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Geostatistics in Mineral Exploration: A Review

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As mineral exploration advances, large and complex spatial datasets are generated from diverse sources. Extracting reliable and decision-relevant information at various stages of the exploration project becomes critical. During conceptual or scoping studies, geological data are derived from a limited number of samples/ drill holes. As projects progress to pre-feasibility and feasibility stages, the geological confidence increases with the incorporation of detailed information on lithology, structural controls, mineralogy, alteration patterns, and grade distribution. This progressive maturity of data sets highlights the necessity for quantitative approaches capable of integrating data while preserving geological consistency.

Unlike classical statistical methods, geostatistics provides a rigorous framework for analyzing spatially correlated data, enabling both the quantification of mineral potential and, importantly, the assessment of uncertainty. Core applications include optimizing drill-hole spacing to balance exploration costs with information gain, modeling spatial continuity of geological and grade variables, and estimating mineral resources with greater reliability. These tasks rely on robust geostatistical analyses conducted by experienced geoscientists with strong theoretical knowledge and industry experience.

As the project advances, more sophisticated geostatistical algorithms such as conditional simulation can be used to characterize uncertainty and support critical decision-making processes. Advances in computational power have significantly expanded the accessibility and efficiency of these methods, allowing for more comprehensive and realistic modeling of subsurface variability.

This presentation highlights the application of geostatistics through selected anonymized case studies, demonstrating its role as an indispensable tool in modern mineral exploration. It also emphasizes the importance of integrating geostatistics into university-level mineral exploration curricula to better prepare future professionals for data-driven, risk-aware decision-making.