**Advanced Multivariable Geological Modeling – Case Study of Orogenic Au Deposit with Multi-Generational Quartz Veins**

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**ABSTRACT**

This case study reviews the application of Machine Learning in modeling complex multi-generational quartz veins of an Orogenic Gold deposit. Traditional geological modeling methods often rely on subjective interpretations and struggle to incorporate multiple variables, leading to bias and inefficiencies. Machine learning offers a transformative solution by integrating various geological inputs, such as structural data, vein intensity, and mineral associations, into a single multivariable model. This approach improves modeling efficiency, allowing geologists to focus on other critical tasks like geological logging, mapping, and resource calculation, supporting a more holistic interpretation.

By leveraging Machine Learning, geologists can test structural hypotheses and explore multivariable inputs, producing more accurate and realistic geologic models faster than traditional methods. This allows geologists to evaluate how different hypotheses impact downstream interpretations. The case study compares 3D geologic interpretations from both traditional and machine learning methods, highlighting key lessons in modeling the complexity of multigenerational quartz veins in an Orogenic Gold deposit.

Chosen for its complexity and multiple generations of quartz veins with strong structural controls, this deposit demands advanced modeling techniques. Applying machine learning enhanced structural analysis and multivariable integration, leading to models that better reflect the intricate relationships between vein structures and mineralization. This approach respects the geological variability and structural complexity of the deposit, improving prediction reliability and understanding of mineralization controls within the Orogenic Gold System. Additionally, adjusting block model resolution and delimiting models to solids or surfaces offers flexibility in optimizing model accuracy and resource estimation.

In conclusion, this case study demonstrates how cloud computing and machine learning provide an efficient and adaptable solution for modeling complex deposits. Integrating multiple geological variables and reducing processing time enhances confidence in resource estimation, supports real-time decision-making, and deepens understanding of the deposit's structural framework.