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POROSITY AND PERMEABILITY ESTIMATION BASED ON INTEGRATED PREDICTION ERROR FILTER ANALYSIS AND WELL LOGS

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Reservoir properties, including porosity, permeability, shaliness, and saturation, are crucial for understanding production and injection capabilities. Porosity is categorized into total, effective, and dynamic. Permeability reflects fluid flow through a material, and it, along with porosity, relies on the rock's mineral content, structure, and texture.

Well logs offer detailed insights into deep geological structures and reservoir parameters. Their resolution can sometimes average out finer details depending on the methodology and tooling. High-resolution alternatives, like core lab measurements, offer more accuracy. However, they're point-specific, and more measurements increase costs.

Thus, lab data often calibrates well log interpretations. An intriguing approach involves neural networks to predict porosity and permeability by integrating well log and lab measurements, further enhanced by advanced log analysis algorithms.

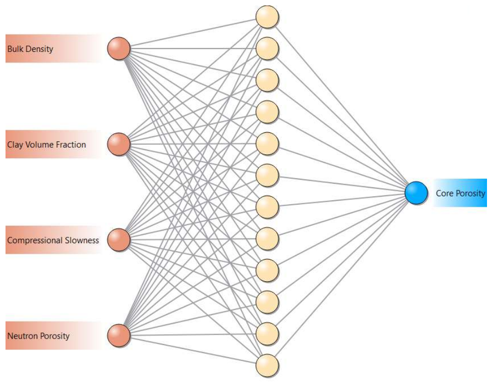

Figure. Scheme of multilayer perceptron network

Geological samples from the Miocene period were sourced from well A located in the Carpathian Foredeep, southeast Poland. The well log analysis encompassed GR (natural gamma-ray radioactivity), NPHI (neutron porosity), RHOB (bulk density), and DT (compressional slowness) logs.

The examined rock samples were retrieved from depths exceeding 2000 m and are characterized by a mix of sandstone/siltstone and mudstone sediments, suggesting a potentially gas-bearing formation. Laboratory tests on these samples, taken horizontally aligned with bedding, included Nuclear Magnetic Resonance (NMR) and permeability assessments. These tests served both for computational purposes and validation.

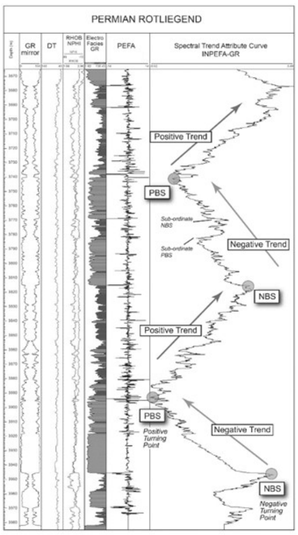

Figure. Example of using INPEFA algorithm

The INTEGRATED PREDICTION ERROR FILTER ANALYSIS (INPEFA) algorithm is a geophysical method employed in sequence stratigraphy to highlight significant stratigraphic features, identify cyclic patterns, and determine data boundaries. Inspired by the potential to detect Milankovitch cycles in stratigraphic data, this technique emerged from the notion that orbitally-driven climate shifts are captured in rock strata due to the varying solar energy impacts on erosion, transport, and deposition processes. With the ability to detect periods ranging from tens to hundreds of thousands of years, INPEFA offers superior resolution than traditional biostratigraphy and seismic stratigraphy techniques and even highlights discontinuities within singular geological units.

Crucially, INPEFA is adept at zoning, correlating, and spotting subtle well log changes that might be overlooked in standard interpretation. Key to its analysis is the choice of the calculation window for the selected well log and pointing Positive and Negative Turning Points, which distinguish curve trends.

However, applying INPEFA to thinly-layered and varied formations necessitates expertise, particularly in choosing the right window and marking turning points. Thus, for a holistic understanding, one must analyze both broadly (general curve features) and in details.

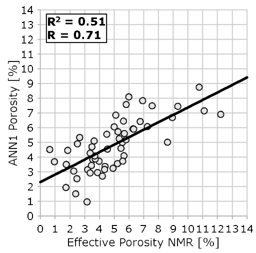

Figure. Comparison of laboratory measurements with porosity estimated using neural networks.

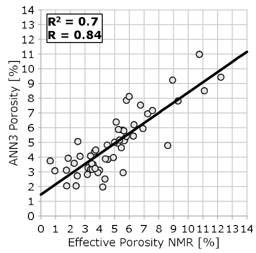

Figure. Comparison of laboratory measurements with porosity estimated using neural networks and INPEFA algorithm.

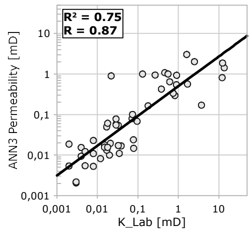

Figure. Comparison of laboratory measurements with permeability estimated using neural networks.

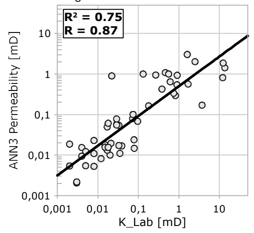

Figure. Comparison of laboratory measurements with permeability estimated using neural networks and INPEFA algorithm.

Analyses showed that neural networks effectively predict porosity and permeability using well logs and lab samples, outperforming traditional methods. In complex terrains, these networks enhance outcomes, though they still need refinement. The INPEFA algorithm for the GR curve notably enhances predictions, especially when added as supplementary data. Choosing the right interval between successive turning points on the INPEFA curve is vital. For porosity, every trend change on the INPEFA curve is effective, while permeability benefits from larger steps. Determining the best step distance requires extensive testing, influenced by factors like rock formation complexity.

ACKNOWLEDGEMENT

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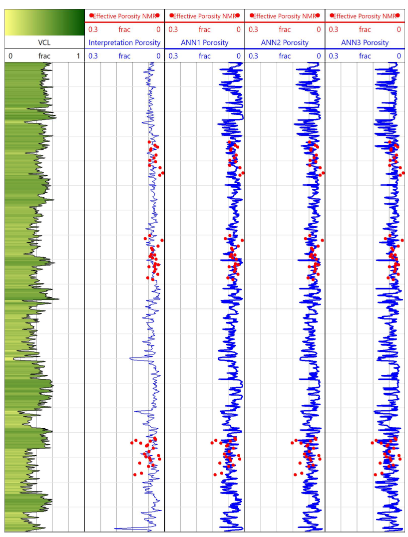

Figure. Results of porosity estimation by an artificial neural network and a network enhanced with the INPEFA algorithm.

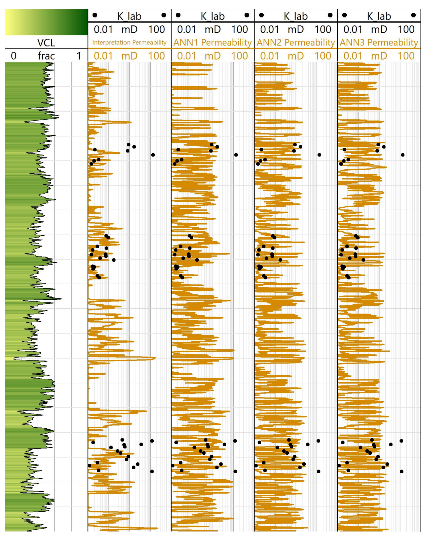

Figure. Results of permeability estimation by an artificial neural network and a network enhanced with the INPEFA algorithm.