Unlocking Big Opportunities in Small Packages: Application of Novel SEM Imaging Techniques and Nano-Scale HRTEM Studies to Enhance Mineral Exploration and Mining Efficiency

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Abstract

Mineral exploration is an exceedingly expensive endeavor for mining companies. Any tool that increases exploration or extraction efficiencies has the potential to create economic returns of millions of dollars. The *in situ* characterization of minerals associated with ore zones and geochemical anomalies is one such tool. The knowledge of how gold occurs within sulphide minerals (e.g., in the lattice or as nano-particles) is of great importance to mineral exploration and mining companies in order to define effective exploration and extraction methods. Bulk rock and microprobe analyses alone lack the spatial resolution and sensitivity necessary to accomplish the required level of characterization. We present a suite of advanced SEM/TEM techniques and FIB technologies that can be applied in sequence and in a short time. Two samples from the Timmins-Porcupine gold camp (Canada) and the Witwatersrand gold/uranium deposit (South Africa) were subjected to high-resolution large area SEM-BSD imaging, microprobe analyses, FIB milling, and subsequent HRTEM investigations. Samples from the Timmins camp contain free gold and gold inclusions in pyrite. The gold in the Witwatersrand samples is associated with pyrite, uraninite, and solidified bitumen in certain conglomerate horizons. The samples were imaged with the large area SEM imaging tool AtlasAT, which provides a comprehensive and fast means to observe images on a SEM system at very high resolutions and to acquire multi-image mosaics of entire petrographic thin sections. The image mosaics were combined with microprobe elemental maps and areas for FIB foil extraction were identified. The HRTEM analyses on the Witwatersrand sample revealed that uraninite and gold crystallization occurred during liquid oil and water intermixing. The sequence of techniques used in this study enabled quick and systematic characterization of gold mineralization from a micro to the nanometer scale in a reasonable time that is of great interest for mineral exploration companies.