LiDAR return intensity data for detecting hydrothermal alteration: a preliminary study from laboratory

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Introduction

Traditional remote mapping for hydrothermally altered ground, a crucial part of geothermal exploration, becomes problematic in densely vegetated areas because of the limited ground view due to the thick canopy. Therefore, it needs datasets and techniques that can overcome the problems of limited spatial resolution.

Light Detection and Ranging (LiDAR), active remote sensing, can be an alternative source of ground information as it produces high spatial resolution data from point-based scanning. LiDAR return intensity (LRI), a strength value of reflected energy to the sensor, contain collective information, e.g. ground reflectivity, the distance between sensor and target, the incident angle at target, and laser power. Although correction might be needed to refine the value representing ground reflectance, the LRI value can be a proxy for rock detection (Burton et al. 2009).

Here, we investigate if the alteration (i.e. alteration degree, Fig 1) can be recognised from their LRI values in laboratory setting using a terrestrial laser scanner (TLS) at 1550 nm (Fig 2). This preliminary study is our base for mapping alteration from an airborne platform.

Methodology

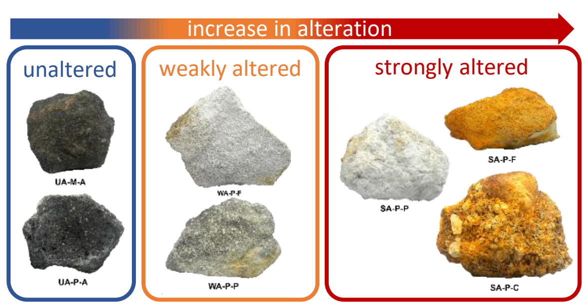

Fig 1. Hand-sized samples that representing alteration degree from geothermal fields of Bajawa-Flores, Indonesia were scanned using a terrestrial laser scanner under controlled conditions of moisture and temperature.

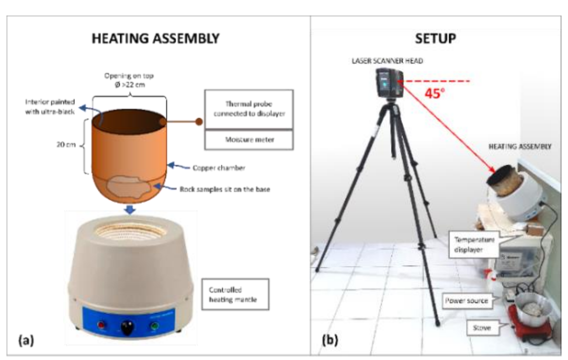

Fig 2. The experiment was conducted by placing the rock samples in the heating chamber (a) and scanning the samples using a terrestrial laser scanner FARO 350S at 1-m distance (b). Moisture and temperature were controlled in each scanning (i.e. dry-cold, wet-cold, dry-hot, wet-hot).

Results

Our results show that **the alteration degree is kept intact in LRI values**, even with different levels of moisture and temperature (Fig 3). Here, strongly altered rocks have higher LRI values (brighter in grayscale) than unaltered rocks in all conditions. Moistening the samples decreases LRI values (shown as darker than dry conditions).

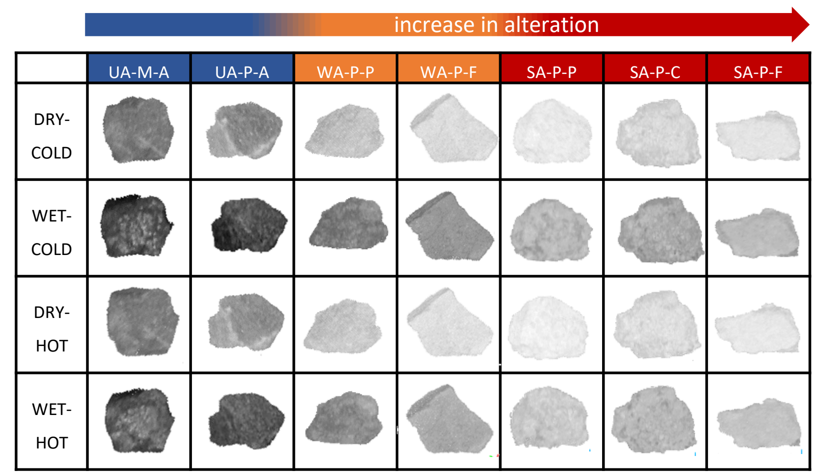

Fig 3. LRI images of rock samples. Visually, it is clear that alteration degree is in order in LRI values, even in different conditions

Strongly altered and unaltered rocks can be differentiated from their vast difference in LRI values (Fig 4). Weakly altered rocks always have LRI values between strongly altered and unaltered rocks.

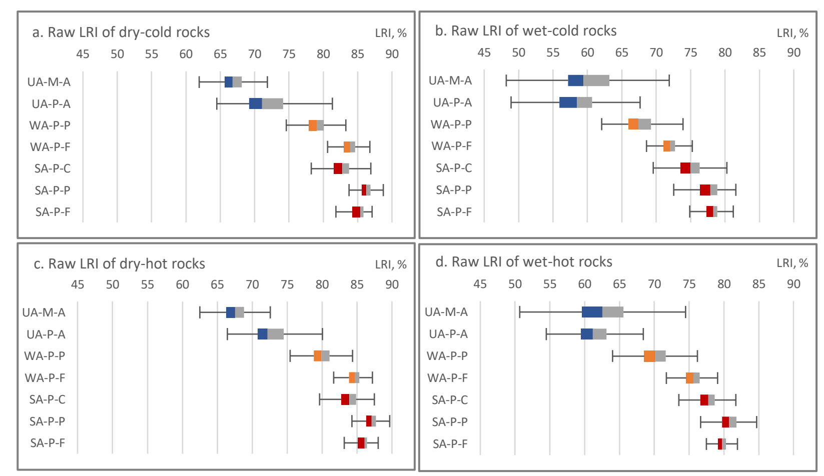

Fig 4. Distribution of the LRI images of rock samples in different conditions of moisture and temperature.

Our results also show that **moisture has significant effects** (Fig 5) whilst the temperature effect is negligible. Different LRI values of strongly altered-, weakly altered-, and unaltered rocks is a function of mineral alteration assemblages, rock surface texture, and rock porosity—all these factors are associated with moisture.

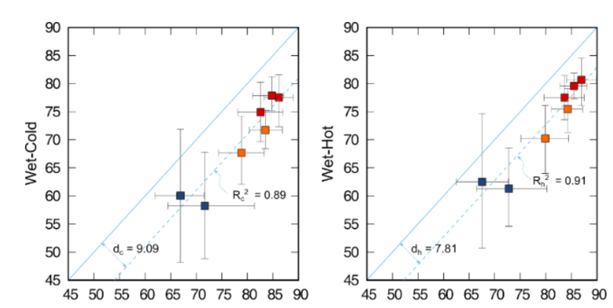

Fig 5. The effect of moisture decrease the LRI values.

This intact order of alteration degree in LRI values opens up the possibility of mapping alteration using LRI values from airborne surveys. However, there are some considerations for alteration mapping from airborne LiDAR, at least:

1. *Range and incident angle compensation.* The longer range, the longer time for beam's pulse to travel and be interfered by many factors. The incident angle (i.e. topographic slope) might also influence the LRI values.
2. *Homogeneity of ground condition in terms of moisture content.* Moisture can be vary within small particular area. Therefore, other ground information might be needed for eliminating moisture effect.
3. *Wavelength used in the airborne scanning.* For mapping, a near-infrared domain that is sensitive to alteration should be utilised.

Conclusions

By analysing laboratory LRI with a LiDAR beam at 1550 nm, we can determine the order of the alteration degree of rocks within the same controlled environmental conditions. Qualitatively, strongly altered rocks result in the highest LRI and unaltered rocks in the lowest LRI with weakly altered rocks in between. Our analysis can distinguish altered from unaltered rocks qualitatively without requiring validation data. It is very useful for applying this technique for airborne surveys over larger areas.

Reference

Darrin Burton, Dallas B. Dunlap, Lesli J. Wood, Peter P. Flaig; Lidar Intensity as a Remote Sensor of Rock Properties. *Journal of Sedimentary Research* 2011; 81 (5): 339–347. doi: https://doi.org/10.2110/jsr.2011.31

For more information

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