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ADVANCING LUNAR ROCK ANALYSIS: MACHINE LEARNING TECHNIQUES FOR ROCK AND MINERAL IDENTIFICATION IN THIN SECTIONS OF APOLLO ROCKS

Abstract

Collecting rock samples is one of the key scientific goals of returning to the Moon. By studying the type of rock and its mineralogy, researchers can better understand lunar geology and make decisions about using the material for specific experiments or bringing it back to Earth. The vast collection of Apollo rocks has been studied extensively, including by creating ultra-thin slices of the material and taking images of the slices under different lighting and angles. This research uses cutting-edge techniques to classify, cluster, and identify minerals in thin slices of Apollo rocks.

Two databases are used: The NASA PDS database and the Lunar Institute Data. These databases contain digitally scanned images of rock, soil, and core samples collected during the Apollo missions. The images of thin sections of lunar rock are recorded under different light conditions and rotations.

The study presented here is divided into three approaches. The first approach is binary classification, where a convolutional neural network model called Inception-ResNet-v2 is used to classify whether the sample was breccia or basalt. The second approach is the clustering of minerals within a thin section of lunar rock, where a contrastive learning method called SimCLR is used. The neural network was trained using the SimCLR framework and fine-tuned on images of thin sections of lunar rocks. The third approach was the identification of minerals, using semi-supervised deep CNNs to perform semantic segmentation of images. A suitable dataset is created with corresponding image-level and pixel-level labels from the available online data provided by Virtual Microscope. Three different multi-view models were tested to segment and identify minerals in the thin sections of lunar rock.

Our study shows that convolutional neural networks can effectively classify lunar rock types into their major categories. While the clustering of minerals had some limitations, the identification of minerals using semi-supervised deep CNNs achieved promising results. In conclusion, we demonstrate the effectiveness of machine learning methods in advancing the classification and identification of minerals in thin sections of Apollo rocks. This study may pave the way for further research in the field of lunar geology.