Geophysical Research Abstracts
Vol. 21, EGU2019-11132, 2019
EGU General Assembly 2019

Correlating physical and mechanical properties with hyperspectral imagery to build volcano geotechnical maps

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The geotechnical and geomechanical characterization of volcanic material is critical for models of instability and mass flows, or interpreting geophysical signals of volcano unrest (e.g. volcano-seismic or geodetic). However, sampling a representative amount of material is challenging on active and hazardous volcanoes, which typically have difficult terrain. Additionally, testing the physical and mechanical properties of a large amount of material in the laboratory is unreasonable due to the excessive time requirements and high laboratory costs. Remote sensing, which produces large-scale and cost-effective images over relatively short time scales, can serve as a solution by complementing field and laboratory work, and thus improving our ability to monitor and forecast volcanic hazards. This project seeks to correlate geotechnical properties of key samples with electromagnetic (i.e. chemical) signatures collected from a hand-held spectral instrument, which are then used to statistically predict geotechnical properties of representative lithologies of Mt. Ruapehu volcano in New Zealand. Ultimately, we aim to transfer these predictions to a newly acquired aerial hyperspectral imagery of Mt Ruapehu.

Hyperspectral imaging collects information from hundreds of spectral bands between 370 and 2500 nm, capable of identifying materials within each pixel of an image via the material's unique electromagnetic fingerprint. A hyperspectral aerial survey of Mt. Ruapehu, one of New Zealand's most active and visited volcanoes, was acquired using a fixed-wing aircraft in 2018. Over 30 locations with distinct hyperspectral signatures were visited to conduct in-situ strength and permeability measurements. The mineralogy, and specifically chemically altered minerals, were established using X-ray Fluorescence (XRF) and lab-based spectroscopy. The physically properties of the samples, including porosity, permeability, P- and S-wave velocities, and strength, were measured in the laboratory and correlated to the degree of alteration. We find that the degree of alteration (i.e. amount of clay minerals) is inversely correlated towards longer electromagnetic wavelengths, and is also positively correlated with porosity and inversely correlated with strength. This highlights the opportunity to fuse these datasets to predict geotechnical properties from hyperspectral imaging.