Machine learning applied to autonomous identification of fission tracks in apatite

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This project's goal was to automate the process of locating fission tracks in apatite for thermochonological analysis, enabling geologists to more efficiently analyze samples. This automation was based on on machine learning, a branch of algorithms that are able to learn the properties of datasets and predict the properties of novel data.

The dataset used consisted of stacks of digital images (AVIs) of etched surface fission tracks (SFTs) and confined fission tracks (CFTs) in apatite (Ap), which were collected for standard U-FT analysis: one AVI for reflected light; one AVI for transmitted light; both AVIs spanning 30 μm in X and Y directions at 24 pixel · μm-1 resolution; 33 frames separated by uniform 0.3 μm; 8 frames above Ap, frame with Ap surface in focus, 24 frames below Ap surface and within Ap volume.

The following algorithm was developed: reduce an image stack to a single image that captures the important features, then run a feature detector that finds regions lighter than their surroundings. Each feature was then hand-labeled as either a fission track or not. The dataset consisted of 43 positive samples and 247 negative samples. This set was randomly divided into testing and training data, and a support vector machine (SVM) was trained on the training set. Finally, the SVM was tested on the testing portion of the dataset.

The SVM achieved a precision of .88 and a recall of .93. Another test was done where the data had been transformed using principle component analysis (first three components), which resulted in a precision of .88 and a recall of .96. These were very promising results, and demonstrate the potential of automated fission track analysis.