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Integrating Borehole Image Logs and Seismic Anisotropy: A Systematic Review of Geostatistical Models for Basement Fracture Networks in Uganda's Lake Albert Rift

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Abstract

Basement reservoirs within the Lake Albert Rift, Uganda, present significant exploration challenges due to their complex fracture-controlled porosity and permeability. Accurately characterising these fracture networks is critical for field development. Borehole image logs provide high-resolution, localised fracture data, while seismic anisotropy offers broader-scale structural insights. However, a systematic synthesis of geostatistical methods for integrating these disparate data types in this specific geological context is lacking. This systematic review aims to identify, evaluate, and synthesise published geostatistical models and workflows used to integrate borehole image log data with seismic anisotropy for the characterisation and modelling of fracture networks within the crystalline basement of the Lake Albert Rift. A systematic search was conducted across multiple scholarly databases using predefined search strings. Studies were screened against strict inclusion and exclusion criteria, focusing on methodologies applicable to fractured basement reservoirs. Data on geostatistical techniques, integration approaches, and model validation were extracted and thematically analysed. The review identified discrete fracture network (DFN) modelling as the predominant geostatistical framework. Successful integration typically uses borehole image logs to define fracture set statistics and seismic anisotropy to constrain fracture orientation and intensity at the reservoir scale. The

effectiveness of this integration is highly dependent on the scale of seismic data and the calibration of anisotropy vectors to interpreted fracture sets. Geostatistical integration of borehole and seismic data is essential for constructing reliable fracture models in the Lake Albert Rift basement. DFN modelling emerges as the most documented and adaptable approach. The principal challenge lies not in the choice of model, but in the quantitative calibration and scaling rules used to merge high-resolution well data with lower-resolution seismic attributes. Future work should focus on developing standardised protocols for anisotropy calibration and quantifying uncertainty in integrated fracture models. Research should also investigate advanced geostatistical methods for directly incorporating seismic anisotropy attributes into model conditioning. fractured basement reservoir, geostatistical modelling, discrete fracture network (DFN), borehole image log, seismic anisotropy, Lake Albert Rift, Uganda, data integration. This review provides a consolidated synthesis of geostatistical approaches for integrating borehole and seismic data to model fractures in a complex African rift setting. It clarifies the dominant methodological framework and identifies specific gaps in calibration and scale integration for future research.