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High Throughput Shale Rock Imaging Using Multi-Beam Scanning Electron Microscopy

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Even though there has been decade-long ongoing progress in the advancement of scanning electron microscopes (SEMs), the data acquisition rates and therefore the realistically addressable region of interest has been more or less unaltered since. Using multiple electron beams in parallel can overcome the inherent throughput limitations of conventional single-beam electron microscopy. The setup of such a multi-beam SEM has been described elsewhere [1]. Figure 1 visualizes the basic principle of operation.

Since its commercialization in 2014, ZEISS MultiSEM is predominantly used for biomedical research. However, interest from other fields of research is growing. In Geosciences, for example, characterization of the pore space and the highly heterogeneous microstructure of shales is crucial for many applications [2]. With conventional single-beam SEMs, the distribution of nanometer sized pores on centimeter-sized samples can only be assessed by randomly sampling only few small regions of interest. ZEISS MultiSEM with its extended field of view enables researchers for the first time to image larger areas at nanometer resolution in a much shorter period of time [3]. When coupled with correlative mineralogy information, advanced image segmentation techniques are promising tools for elucidating the composition of the sample down to the nanometer scale. Figure 2 shows multi-beam SEM data, correlated with EDX signal from a single-beam SEM at the same area of a high maturity shale rock sample.

We will give an overview of first experimental results using multi-beam SEM to image large areas of broad ion beam polished shale rock samples. This ongoing application development aims for evaluating the usability of image data generated with ZEISS MultiSEM for geological and mineralogical research.

References:

[1] A. L. Eberle *et al*, Journal of Microscopy **259** (2015), p. 114-120.
[2] R. G. Loucks *et al*, AAPG Bulletin **96** (2012), p. 1071–1098.
[3] J. Heath *et al*, presented at the AGU Fall Meeting, San Francisco (2016) MR51C-2719.

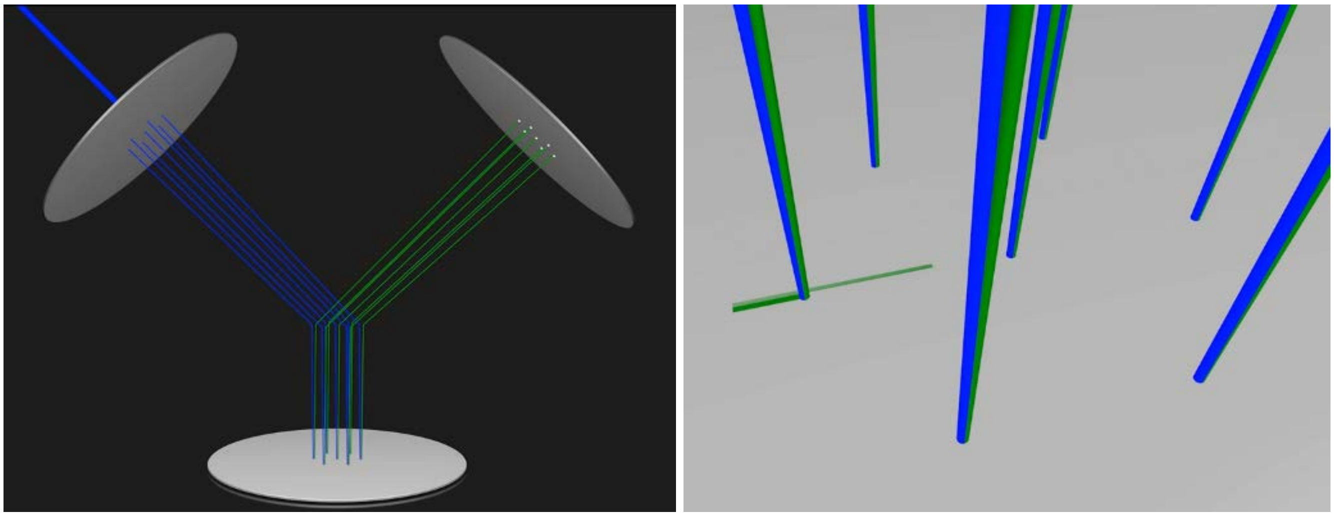

Figure 1. Visualization of the basic principle of operation. Multiple primary electron beams (blue) within a single column are scanned in parallel over a sample. One dedicated detector per secondary electron beam (green) enables parallel detection of the signals from all beams. For simplicity, only 7 beams are shown in this sketch. A video animation of the operation principle is available on the internet at https://p.widencdn.net/fvzxio/principle_MultiSEM.

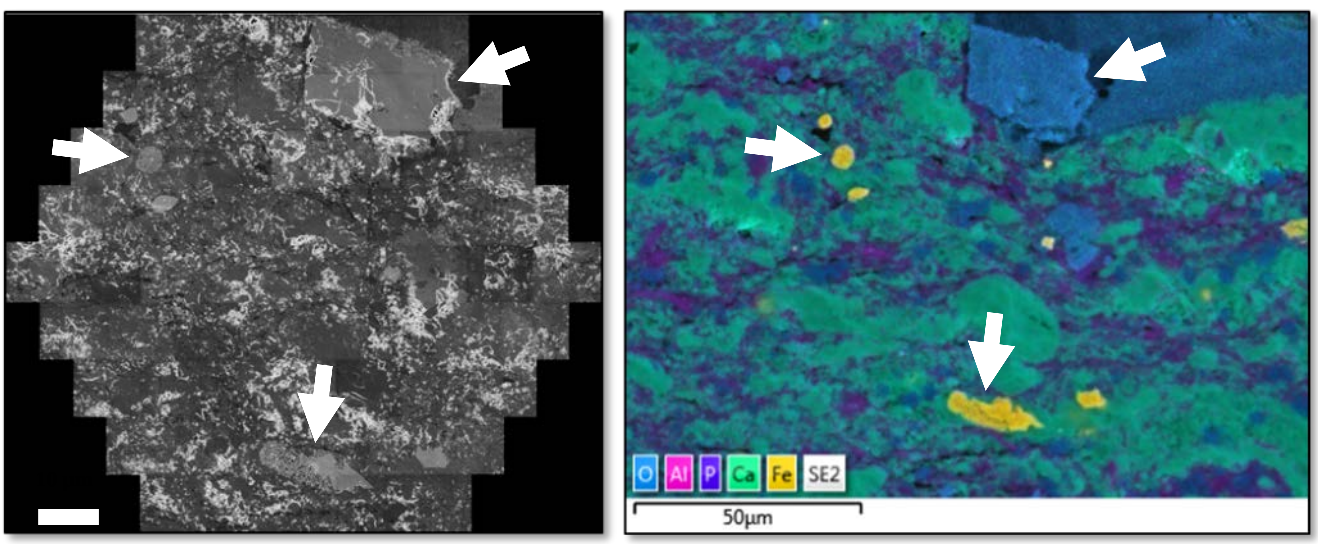

Figure 2. Left: Image example taken on ZEISS MultiSEM 505, different materials show different gray levels, brightest regions of the image highlight edges of pores; right: Same area (see white arrows for comparison) imaged on ZEISS Sigma 500, showing elemental information (EDX). Sample: high maturity shale rock, surface broad ion beam polished and carbon coated (with courtesy from Lori Hathon, University of Houston).

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