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Atoms to Orebodies: Multiscale Data Integration and the Future of Deposit Characterisation

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The last two decades have produced a step change in the resolution and throughput of analytical technologies available to economic geologists. Atom probe tomography now resolves trace element partitioning at the nanoscale. LA-ICP-MS mineral chemistry datasets, increasingly routine in scale, are redefining how bulk lithogeochemical signatures are interpreted and what they record about fluid pathways and metal sources. At the core and district scale, LIBS, hyperspectral imaging, and automated mineralogy are generating continuous, high-density datasets across entire drillhole programs, while traditional methods such as x-ray diffraction and optical mineralogy continue to evolve and offer value.

This presentation argues that our ability to understand ore bodies and their formation is now at an inflection point, influenced not by any single "new" technology but by the growing ability to connect data and expert insight across technologies. Industry continues collecting large, multiscale datasets spanning geophysics, geochemistry, mineral chemistry, and hyperspectral sensing, and the volume and breadth of data (and new technologies) continues to grow. The ongoing complaint that we are "drowning in data" remains valid. However, we now "starting to swim". Agentic AI, and advanced data science methods, all enabled with high performance computing, are enabling geologists to integrate, interrogate and model data (and uncertainty) through space and time, in ways not previously practical.

Published case studies insights drawn from numerous deposit types (e.g. sediment-hosted copper, Carlin-type gold, epithermal, and porphyry deposits) change both deposit-scale geological interpretation as well as downstream value chain decisions, with implications for exploration models and decision making through to mineral processing and closure. Integration of data, with geological and engineering expertise firmly "in the loop", will lead to fundamental new ore body knowledge insights and deposit models, which will change the way that we not only explore and mine, but also interact with government regulators and communities.