

## **Integrating Simulation, Core Scanning, and Adaptive Drilling for Real-Time Exploration Optimization at the Zonia Copper Deposit**

**Patrick Redmond**<sup>1</sup>

<sup>1</sup>Resource Exploration Strategies - GeologicAI, Calgary, Canada

The Zonia porphyry copper deposit in Arizona is a brownfields oxide copper project that has been the focus of intermittent exploration and mining for more than a century. Despite extensive historical exploration, significant uncertainty remained regarding geology, resource size, and metallurgical variability. To address these challenges, an integrated exploration workflow was implemented that combined conditional simulation, drill hole optimization, multi-sensor core scanning, and adaptive drilling to support real-time exploration decision making.

The workflow began with conditional simulation of historical geological and assay data to quantify spatial uncertainty and identify areas where additional drilling would most effectively improve resource confidence. Drill hole optimization algorithms were then used to design a drilling program that maximized information gain while minimizing drilling costs and metres.

Historical and newly collected drill core were characterized using a multi-sensor scanning platform and integrated within a digital core environment. These data generated quantitative information on lithology, alteration, mineralization, and geochemical variability at scales and densities exceeding those achievable through conventional logging and sampling.

Unlike conventional workflows that rely on visual logging and laboratory assays, multi-sensor datasets were available immediately following scanning and could be incorporated into geological models and targeting decisions months before assay results were received. This enabled continuous refinement of geological and resource models and dynamic adjustment of drill hole locations, orientations, and priorities while drilling was underway. The result was a faster, more cost-effective process that accelerated learning, improved targeting efficiency, and reduced reliance on lengthy laboratory turnaround times.

The resulting dataset also provided a foundation for geometallurgical domaining by integrating geological, mineralogical, and geochemical characteristics relevant to copper recovery. The Zonia exploration program demonstrated how integrating conditional simulation, drill hole optimization, multi-sensor core characterization, and adaptive drilling reduced geological uncertainty, accelerated decision making, lowered exploration costs, and unlocked value from a mature mineral deposit.