

Subsurface Alteration in an Active Geothermal System: Analysis of Hyperspectral Core Scanning Data on Core from Yellowstone National Park, Wyoming

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Recent developments now allow widespread application of core scanning technology in mineral exploration and mineral systems research. Here we report on the results of imaging spectroscopy (hyperspectral imaging) data from core scanning of legacy research drill core from Yellowstone National Park, Wyoming. The results provide new insights into the distribution of alteration minerals in the shallow subsurface in a modern geothermal system. Drilling at several geothermally active sites in Yellowstone was performed in 1967 and 1968, with all 13 cores being stored at the U.S. Geological Survey (USGS) Core Research Center in Denver, Colorado. The drill core was initially imaged during a scanning campaign in 2015 and 2016 by Corescan using the mobile Mark III Hyperspectral Core Imager. In addition, selected core was reimaged in 2025 using a core scanner equipped with a HySpex SWIR 384 camera at Colorado School of Mines, providing finer spectral and spatial resolution datasets.

The hyperspectral data were classified using the USGS Material Identification and Classification Algorithm (MICA) in order to map mineral distributions and relative abundances. Modifications to the MICA command file improved discrimination for selected minerals in the laboratory data by incorporating reflectance features from spectral regions traditionally excluded from classification algorithms because they overlap with atmospheric absorptions. Core Y-12 (vertical; 331.6 m) provided an example for how changes in the subsurface mineralogy can be linked to the conditions of the hydrothermal system. Near surface, alunite-kaolinite alteration with varying amounts of hydrated silica records alteration in the steam-heated environment. Below, the alteration grades from kaolinite to kaolinite-smectite mixtures and then transitions into a smectite-dominated zone. In the deeper parts of the core, muscovite is the spectrally dominant mineral, with varying amounts of illite present. The distribution of spectrally dominant minerals is directly comparable to alteration zoning in low-sulfidation epithermal environments.