Life On Mars: Fluorescence Analysis of Mineral Composition

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The Rover Project

Since the summer of 2019, a team from Saddleback College has been constructing an autonomous Mars rover. To participate in the University Rover Challenge, our rover, Odin, must be capable of identifying extinct and extant life on Mars. One method of testing for extinct life is through the analysis of fluorescing geological samples.

Theory & Methodology

There are many possible indications of extinct life on Mars, but none as subtly promising as the search for water. For Saddleback College's team, determining past presence of water is conducted via the search for evaporites. Evaporites are minerals deposited following the evaporation of a body of water; since water is critical for life as we know it, the presence of evaporites suggests a past environment suitable for life.

When exposed to ultraviolet light, many evaporites are known to fluoresce with distinctive hues. Thus, examining the fluorescent properties of various minerals in the field is an efficient method to search for past presence of water. Additionally, evaporites are prosperous sites for life detection due to their ability to encapsulate microbial structures when precipitation occurs. Life may also be found trapped within liquid inclusions of evaporites such as halite.

To accomplish our goal, the team constructed a shroud to seal off a mineral sample from external light. Attached to a specially designed robotic arm, the shroud will approach a mineral sample, and a longwave ultraviolet light (368 nm) will illuminate it. A microscope in the shroud will capture the resulting mineral fluorescence. The image will then be run through software that analyzes the hues of fluorescence.

Data Analysis

Based on collected data from each pixel, a graph will be generated to measure the abundance of each hue value present in the image. The hue values are a measurement of color related to the color wheel, whose specific value is determined by the RGB composition of a pixel. A custom computer program was built to analyze hue values of every pixel to construct a graph of abundance vs hue for each mineral (refer to **Figure 1**). Cross referencing a team-built database of these graphs allows the team to determine if any evaporites are present.

Like spectroscopy, the dominant value correlates to a specific composition. Although such programs analyze single wavelengths, the team found hue value to be the best method of mineral identification for various reasons. First, the light source for excitement of the samples does not provide a single wavelength of UV, and therefore the resulting fluorescence is a range rather than a specific wavelength. Additionally, the construction of an apparatus based on cameras and light sources is significantly more efficient than a spectrometer for the means of the task.

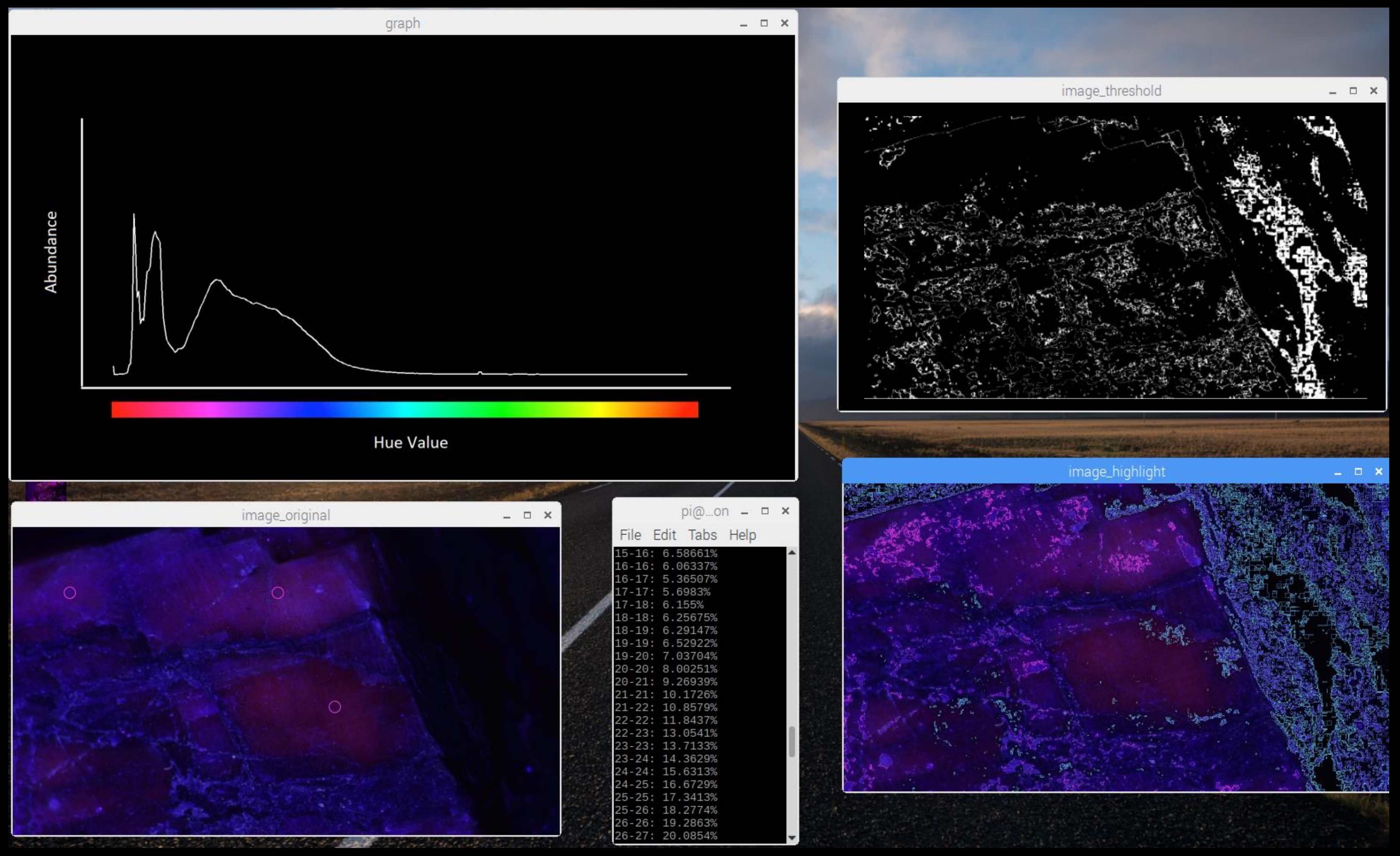

Figure 1: Calcite analysis

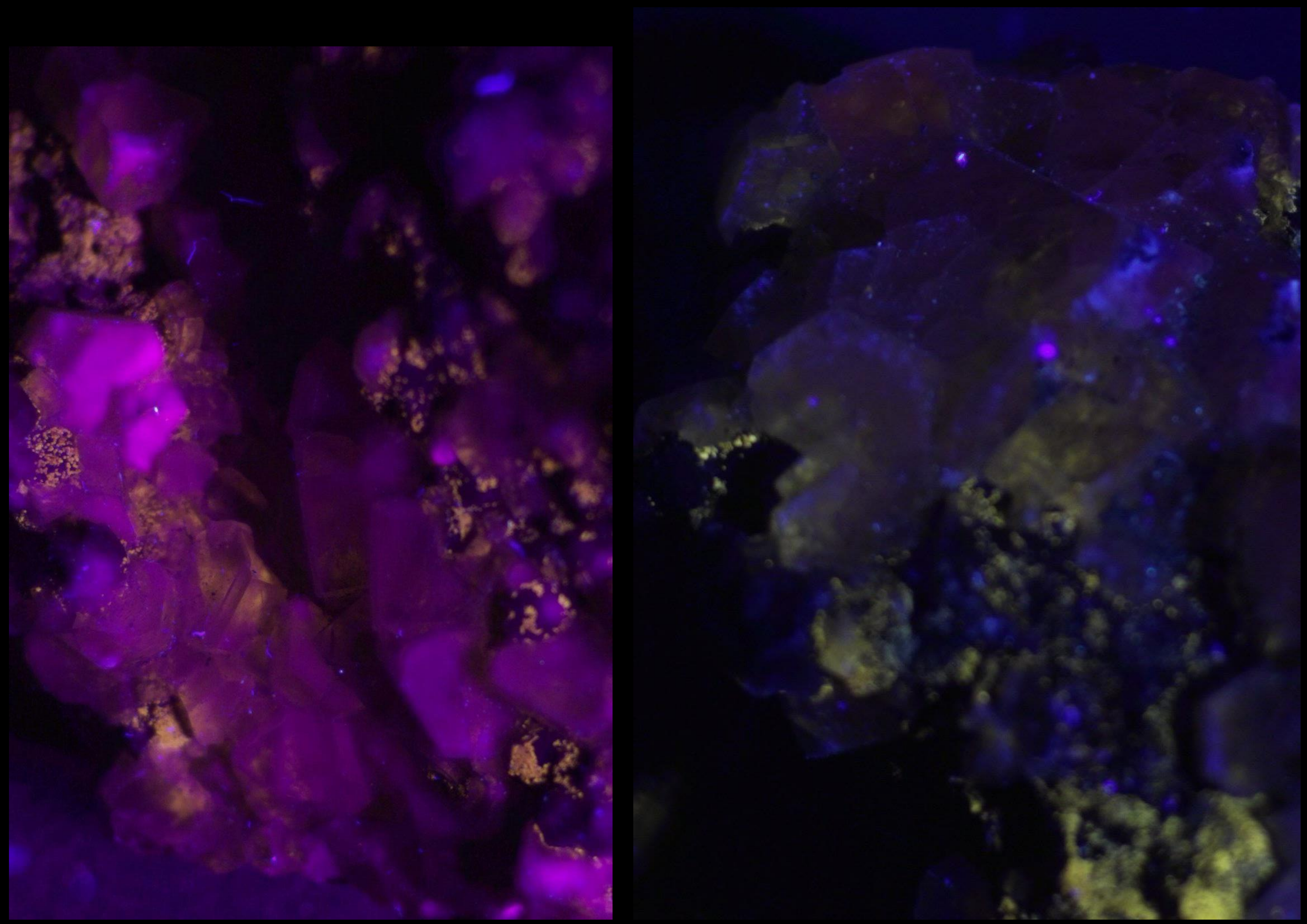

Figure 2: Calcite fluorescence captured without filter (left) and with filter (right)

What is Fluorescence?

When the surface of a fluorescent material is stimulated by high energy electromagnetic radiation, the electrons absorb energy quanta and reach an excited and unstable state. While in this state, atoms undergo vibrational relaxation as some energy is converted into vibrational and kinetic energy. As a result, the photons emitted during the transition back to the ground state are lower in energy than the incident photons. This shifts the emitted light into the visible spectrum to produce fluorescence. Because this process is active on the atomic level, the observed fluorescence is unique to the chemical makeup of each material and is therefore a useful tool to identify geological samples.

As fluorescent materials are expected to emit light in the visible band of the electromagnetic spectrum (wavelengths between 400 and 750 nm), a long-pass optical filter was integrated into the microscope apparatus to eliminate interference and unwanted reflections from the high energy ultraviolet incident light. Observe **Figure 2** for comparison of images with and without the long-pass optical filter.

Works Cited

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