Thirteenth Quarter Technical Report For

A Real Time Coal Content Ore Grade (C^2OG) Sensor

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Abstract

This thirteenth quarterly technical report describes data collection at the Stillwater Mine and an additional improvement to the lighting system. The data collection system was returned to the Stillwater Mine during this reporting period and a large amount of data was collected. The data will be analyzed and correlated with fire assays in the next reporting period.

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1. Introduction.

The majority of work done this quarter has been devoted to collecting data from cores scanned in the Stillwater Mining Company core room. This work is somewhat tedious and tiresome, but essential to: (1) obtain enough data to reliably determine the correlation between assay results and spectral imaging results; (2) find bugs and glitches in the system that arise only periodically or after long periods of use; and (3) obtain data on the natural (and man-made) variations in the Stillwater ore that may confuse the machine vision algorithms.

The technical portion of the report below is organized into subsections as dictated by the DoE contract for this effort. These sections are: Experimental Apparatus, Experimental and Operating Data, Data Reduction, and Hypothesis and Conclusions. Partners for Year-3 of this effort are: Resonon, Inc., Montana Tech of the University of Montana, Stillwater Mining Co., and the Montana Board of Research and Commercialization. Additional contributions during years 1 and 2 have come from TIMET, Inc., Barrett's Minerals Inc., Western Energy Company A Westmoreland Mining Company, and MSU TechLink. The Naval Research Laboratory has also provided assistance via a Cooperative Research and Development Agreement (CRADA).

EXPERIMENTAL

2. Experimental Apparatus.

As noted in the previous report, lighting is critical to hyperspectral imaging. In principle, lighting variations can be removed by regular calibration, but this is time consuming and typically not completely effective. Ideally, the lighting source is constant and, for the core samples investigated in this effort, it should be extremely diffuse to minimize the effects of facets.

To address this problem, a simple diffusing system was constructed using PVC pipe and high-reflectivity paint. The details of this system will be described elsewhere, but as can be seen from the data below, this appears to have improved the classification accuracy of the system. A serious disadvantage of this diffuse lighting system is that it is difficult to get a sample positioned properly without moving the lighting source. Consequently, practical problems lead to lighting variations. This issue will likely be revisited during the next reporting period.

There were no other changes in the experimental apparatus from what was previously reported. The core scanning system was, however, used extensively and for long periods of time. Except for some occasional software bugs, the system worked extremely well.

3. Experimental and Operating Data.

Currently, Stillwater Mining collects core samples from within the mine at intervals that range from 38 feet to 50 feet. This core is taken to their core room where geologists examine the core. Sections of the core with a sufficient quantity of sulfides, as determined from visual estimates, are assayed for ore grade to help guide the mining. It should be noted that data collected by Stillwater Mining indicates spatial variations occur on scales much smaller than 38 feet, and consequently there is a need for higher resolution mapping of the ore, such as may be achieved with the down-hole probe Resonon is developing with SBIR Phase II funding from the Dept. of Energy.

The core to be assayed is divided into small sections, typically ranging between 1 foot and 3 feet. Because these sections represent the only "true" ore grade information available, Resonon personnel image these sections with the apparatus described in previous reports and then measure the percentage of sulfides on the surface to correlate with the assays. The imaging system collects data from only about 4 inches of core per scan, which consists of a data cube with 480 by 625 pixels, each with 213 spectral channels. Thus several scans are required per assay data point. To date, the best day of data collection resulted in 13 data points.

RESULTS AND DISCUSSION

4. Data Reduction.

Data collection with the core imaging system is tedious, and we are dependent upon when Stillwater obtains cores with suitable ore. Additionally, it takes a considerable amount of time to analyze the data. Consequently, results on the correlation between ore grade and spectral measurements are not yet complete.

The effect of the new lighting system, however, can be at least partially ascertained by examining Figure 1.

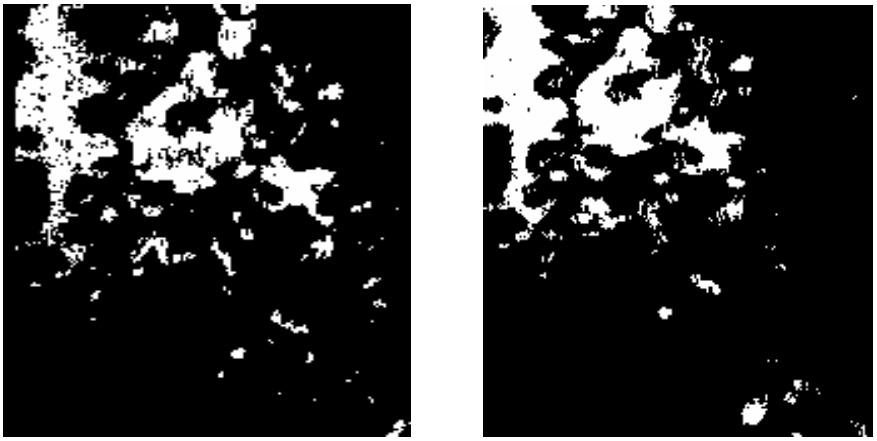

Figure 1. The two images show the classification maps for a section of sulfides in Stillwater ore. White indicates regions of sulfides. The left image was lit with the rod lens system described in the previous report and the right image used the new lighting system developed during this reporting period. Note the numerous omissions in the left figure as compared to the right figure.

It is somewhat difficult to appreciate the difference the new lighting system has made without having the core sample in hand. However, in Figure 1, there should be no black spaces within the large regions of white because these correspond to continuous sulfide blebs. Note that the right image clearly has many fewer omissions. Similarly, there are many more false positives in the left image that can not be seen without having the core sample in hand.

The new lighting system is now being used for data collection at the Stillwater Mine. Similarly, a diffuse lighting system will be developed for the down-hole probe that will be assembled for our SBIR Phase II project.

CONCLUSION

5. Hypothesis and Conclusions.

The imaging system has been returned to the Stillwater Mine and a large quantity of data has been taken. Preliminary results suggest that a diffuse lighting system provided improved results, but it is still difficult to use and to make repeatable.

During the next reporting period the data will be analyzed and correlated with Pt/Pd assay results. Natural variations, tool marks, rust stains, breaks in the core, and lighting variations degrade the accuracy of the approach. Most of these difficulties appear to be solvable. Overall, it appears that sufficiently large blebs of sulfides will be accurately identified with the current system.