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# Extending Rock Type Classification and Flow Unit Identification Beyond Cored Intervals

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## Summary

Reservoir characterization and formation evaluation are fundamental to understanding rock fabric and its influence on subsurface performance, including hydrocarbon recovery, geothermal development, and carbon sequestration. Central to this characterization is the relationship between storage capacity (porosity) and flow capacity (permeability), which governs fluid movement within the reservoir. Core-derived porosity and permeability measurements form the basis for defining rock types and hydraulic flow units; however, these interpretations are inherently constrained by the spatial and vertical availability of core. The work presented here demonstrates how machine learning workflows can be applied to propagate core-based insights into non-cored intervals, both within cored wells and across offset wells, thereby extending reservoir understanding beyond the limits of direct measurement.

## Theory / Method / Workflow

It is well established that the relationship between porosity and permeability is not solely dependent on pore volume, but by the distribution, geometry and connectivity of pore throats, which determine fluid flow capacity. The ease of fluid flow, or permeability, can be significantly impacted by variations in rock fabric, cementation, and grain size distribution, among other variables (diagenesis, for example). As a result, it is common for rocks to have similar porosity, but markedly different permeability, sometimes varying by orders of magnitude.

Given the potential for such significant differences in permeability, Ebanks (1987) developed an integrated approach to aid in rock typing and hydraulic unit identification. Amaefule extended this work with a classification based on rock quality index (RQI) versus normalized porosity (PHIN) to calculate a flow zone indicator (FZI) parameter. Using this approach, permeability can be more accurately constrained than using the traditional porosity/permeability cross plots, particularly in zones of higher clay or shale volumes.

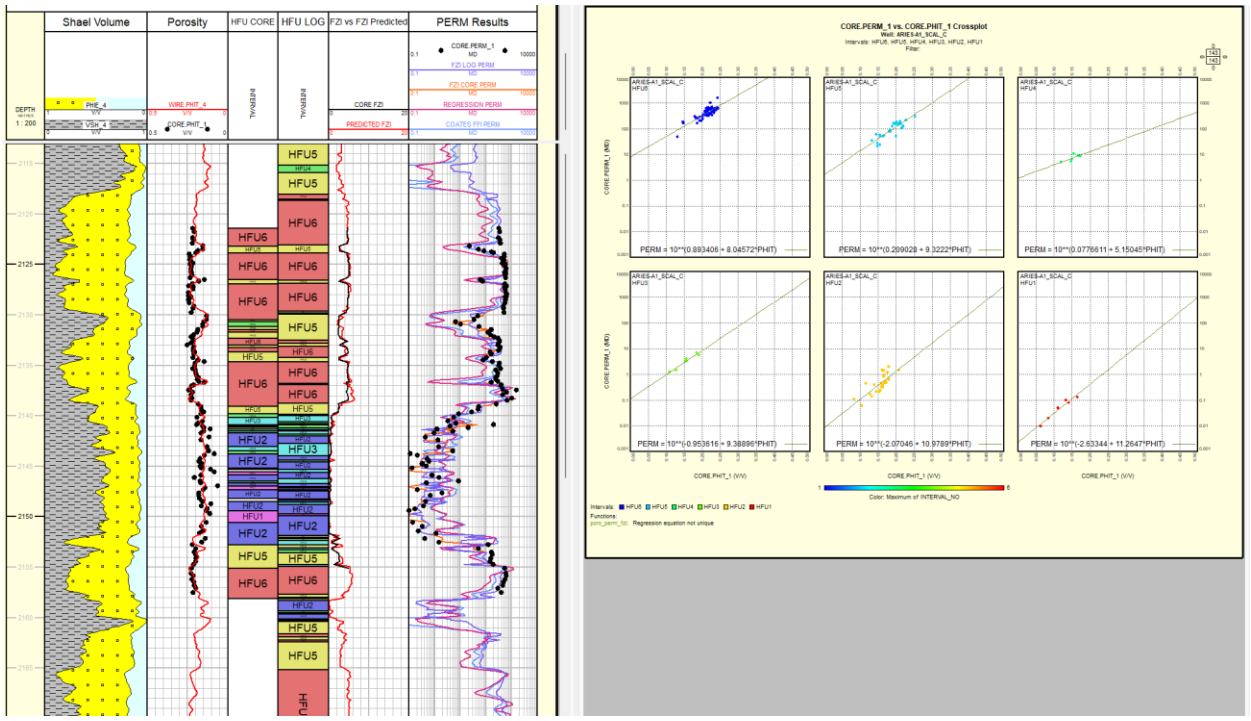
While the rock typing and flow unit identification methodology gives added insight and improved permeability modeling, the precision and accuracy of this technique is limited to the extent of core data. Given the limited spatial coverage of core data, a key challenge in reservoir characterization is the extension of core-derived property relationships to non-cored intervals and offset wells. The work presented here will demonstrate the application of a machine learning workflow to permeability characterization in non-cored intervals and wells.

An initial approach to extending the rock typing methodology beyond cored intervals applies a regression relationship between core porosity and permeability, and extrapolating results beyond the cored interval. While such methodologies can provide results beyond the cored zone and non-cored wells, these results can often over-estimate permeability in zones with higher clay content.

The methodology presented here combines the traditional method of determining permeability from the core porosity/permeability cross plots, and the RQI vs PHIN to generate an FZI log. Then, using a k-nearest neighbor (K-NN) approach, predict and propagate the FZI log beyond the cored interval. The methodology combines the predicted FZI log with porosity vs. permeability cross plot regression relationships and yields a more accurate permeability curve over cored intervals, thus providing more confidence in the results when propagating beyond the cored zone and to wells without core data.

## Results, Observations, Conclusions

The attached figure presents the vertical extent of core coverage and compares permeability estimates from the Coates model and a core-based porosity–permeability regression. Both approaches overpredict permeability between approximately 2140 m and 2150 m. In contrast, FZI-derived permeability from both core and log data exhibits a markedly closer match to measured core permeability, increasing confidence in the extrapolation of permeability beyond the cored interval.




## Novel/Additive Information

The key contribution of this work is the direct prediction of Flow Zone Indicator (FZI) rather than permeability from porosity–permeability regressions. This approach preserves rock fabric and hydraulic flow unit characteristics derived from core-based rock typing and enables their propagation into non-cored intervals. As a result, permeability estimates more consistently honor

rock texture and reservoir quality, particularly in clay-rich and texturally complex zones where conventional regression methods are prone to overestimation.

## Acknowledgements

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### References

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