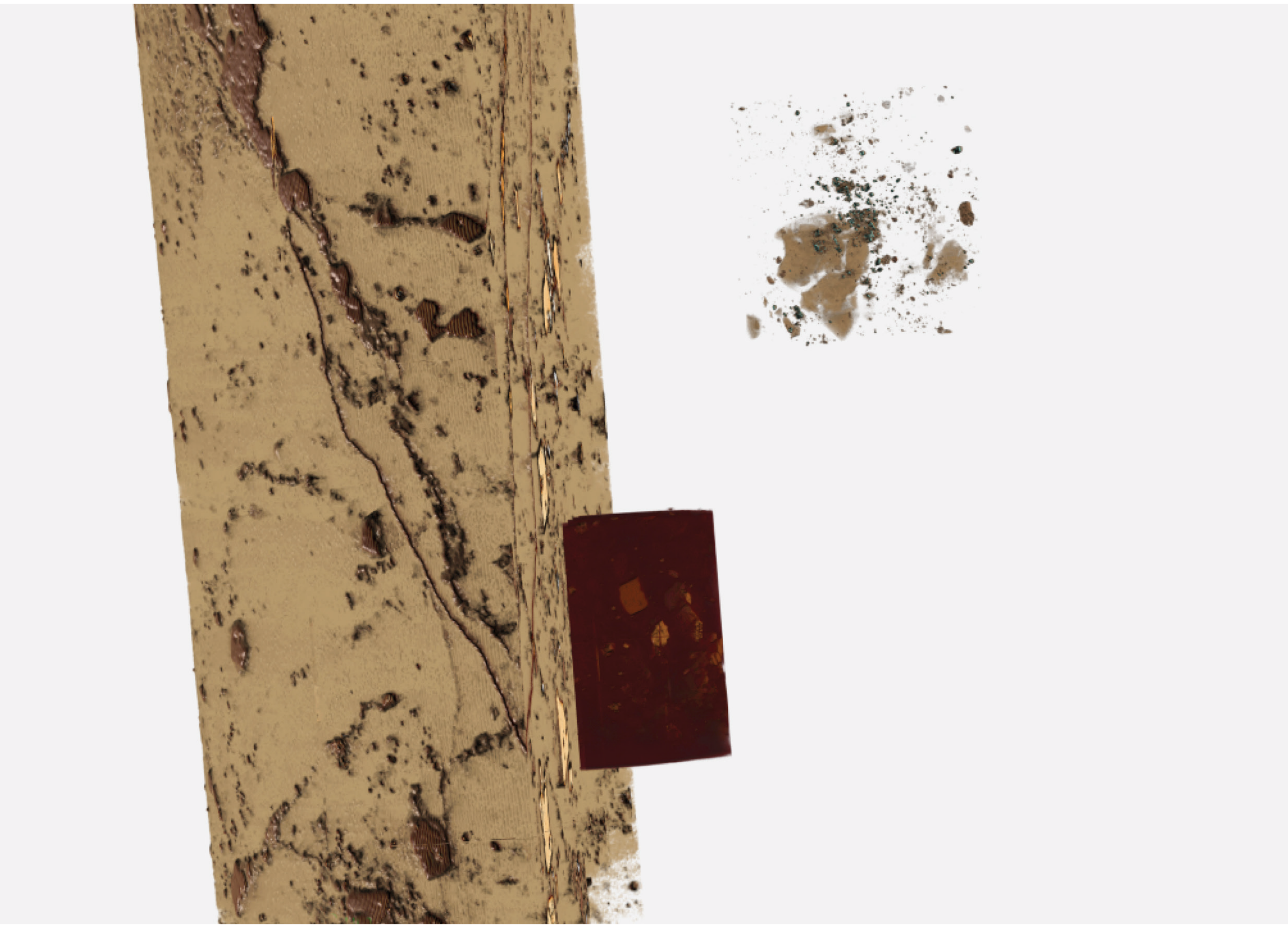
Application Note



3D Drill Core Scout and Zoom

for Gold Mineralization Characterization

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Textural characterization of gold mineralization is critical for optimizing gold recovery in downstream mineral processing. Traditional techniques study numerous 2D sections studied with light microscopy and automated quantitative mineralogy. While these methods have proven successful in characterizing gold mineralization, they have numerous limitations based on sampling bias, stereological artifacts and statistical representativity of the 2D cross section. Many of these limitations can be overcome by applying 3D analysis techniques such as those available using the ZEISS Xradia Versa X-ray microscope (XRM).

Introduction

In this paper, we use X-ray microscopy (XRM) to show how non-destructive, large representative volume, high resolution analysis of samples can be used to understand and characterize gold mineralization over representative volumes of drill core.

Advantages over 2D Analysis

Throughout the mining value chain, from exploration to process mineralogy, sample characterization usually centers on extracting quantitative information from samples, such as bulk mineralogy, ore texture, ore association and distribution, and particle grain size. Typically these parameters are identified using a variety of 2D analysis techniques, including light microscopy, electron microscopy, and automated mineralogy.

2D analysis, though critical in providing this valuable information, has limitations. These techniques require laborious 2D preparation of samples, which invites a stereological and sampling bias. This situation is compounded further with precious metal bearing samples, as the precious metals in question are in "trace" amounts (<50 µm) with a sparse and heterogeneous distribution. Often described as the "nugget" effect, it often requires prohibitively large 2D areas to be analyzed to provide a statistically valid characterization of the mineralization.

Here we present a solution where X-ray microscopy techniques are used to texturally characterize the distribution of gold mineralogy within drill core by employing a multiscale "Scout and Zoom" workflow. First, the ZEISS Xradia Versa macroscopically images the whole sample tolocate precious metals using its rapid Flat Panel Extension (FPX) detector. Versa then switches to imaging with its high Resolution at a Distance (RaaD) optical detectors to produce the high-resolution interior tomography images required to characterize the mineralization.

Figure 1 *"Scout" view of the entire drill core (segmented to show the different mineral groups of silicates and sulphides).*

Macroscopic analysis – "Scout"
A single piece of drill core was selected for XRM study with the aim of identifying regions where precious metal grains are located. This section of drill core was *c.* 6 cm in length. It was analyzed using a ZEISS Xradia Versa with FPX detector. The full core (Figure 1) was scanned in approximately 11 hours using the FPX detector with a voxel resolution of 10 µm.

The FPX detector is able to provide large field of view imaging with a high sample throughput, ideal for providing initial investigative "Scout" scans. These initial scans were used to provide a macroscopic description of mineral distribution. They also identified two regions of interest where highly attenuating phases are located, which are believed to be gold.

High Resolution Analysis – "Zoom"
Two regions were then selected for high-resolution imaging using interior tomography to find the volumetric and textural association of the gold. Typically µ-CT imaging relies solely on geometric magnification, requiring significant sample preparation to successfully achieve the necessary resolution of these fine-grained gold particles to ensure the targetregion can be as close as possible to the X-ray source.

Uniquely, the ZEISS Xradia Versa family of X-ray microscopes combine both geometric and optical magnification. Regions of interest can be noninvasively imaged at large source-sample working distances. This enables the Resolution at a Distance (RaaD) capability that allows for the imaging of regions within a large sample, without sample preparation (Figure 2).

The two regions of interest show how the gold in this part of the deposit is distributed as discrete clouds, containing multiple gold grains that are <25 µm, hosted within the quartz vein. The analysis also shows that the gold has a close spatial relationship with pyrite and the mineralized vein that cross-cuts the sample.

The Importance of Representative Sampling
It is clear from the low-resolution scans that the gold mineralization is heterogeneously distributed within the core, posing a significant challenge when sampling. By imaging and quantifying the entire core volume using the Scout and Zoom workflow, sample representativity is assured and resource characterization can be improved.

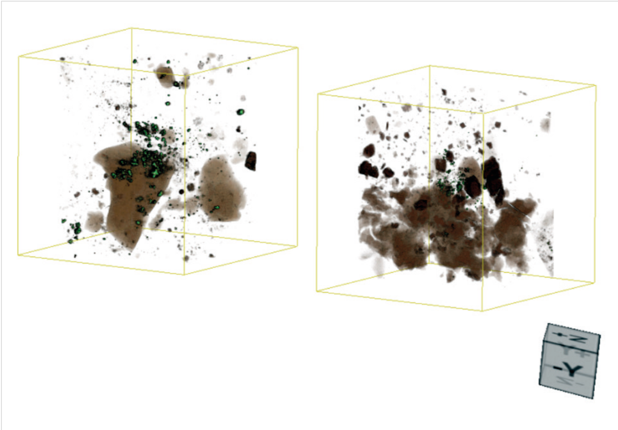

Figure 2 *The two gold-bearing areas of interest imaged with a 4 µm voxel resolution and the 4x objective. These two scans were conducted with a 4 µm voxel size. They took approximately 7 and 6 hours to scan, respectively.*

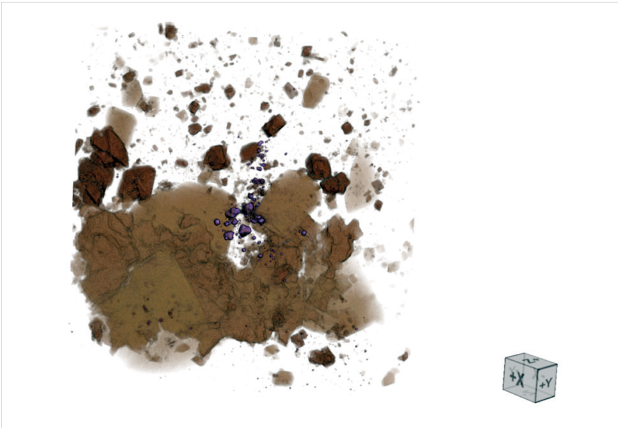

Figure 3 *Detailed view of one of the gold bearing regions. The gold mineralization can be clearly seen as the purple colored particles.*

Conclusion
ZEISS Xradia Versa equipped with FPX detector provides a high throughput solution capable of imaging large areas at high resolution. These "Scout" scans are used to identify regions and features of interest, which are used, in turn, to detect regions of interest for further analysis, producing higher resolution interior tomograms to complete the "Scout and Zoom" workflow.

This study outlines how ZEISS Xradia Versa was quickly capable of identifying and characterizing gold mineralization with minimal sample preparation and sample analysis. This data can then be used as part of a workflow to guide 2D sample preparation for further analysis using automated mineralogy, or for quantitative gold distribution analysis.

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