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Application of BIB-SEM technology to characterize meso- and macropore morphology in coal

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Coalbeds are very heterogenous in composition, which in turn affects the connectivity and transport of fluids within the coal. The composition of a coalbed influences the pore structure. Pore structure as well as pore size distribution are two important parameters used in estimating reservoir properties. This study examines the morphology and distribution of macro- and mesopores in coal samples, using broad ion beam (BIB) milling to prepare relief- and damage-free polished surfaces of coal samples for high-resolution SEM imaging.

The BIB-sections of a few square millimeters are not large enough to be statistically representative so that the results cannot be easily interpreted from a coal seam standpoint. Therefore, porosity was investigated as a function of maceral type to characterize pore morphologies. Macerals were selected from the vitrinite group, e.g. telocollinite, and from the inertinite group, e.g. fusinite and macrinite. The selected macerals were BIB-milled parallel to bedding and subsequently milled perpendicular to bedding. Pore morphology and pore size distribution was examined in each of the milled sections. For a vitrinite maceral type, we found no visible macroporosity within the resolution limits of the SE detector. Pore morphology in an inertinite maceral is dependent on the original maceral. Fusinite yields large, elongated pores (often filled with mineralization), while macrinite shows comparatively smaller, rounder pores.

The BIB-milled sections perpendicular to bedding often showed an alternating sequence of bedding, with bed thicknesses varying between a few micrometers to greater than half a millimeter. The distribution of pores is also reflected by bed thickness in the sections perpendicular to bedding, with many pores being concentrated in association with the beds. The distribution of pore sizes follows a similar power law at different magnifications of the same BIB-milled surface. Our results show that micropores and macropores in coal belong to different populations, with different size distributions and morphologies. Furthermore, each maceral type studied yielded a different power law distribution.

BIB-SEM imaging is a useful tool to study meso- and macropore morphology, especially in the size range between 10 nm and 10 μm. In a future study, more maceral types should be examined for a better characterization of maceral porosity at different stages of coalification.