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Evaluation of image classification routines for determining modal mineralogy of rocks from X-ray maps

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Abstract

The mineral proportions of rocks or rock fragments in thin section can be retrieved from electron microprobe element X-ray maps using multispectral image classification software. However, different image classification algorithms can yield different inferred mineral proportions and thus deviate from the true modal mineralogy. Several image classification algorithms (implemented in the programs Erdas Imagine and Multispec) were evaluated on a very simple rock—a fragment of noritic anorthositic granulite in a thin section of lunar meteorite ALHA81005. This fragment contains only plagioclase, orthopyroxene, olivine, clinopyroxene, and chromite; each has a constant composition across the fragment. The true (reference) mineral proportions of the fragment were measured manually from the X-ray maps. Results of classification algorithms varied widely in accuracy—from ~1% to more than 15% misclassified pixels compared to the reference. The best match for this fragment comes from an unsupervised classification using the ISODATA algorithm (most minerals were placed into multiple classes, which had to be manually recombined), and the second closest match was a supervised classification using a Euclidean distance classifier. The results of supervised classifications depend strongly on the user's selection of training areas, and small errors in defined training areas (e.g., a training area for one phase contains an inclusion of another) can produce large errors. The most common source of misclassification is "mixed pixels"—those that contain signatures from multiple phases. In this example, pixels including both plagioclase and olivine tend to be classified as clinopyroxene. Thus, mineral proportions calculated from classification of X-ray maps must be considered critically, even for simple rocks. In more complex samples, like those with more phases or with chemically zoned phases, mineral classification of X-ray maps are likely to require care and may be difficult to validate.

Keywords: Multispectral classification, modal analysis, image processing, element map, mineralogy