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Multi-scale SR-µXRF Imaging and Characterization of Gold Mineralization at the Monument Bay Deposit, Stull Lake Greenstone Belt, Manitoba, Canada

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Introduction: The Monument Bay Project is located within the Oxford-Stull Domain of the Northwestern Superior Province, in northeastern Manitoba and along the border of Ontario. The Oxford-Stull Domain hosts abundant lode gold along with major and minor structures in faults and shear zones of large greenstone belts. The Monument Bay Project is composed of six targets: Twin Lakes, Twin Lakes West, Mid-East, AZ and Fence. Initial research in this area with Yamana Gold Inc. determined the relationship between lithology, alteration, geochemistry and gold mineralization [1]. Research is ongoing to understand the geometallurgy and gold mineralization at the Monument Bay Deposit. This research combines traditional petrography with synchrotron micro X-ray fluorescence (SR-µXRF) mapping and X-ray Absorption Near-edge Structure (XANES) Spectroscopy to enhance our understanding of the geochemistry. SR-µXRF mapping provides high-resolution micron-scale trace elemental variation maps on the flat surface of drill core samples. This information is used to define the mineralizing system by understanding the spatial relationships between key trace elements. XANES spectroscopy is then used to identify the speciation of Au and As, and constrain redox, speciation, and coordination of key elements.

This research is providing new information about the gold type, gold distribution, and multi-episodic fluid history of the Monument Bay Deposit. The results will lead to a better understanding of the mineralogical expression of gold mineralization in a portion of the Stull Lake Greenstone Belt and lay the foundation for building a reasonable gold mineralization model. Moreover, the model will help locate new high-grade gold deposits more effectively in this region. This knowledge can also be applied in the exploration and discovery of new greenstone-hosted gold deposits in northern Canada.

Experimental: 31 representative drill core samples with gold grades >1ppm were selected from across the project area. The samples were analyzed by SR-µXRF and XANES at 20ID and 8BM beamlines at the Argonne National Laboratory (APS) in Chicago, USA and at the VESPERS beamline at the Canadian Light Source (CLS) in Saskatoon, Canada.

Large-scale 8 cm x 10 cm SR-µXRF mapping was done by rastering across the sample with an 800µm spot size, incident energy of 15 to 27 keV, and dwell times of 200 msec to 5 sec, depending on the beamline setup. The full-spectra MCA SR-µXRF data were processed using Peakaboo 5.3.0 to create element maps [2]. From these maps, 1 cm x 1 cm regions of interest were identified for additional high-resolution SR-µXRF mapping with a 100 or 60 µm spot size and the high-intensity spots corresponding to Au and As were marked for XANES. As K-edge and Au L_3-edge XANES spectra were collected in fluorescence mode using an energy range of -200 to +300 eV (relative to the edges) with a dwell time of 1-3 sec per point and a step size of 0.5 eV near the edge. XANES data were processed using Athena [3]. Thin sections were then made from the same samples studied by SR-µXRF. The petrographic analysis was conducted using a Nikon LV100POL optical microscope under plane-polarized light, cross-polarized light, and reflected light at High-Resolution Earth and Planetary Materials Imaging Facility at Western University. Rock type, major minerals, alteration, and textures were used to help interpret the SR-µXRF element maps.

Results and Discussion: From the SR-µXRF element maps, free Au is associated with K, Ca, Fe, Mg, and Mn in most samples, which corresponds to sericite and carbonate alteration observed in the petrographic analysis. Some Au is associated with As, Cu, and Pb, as inclusions appearing within arsenopyrite, chalcopyrite, and galena grains, respectively (Fig.1A). Vein cross-cutting relationships and foliation structures observed in SR-µXRF element maps can be used to infer the spatial and timing relationship of fluid events associated with gold mineralization. As K-edge XANES spectroscopy identified only As^{-1} in the samples, which corresponds to arsenopyrite grains observed in the thin sections (Fig.1B) and the common association of As and Fe in the SR-µXRF maps (Fig.1A). Au L_3-edge XANES spectroscopy (Fig.1C) identified only metallic gold (Au^0) in the samples, meaning that gold at the Monument Bay deposit is not bound in sulfide lattice structures. Thus, the combination of traditional petrography, SR-µXRF, and XANES analyses provides insight into gold mineralization, geometallurgy, and deleterious element characterization. This information is being used by Yamana to understand the complex auriferous fluid history, geometallurgical characteristics, and environmental characterization of the Monument Bay deposit.

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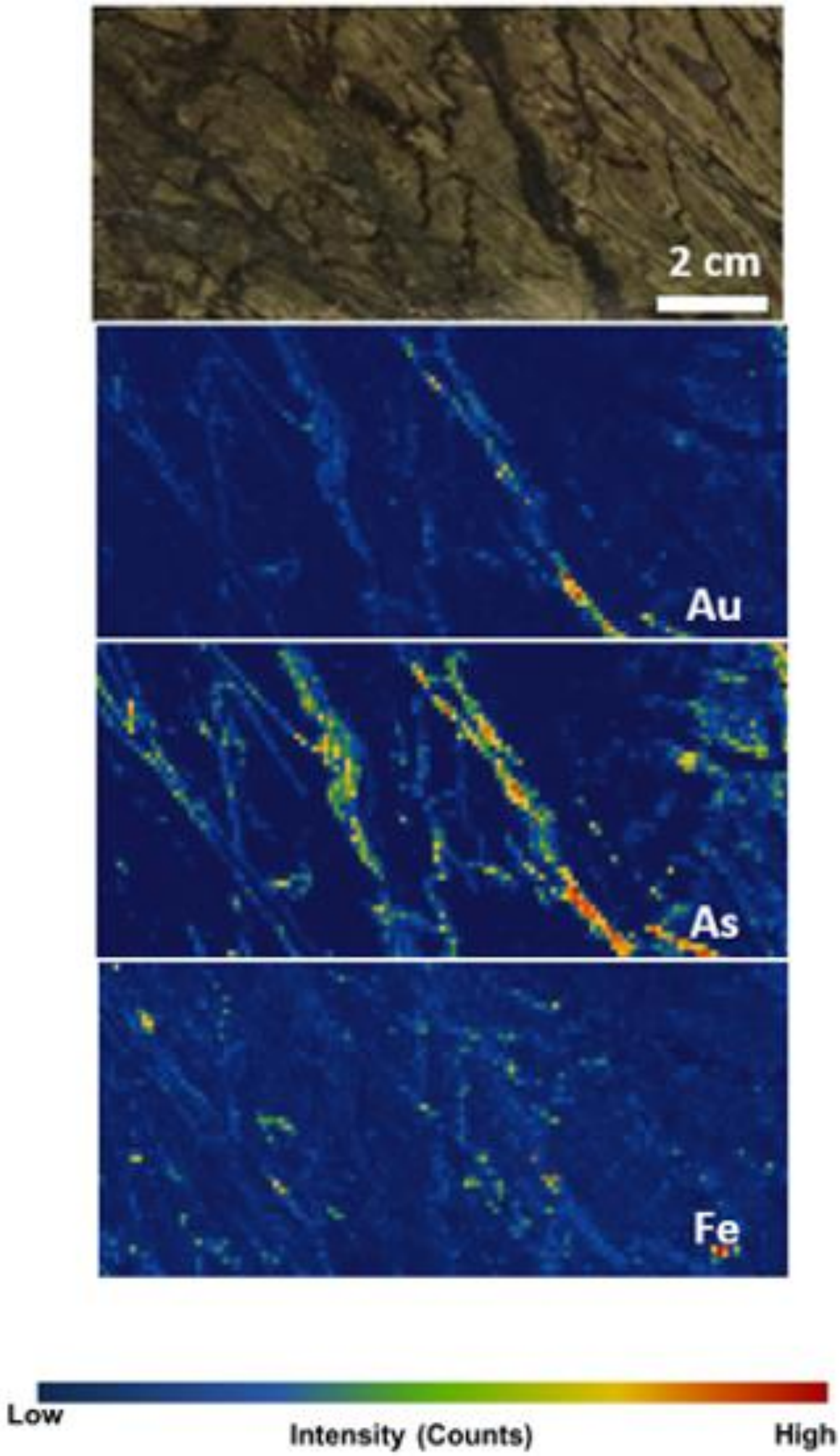

Figure 1. Photomicrograph of a typical half-core drill core sample and corresponding large-scale 2D SR-µXRF trace element maps of Au, As and Fe. The red squares correspond to regions mapped at a higher resolution.

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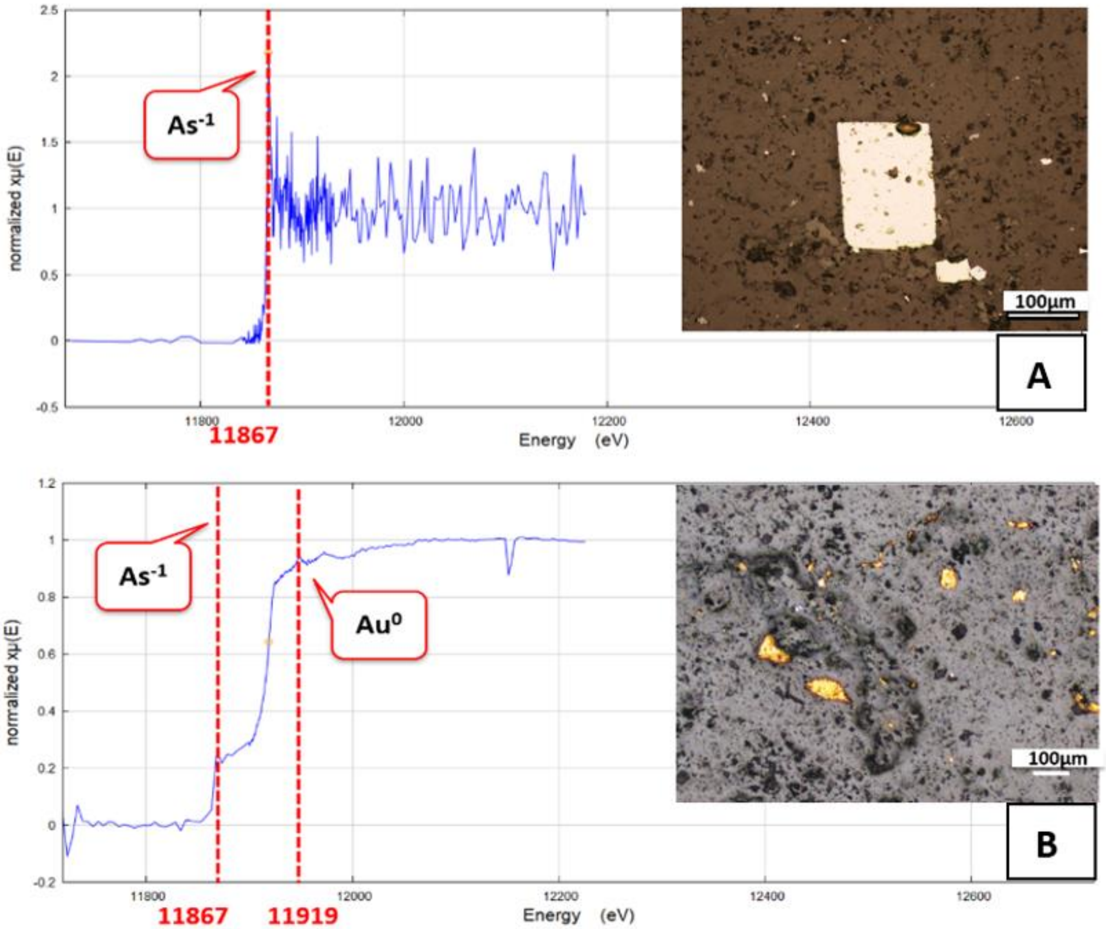

Figure 2. A. Typical As K-edge XANES spectrum collected directly on the drill core and an example of euhedral arsenopyrite found in the corresponding thin-section under cross-polarized light. B. Typical Au L3-edge XANES spectrum collected directly on the drill core and representative examples of gold grains observed under cross-polarized light.

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