailings with no prior history. These older and abandoned tailings are viewed as potential sources of critical minerals and environmental liabilities. Tailings, therefore, demand renewed attention through modern, scalable technologies.

This study presents a technology-driven, GIS- and remote sensing-based workflow for the identification and mineralogical characterization of mine tailings across South Africa. Using Google Earth Pro for initial visual interpretation based on morphological features such as shape and surface discoloration, over 50 abandoned tailings sites were mapped, with particular emphasis on the Witwatersrand Basin and the Barberton Greenstone Belt.

To characterize the tailings, multispectral satellite data from ASTER and Sentinel-2 were processed in ArcMap using band ratios and other spectral enhancement techniques to extract spectral signatures linked to mineralogical variation. A subset of tailings from the West Rand Goldfields and Fairview Gold Mine underwent further validation through laboratory techniques, including X-ray Diffraction (XRD), the Tescan Integrated Mineral Analyser (TIMA), and petrography. This bridged remote characterization with micro-scale mineralogical analysis.

By integrating open-source satellite data, advanced GIS tools, and analytical mineralogy, this research demonstrates how innovative geoscience technologies can be applied at multiple spatial scales to address both environmental risks and resource recovery potential. Preliminary findings suggest that spectral patterns from known tailings, grounded in local geology, can be used to classify unknown or abandoned tailings—especially those with limited or no historical documentation. This adds the older and abandoned tailings to the already developed national tailings inventory and promotes a data-informed approach to reprocessing, environmental management, and future exploration in legacy mining landscapes