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Integrated Microstructural Analysis of Rock Samples: Quantifying Porosity and Mineralogy with SEM and Machine Learning

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Integrating Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS), and advanced machine learning techniques like the U-Net model offers new tools and approaches for research in the fields of microstructure analysis and mineralogy. This interdisciplinary approach not only increases the precision of data analysis but also expands the scope of research methodologies.

This study details a methodical approach to the microstructural analysis of rock samples, focusing on the precise quantification of porosity and mineral composition. The process begins with the preparation of rock samples using Broad Ion Beam (BIB) polishing, ensuring optimal surface quality for imaging. The prepared samples are then examined using Scanning Electron Microscopy images, revealing detailed microstructural features.

A significant advancement in our methodology is the use of a pre-trained U-Net model for accurate pore segmentation [1]. This machine learning approach efficiently delineates the pore structures within the rock matrix from secondary electron (SE2) images. Subsequently, the study involves analyzing the mineralogical composition of the rock samples. This is achieved through the use of high-resolution backscattered electron (BSE) imaging coupled with low-resolution EDS data. A semi-automatic phase segmentation tool is employed to identify and quantify the different mineral phases present in the rock. This tool incorporates advanced algorithms for pixel-wise image segmentation and labeling, using a decision tree to pinpoint specific minerals [2].

The culmination of this study is the alignment of SE2 and BSE images, enabling the correlation of porosity data with the distinct mineral phases. This innovative technique offers a comprehensive view of how porosity is distributed among various minerals, providing a deeper understanding of the rock's microstructural properties.

This research methodology offers a unique and in-depth perspective on rock microanalysis, with significant implications for geological research and practical applications across various industries.

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References

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