doi:10.1017/S1431927622011102
Microsc. Microanal. 28 (Suppl 1), 2022

Object detection in SEM images using CNN: Geological application on size distribution of pyrites in Mudrocks

Artur Davletshin[1], Lucy Tingwei Ko[2], Kitty Milliken[2], Priyanka Periwal[2*], Chung-Che Wang[2], Wen Song[1]

[1] Department of Petroleum and Geosystems Engineering, University of Texas at Austin, Austin, TX, USA
[2] Bureau of Economic Geology, University of Texas at Austin, Austin, TX, USA
*Corresponding author: priyanka.periwal@beg.utexas.edu

In geology, mudrocks are fine-grained (<62.5 µm) rocks mainly composed of clay minerals, quartz, carbonates and feldspars with minor amount of organic matter and pyrites and other accessory minerals. Out of all, pyrites (FeS_2) may be present in different forms and framboidal pyrite is the most common form found in organic-rich mudrocks of all geological ages. They are of utmost importance as their sizes gives information on the redox depositional conditions [1]. Their sizes are established during early diagenesis and can be preserved through time. Scanning electron microscope (SEM) imaging is used to detect the framboidal pyrites in the mudrocks and these pyrite framboids typically stand out in sharp contrast to the dominant minerals in back scattered electron image (BSE) (Figure 1). Currently, their size distribution in SEM images is calculated by either manual tracing, which is a time-consuming and laborious process or by semi-automated image processing methods including histogram thresholding, K-means clustering, and watershed segmentation. However, variations in instrument settings (e.g., magnification, electron energy, and imaging aperture) introduce differences in background image intensities and, therefore, differences in the intensities of framboids, thus limiting the applicability of aforementioned methods.

In this poster, we discuss the automation of size distribution of framboidal pyrites in SEM images using a Machine Learning method. We have used several CNN architectures including Inception, ResNet, Inception-Resnet, and Mask R-CNN to characterize framboidal pyrites. The training and testing data set included ~6,800 framboids from 128 grayscale and 32 colored SEM images. We have compared the results obtained from manual and Machine Learning methods using Kolmogorov-Smirnov tests, visual inspection and box and whisker plots. We have shown that Inception ResNet model, Kolmogorov-Smirnov test detected framboids with up to 99% precision [1]. Importantly, once trained, the CNNs were ~100 times faster than current manual tracing. A straightforward extension of this work includes the application of CNNs to characterize organic matter pores, fractures, and/or mineral grains in geological materials [2].

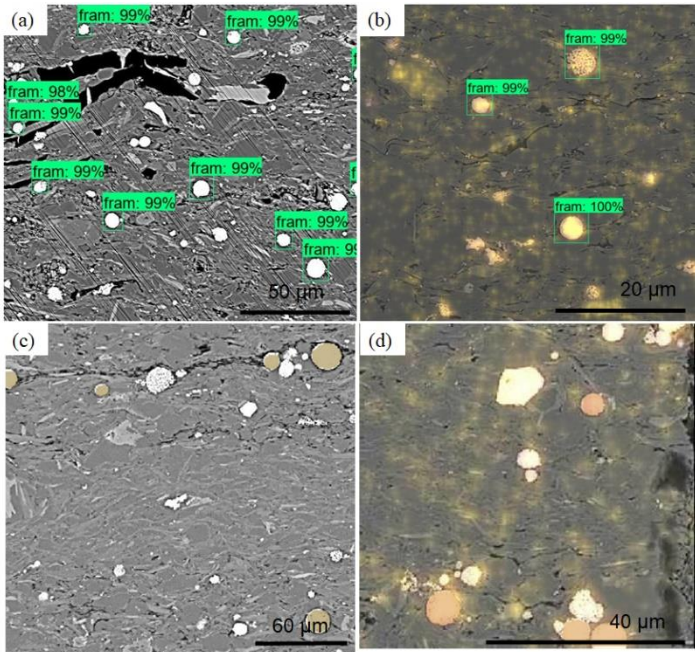

Figure 1: Examples of circular framboid detection on test images. (a) Identification of framboids using object detection, i.e., Faster R-CNN models, from BSE grayscale images. All traced instances containing circular framboids are labeled with IoU values (e.g., 99%). (b) Object detection Faster R-CNN models tested on BSE+EDS maps. (c) Instance segmentation model tested on BSE grayscale images. (d) Instance segmentation model tested on BSE+EDS maps images.

References:

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