Tenth Quarter Technical Report For

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

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Abstract

This tenth quarterly technical report discusses the progress made on a machine vision technique for ore grading based on hyperspectral imaging. A graduate student at Montana Tech has successfully defender her thesis related to this project. Arrangements with Stillwater Mining Company to deploy a machine vision system in their core room have been completed. Designs for they system that will be installed next quarter have been drawn and parts are being machined. Presentations on the spectral imaging system developed during this effort have been made to Stillwater Mining Company and at a remote sensing symposium at Montana State University.

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1. Introduction.

During this reporting period, which is in a no-cost extension period for Year-2 of this effort, preparations for Year-3 have been put in place. This includes finalizing arrangements with Stillwater Mining Company for installation of a system in their core room, we were notified that we received a substantial grant from the State of Montana to cover a large portion of the matching requirements for this effort, and drawings and plans have been made for the system that will be installed at the Stillwater Mine.

Other events related to this project include a presentation given at a remote sensing symposium at Montana State University, the development of new relationships with researchers interested in hyperspectral imaging for non-mining applications (including phytoremediation), and continuing work with agricultural users of hyperspectral imaging.

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 in this effort are: Montana Tech of the University of Montana, Stillwater Mining Co., and the Montana Board of Research and Commercialization. Additional contributions 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.

The system that will be installed at the Stillwater Platinum/Palladium Pt/Pd mine in south-central Montana will be designed to scan core samples. To fully image the cylindrical core samples, they must be rotated. (The imaging system cannot look under the samples.) Therefore, a core-roller has been designed and is currently under construction to role the cores. A model of the core roller is shown in Figure 1.

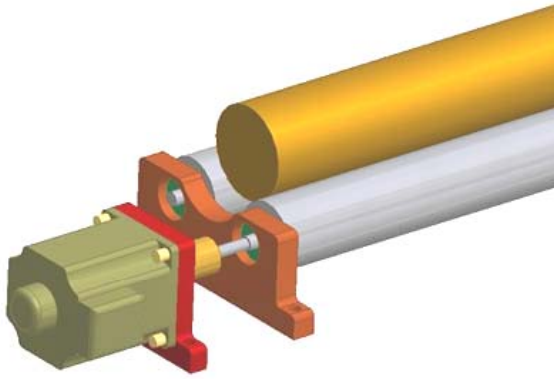

Figure 1. Model of the core roller that will be used to rotate core samples. A stepper motor operated from Resonon's data acquisition software, Hyperfire, will drive the core roller.

The hyperspectral imager and lighting will be mounted above the core-roller on a frame that will be enclosed to control the lighting on the sample. This system will be placed in the core room at the Stillwater mine, where samples can be easily transferred to and from the system with minimal impacts on normal activities at the mine.

3. Experimental and Operating Data.

The rational for installing the hyperspectral imaging system in the core room at the Stillwater mine is as follows. First, the correlation between the indicator sulfide minerals "seen" by the Resonon machine vision system and Pt/Pd ore is not fully understood. Currently, miners look for sulfides to identify ore from waste rock with a "by eye" technique, where geologists simply look at the exposed rock face and estimate the sulfide coverage to determine ore grade. Results from this effort with only 5 core samples did not show a strong correlation between sulfide coverage and ore content, as shown in Figure 2.

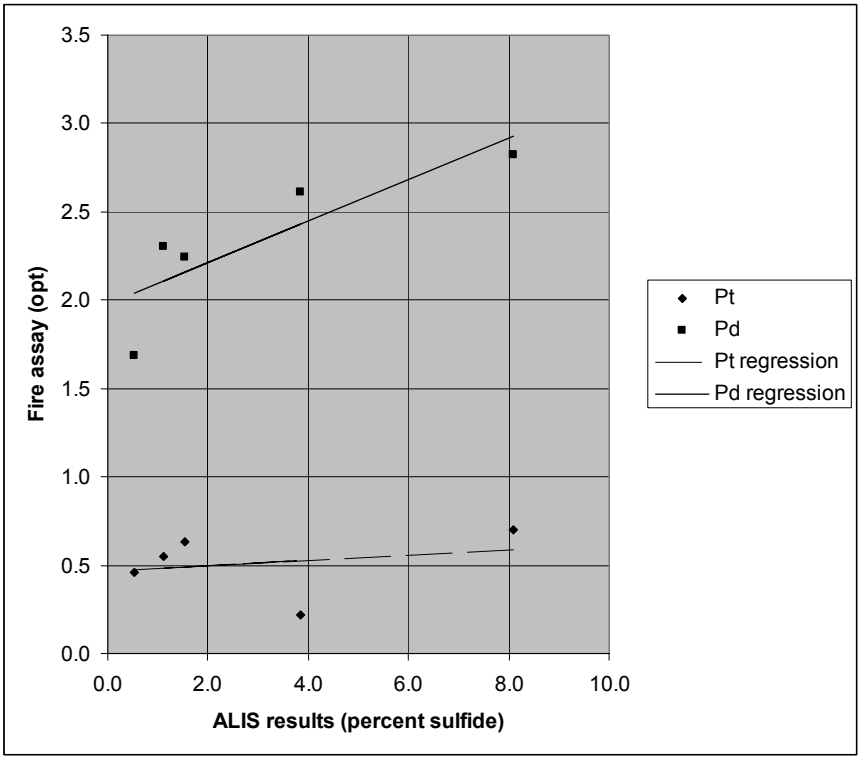

Figure 2. Results from initial sulfide measurements and their correlation with fire assays. The horizontal axis indicates the measured sulfide coverage in percent for 5 core samples, and the vertical axis indicates the fire assay results in ounces per ton (opt).

With only 5 data points, it is extremely difficult to determine the relationship between the indicator sulfide minerals and ore. Therefore, before implementing the hyperspectral machine vision approach in the mine where it can be of most benefit, it is important to gain a better understanding of this relationship. During the Year-3 implementation effort, a large quantity of data will be collected and analyzed to better understand this relationship.

Another reason for installing the system in the core room at the Stillwater mine is that is provides an excellent stepping stone towards real-world use. The location for the system is in a region where there will be some dust, and close to a door where it will be cold at times, but it is not in as harsh of an environment as will be encountered in the mine. Thus, this use of the system will provide a good test of the system's reliability without being in a situation where breakdowns are hugely disruptive or in a situation where breakdowns are inevitable.

RESULTS AND DISCUSSION

4. Data Reduction.

No significant data reduction was performed during the past quarter, as the bulk of efforts were devoted to preparations for Year-3 installation. Initial installation will begin in January and data will be collected almost immediately. The first step will be to

use the data to develop and improve algorithms, which will likely be included in the next report.

Work at Montana Tech has largely been devoted to helping students finish their theses. Kathy Miller, who worked on the data collection interface, successfully completed her thesis.

CONCLUSION

5. Hypothesis and Conclusions.

The proposed deployment effort will provide an excellent test-bed for real-world use of Resonon's hyperspectral machine vision system. Data collected during this effort will lead to a good understanding of the relationship between sulfide coverage and ore grade, which is essential for effective in-the-mine use of this technology. Resonon is pursuing the development of a down-hole probe for in-the-mine use of hyperspectral imaging via an independent SBIR award from DOE. A preliminary model of the down-hole probe, which includes electrodes so electrical techniques can also be used to monitor sulfides, is shown in Figure 3.

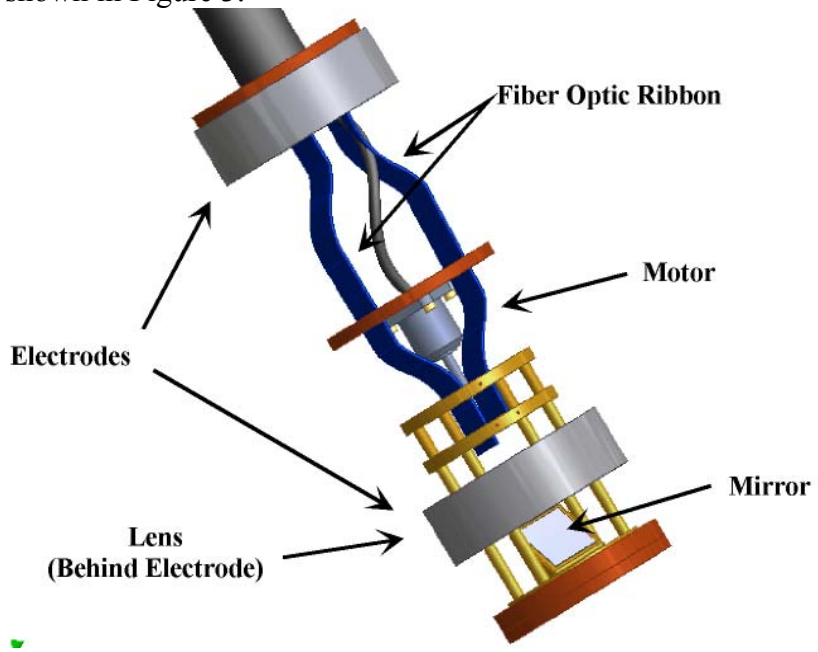

Figure 3. An early model of a down-hole probe being developed with SBIR funding from DOE that will bring hyperspectral imaging into the mine.

With the possibility of the down-hole probe, Stillwater Mining Company has shown increased interest in the hyperspectral approach. Additionally, the State of Montana has awarded Resonon an award to use as matching funds for this effort.

In conclusion, the project to develop near-field hyperspectral imaging for mining applications is on-track and on-schedule. Increasing interest is being shown for the technology, both within and outside mining, and independent efforts promise to utilize this technology for a variety of real-world applications.