Contribution ID: **149** Type: **Oral Presentation**

Towards Pore Super Segmentation on Artificially Enhanced SEM Images of Opalinus Clay by Voting Classification

Tuesday, 31 May 2022 16:45 (15 minutes)

For the safe underground storage of radioactive waste, it is crucial to carefully determine the porosity of the host rock as pores control all of its physical properties, such as the essential low permeability. Specialized scanning electron microscopy (SEM) is an established method in the analysis of Opalinus Clay and used in many studies, e.g. [Houben et al., 2013], [Laurich et al., 2018], and [Keller, 2021]. In the studies, the pores are characterized and evaluated by size, orientation, and frequency using binary segmentation masks. However, the creation of these masks entails some difficulties, such as interpretation limitations, non-standard procedures, and in particular, the nanoscale resolution limit of the SEM. In addition, the overlap of gray values between grains and pores makes conventional methods like the gray value thresholding method not applicable.

Over the past decades, technical achievements in image analysis and machine learning have led to the development of new methods. Especially methods based on self-learning algorithms show the potential to perform even sophisticated analyses. From a geoscientific point of view, the goal is to analyze high-resolution information from sample material in large quantities.
This requires at least a semi-automatic analysis workflow.

This work presents a method that enhances the original micrograph's resolution and improves the quality of pore identification. First, the resolution of the SEM images is artificially increased. Our approach uses an Enhanced Super-Resolution Generative Adversarial Network (ESRGAN) [Wang et al., 2018] trained in the upsampling of SEM images. The enhanced images show much more detailed pores and pore edges so that even small pores can be identified with greater clarity. This step is followed by a voting algorithm that combines several machine learning classifiers (MLC) and calculates a probability field on that basis. Nine different MLC's were trained in this process. This training allows the derivation of different confidence levels that reduce false pore segmentation and capture the pore edges more smoothly and consistently.

The proposed method is able to detect pores in Opalinus clay that were previously undetected or poorly segmented. Thus, even small pores are now detected with better quality and a clear edge identification, which makes it possible to lower the practical truncation limit [Bonnet et al., 2001]. We discuss the results and further ongoing work to improve the reliability of MLC's with ESRGAN images.

Acceptance of the Terms & Conditions

Click here to agree

MDPI Energies Student Poster Award

No, do not submit my presenation for the student posters award.

Country

Germany

References

[Bonnet et al., 2001] Bonnet, E., Bour, O., Odling, N. E., Davy, P., Main, I., Cowie, P., and Berkowitz, B. (2001). Scaling of fracture systems in geological media. Reviews of Geophysics, 39(3):347–383.

[Houben et al., 2013] Houben, M. E., Desbois, G., and Urai, J. L. (2013). Pore morphology and distribution in the shaly facies of opalinus clay (mont terri, switzerland): Insights from representative 2d bib–sem investigations on mm to nm scale. Applied Clay Science, 71:82–97.

[Keller, 2021] Keller, L. M. (2021). 3d pore microstructures and computer simulation: Effective permeabilities and capillary pressure during drainage in opalinus clay. Oil & Gas Science and Technology –Revue d'IFP Energies nouvelles, 76:44.

[Laurich et al., 2018] Laurich, B., Urai, J. L., Vollmer, C., and Nussbaum, C. (2018). Deformation mechanisms and evolution of the microstructure of gouge in the main fault in opalinus clay in the mont terri rock laboratory (ch). Solid Earth, 9(1):1–24.

[Wang et al., 2018] Wang, X., Yu, K., Wu, S., Gu, J., Liu, Y., Dong, C., Loy, C. C., Qiao, Y., and Tang, X. (2018). Esrgan: Enhanced super-resolution generative adversarial networks.

Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

Unsure

Primary authors: Mr BRYSCH, Marco (Federal Institute for Geosciences and Natural Resources); Dr LAURICH, Ben (Federal Institute for Geosciences and Natural Resources); Mr SCHETTLER, Christoph (Federal Institute for Geosciences and Natural Resources); Prof. SESTER, Monika (Gottfried Wilhelm Leibniz Universität, Hannover)

Presenter: Mr BRYSCH, Marco (Federal Institute for Geosciences and Natural Resources)

Session Classification: MS15

Track Classification: (MS15) Machine Learning and Big Data in Porous Media