Development of an Automated Thin Section Image Analysis Using Machine Learning and Image Processing Technologies for the Oil and Gas Industry

Raua Al Maskari[1], Frederic Knap[1], Farhad Khalilzadeh[2], Pelinsu Celebi[2], Abdulrahman Al-Harthy[3], Zuwaina Al Rawahi[3], Nawwar Al-Sinawi[3], Shamsa Al Brashdi[3]

[1]Target Oilfield Services
[2]Target Energy Solutions
[3]Petroleum Development Oman

Abstract

Thin sections are considered major contributors in reservoir characterization as they offer critical insights into rock properties such as lithology, texture, and porosity. Although the process of manual description and interpretation is essential, it is a rather time-consuming and a costly activity, discouraging operators from performing it and compromising geological field studies' consistency and delivery time. To address this issue, image processing, machine learning, and artificial intelligence (AI) methods can streamline the thin section description process by reducing costs while still maintaining precision. Integrating new technologies can help specialists by providing fast and easy-to-use quantitative and qualitative interactive tools, improving upon the conventional analysis, hence further enhancing geological descriptions and interpretations. This study aims to develop an AI-powered thin section image analysis application called Automated Petrography, consisting of two modules for carbonate and clastic thin sections.

The application automates thin section description by determining rock feature abundances and visual estimations based on geological criteria. The AI-detected parameters consist of lithology, staining status, porosity (intra-particle and inter-particle pores), and cement (dolomite and calcite). For carbonate samples the Dunham texture, skeletal grains, non-skeletal grains, and matrix abundances are also determined; while in clastic samples the mineral composition which includes quartz (and quartz overgrowth), feldspar, lithic fragments, opaque minerals, clays, glauconite, and resulting Folk classification (following QFL ternary diagram scheme) are provided. The software applies machine learning classification algorithms for pixel and surrounding area features, deep learning segmentation models for complex elements like skeletal grains, and image classification models for texture. Moreover, it processes all features in under 1 minute, significantly faster and more accurate than the manual and laborious point-counting method. The Expert Mode visualizer provides the user with intuitive tools for in-depth analysis and modifications over the AI-based results. The results can be fine-tuned using the system’s uncertainty analysis, the digital grain separation method for precise delineation of grain boundaries and the associated grain size measurement, roundness, and sorting. A final report is then generated with the incorporation of visual maps of each feature detected along with AI-generated text description.

Additionally, it estimates parameters like 2D thin section permeability and pore size distribution, providing insights into different rock types. This automated analysis yields a quick understanding of reservoir properties, facilitating a better assessment of reservoir facies distribution and potential barriers/baffles. Overall, integrating petrographical descriptions with modern technologies can significantly accelerate thin section description rates, consistency and provide reliable data for reservoir studies. Many thin sections remain uninterpreted due to cost and time constraints. Offering a fast and intuitive system for these samples can yield valuable geological information for field development studies.