Advantages of Material Sorting at the Extraction Face

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1. ABSTRACT

Declining global ore grades and sustainability are two fundamental challenges the mining industry will face for generations to come. Intelligent high resolution ore sorting, via a smart-shovel system that provides real-time ore characterization and grade data variability on every bucket, has been extensively field-tested and proven to maximize ore recovery and minimize dilution. The mine's extraction face, where the ore is most heterogeneous, is where this unique data has the greatest environmental and profit impact.

Every bucket full is a data collection event that unlocks smart, informed truck routing decisions, reduces ore loss and dilution, and provides the ability to optimize downstream processing. Additional benefits also support environmental, social, and governance (ESG) objectives by reducing the use of energy, water, and reagents per tonne of metal.

MineSense's ShovelSense® system measures a range of elements grades such us Cu, Fe, Ni, Zn, As and others and other mineral elements other mineral elements in real-time, using a system of proprietary hardware and software data analytics and algorithms. The system is installed in the bucket of existing production shovels or front loaders without the need for additional capital equipment spend or footprint. Real-time data collection capability allows smart routing decisions for each shovel bucket to be accurately classified as ore or waste before being hauled, increasing operational efficiency, improving the mine plan and profitability.

Automated, smart decision-making optimizes profits by reducing the loss and dilution of ore at the mine face. Additional benefits include optimized operational and sustainability performance in recovery, production, and waste, which are critical to mining operations and stakeholders. In addition, smart decision-making can also increase mine life through the improvement of ore recovery from the existing ore body and target new ore bodies with new geological trend knowledge.

ShovelSense® Global Navigation Satellite System (GNSS) defines the bucket grade and ore characterization for each bucket location. This combination provides a previously unavailable spatial resolution of the ore body. This data adds value in mine planning, by improving the predictive analytics for various downstream operations as shown in the Copper Mountain case study, through the identification of differences in Cu grade and mineralogy not reflected in the mine plan.

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2. INTRODUCTION

Real-time data collection at the mining face allows for instant material sorting which is transforming the way companies operate. Traditionally the method of representing the orebody and geological features is through the means of block model and blasthole data. The data is in the form of a homogenous block (for instance a 10m in length, 10m wide and 5m high), with only one classification or attributes to distinguish the amount of different classification within that block. However, this block is a lot more heterogeneous, consisting of granular sub blocks within the bigger block (Figure 1). Each sub block of ground has uniform characteristics. If you consider the smaller block as ore within a bigger waste block, you will have ore losses i.e., ore that is sent to the waste dumps. If you consider the smaller block as waste within a bigger ore block, you will have dilution i.e., waste that is sent to the stockpiles and the mill which result in a lower mill feed grade.

Mining dilution and ore losses have a massive influence on the economics of mining projects. While mines can identify and quantify capital costs associated with mine site infrastructure and processing, assumptions are often made about dilution and ore losses. The two main reasons for dilution and ore loss are geological variability and the lack of information. The geological variability is apparent in spatial grade distributions, geometry of the ore body and structural controls.

Mining dilution negatively impacts the operating cost, by increasing the tonnes mined and milled at a lower feed grade. It also impacts the efficiency and recovery of most mills. In contrast to mining dilution, ore loss is valuable material left in-situ and have a negative impact on potential revenue.

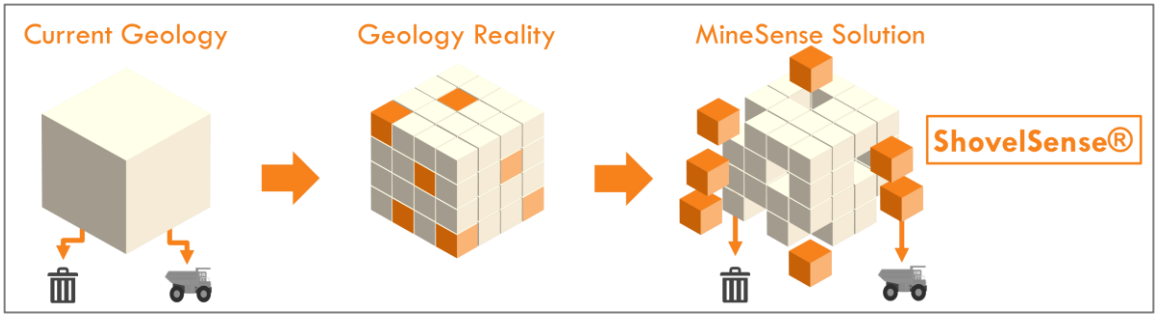

Figure 1 – Geological reality is represented with smaller granular sub blocks.

MineSense Technologies has developed a system that determines the grade of material and precise location at the mine face, which increases a mine's profitability, sustainability, and operational efficiency. This system is called ShovelSense® which is a combination of proprietary hardware, innovative software, and a digital communication network, that is connected to a customer data portal housed securely in the cloud. The system is installed on mine-face shovels and functions as a key component of a mine's operational infrastructure by providing otherwise unavailable information about the mine's ore body in real-time. Mines using this technology improve their profitability by reducing waste dilution in the ore feeding the concentrator; recovering more ore than was originally defined as waste in the mine plan; and increasing life of mine by allowing the mine to identify more of the ore in the ore body.

ShovelSense® scans the mined material using X-ray Fluorescence (XRF) technology while the bucket is being filled at the mine face after blasting. The system then analyses the composition of the material to create a dataset that determines the grade, location, and characteristics of the material in the bucket in real time. The system then automatically sends this information to the Fleet Management System (FMS), enabling real time ore and waste routing decisions. Through the Global Navigation Satellite System (GNSS) the precise location is associated to the categorised material which can be used to update the mine plan and geology.

3. METHODOLOGY: USE OF THE TECHNOLOGY

MineSense has proven the effectiveness of its ShovelSense® system at various operations globally including Copper Mountain mine located near the town of Princeton, in southern British Columbia, Canada. The Copper Mountain mine currently produce approximately 90 million pounds of copper per annum at an average copper grade of 0.24%. Copper Mountain Mine is 75% owned by the Copper Mountain Mining Corp and 25% owned by Mitsubishi Materials Corp. The Copper Mountain mine deposit can be described as structurally complex in a porphyry copper-gold system. The mineralization is in the form of veins, fracture fillings and disseminations and consists of chalcopyrite, bornite, and chalcocite in sulphide ores. This geological complexity is a perfect fit to evaluate the advantages of material sorting at the mine face using ShovelSense®.

The ShovelSense® system can be fitted to shovels, excavators, front-end-loaders and LHD's. Up to four ShovelSense® sensors can be installed in the brow of the bucket. The installation of the ShovelSense® system on one or more shovels on an operation initiates the real-time data collection at the mining face (Figure 2). These sensors then begin analyzing the run of mine material as the bucket is filled at the mine face after blasting. Each sensor collects X-ray fluorescence spectrum every millisecond while the material is rolling into the bucket, obtaining an average of 140 to 210 spectrums per bucket. The responses of these sensors are transmitted to a processing computer in the shovel housing, where they are transformed into elemental grade predictions. Additionally, the system can also identify deleterious elements such as Arsenic, Bismuth and Mercury. The system analyses the deviation between the mine plan or blasthole grades and the ShovelSense® grade estimate. If the algorithm proves a discrepancy in the classified material an instruction can be transmitted to the fleet management system (FMS) that triggers a destination change for the haul trucks.

Figure 2 - Overview of the ShovelSense® system installed on a Bucyrus 495 cable shovel

The long-term benefit of the system becomes apparent when enough data has been collected identifying data trends and patterns that can be related to ore property classification of the material and help to improve the mill performance. As data continues to be collected over months and is then paired with the precise bucket position (using ShovelSense® Global Navigation Satellite System data), the mine operators can then begin to optimize the short- and long-term planning of the mine, by visualizing this data in 3D and feeding it back into the mine plan (Figure 3). The geological trend knowledge can also be verified and adjusted for better interpretations.

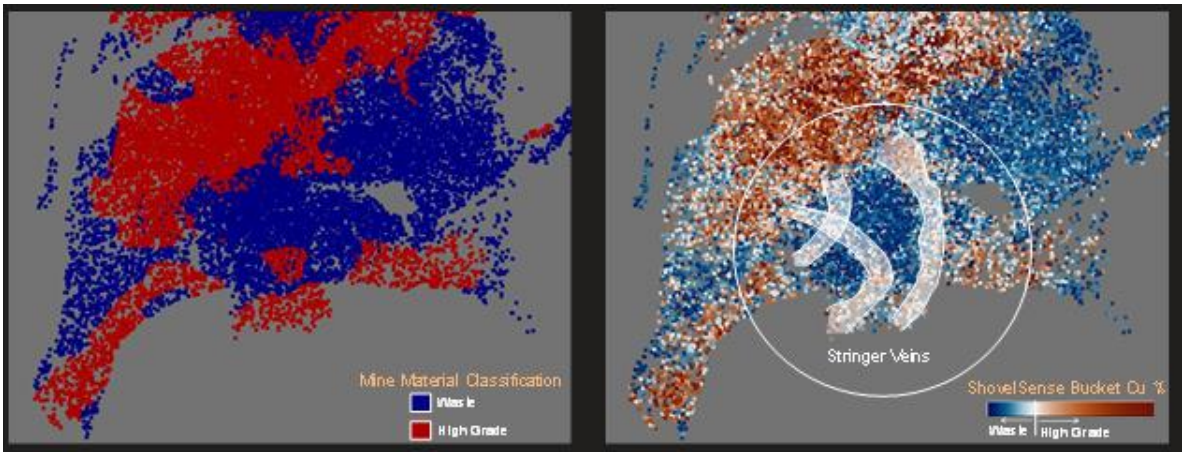

Figure 3 - The ShovelSense® bucket predicted grade view that highlights the occurrence of stringer veins not observed in the Mine Plan classification.

4. RESULTS AND DISCUSSION

4.1 Case Study

Since installing the MineSense custom ShovelSense® solution in April 2020 on shovels and loaders at Copper Mountain mine until March 2022, the ShovelSense® technology has helped recover 4488 truckloads of economic copper ore from waste (at average of 0.27% Cu) and 1173 truckloads of non-economic waste rock saving millions and reducing energy intensity per tonne of copper produced. In addition, the high-resolution grade and location data collected by ShovelSense® has identified previously unmapped rich stringer veins (Figure 3).

The truck designation and classification for a specific shovel at Copper Mountain mine for the month of March 2022 were analysed in Figure 4 below. The figure shows 146 truckloads or 4.3% of the total truckloads were sent to the mill as economic valuable material, where under normal circumstances would've been sent to the waste dump. In total, the mine diverted 164 trucks allocated to that specific shovel for the month. It is evident that the ore loss is significant in comparison to the amount of dilution.

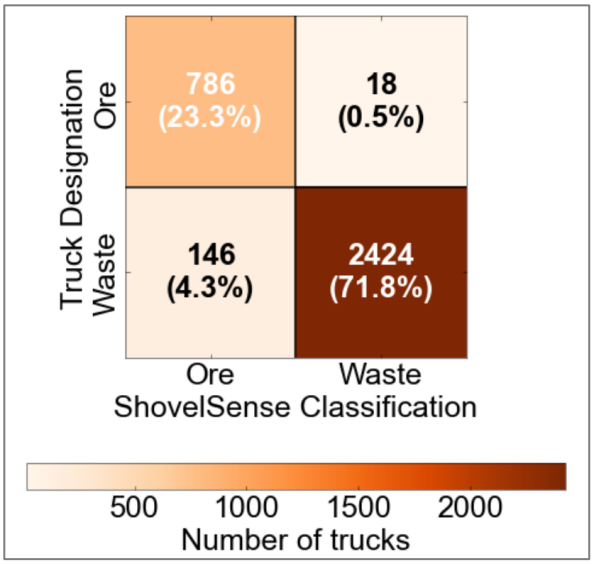

Figure 4 Truck destination classification for a specific shovel for the month of March 2022 at Copper Mountain Mine.

Figure 5 below shows the mine plan grades and the grade estimates of ShovelSense® for a specific shovel during the day shift and night shift of 25 March 2022, at Copper Mountain. The truck material is classified on the figure as aligned or diverted (★) with cut-off value of 0.15% CuTotal (CuT) to distinguish between the two classifications. We observe that a total of 38 trucks were diverted of which 35 trucks were classified as ore from waste, each truck with a 220-ton payload. The ore was diverted from waste with an average grade of 0.18% CuT which corresponds to 13.9 tons of Cu. These trucks were not considered to be processed and by rerouting this material at a copper price of US$10,000 per ton of Cu, Copper Mountain realized a total of US$140,000 of additional revenue not planned for the mine site on that day.

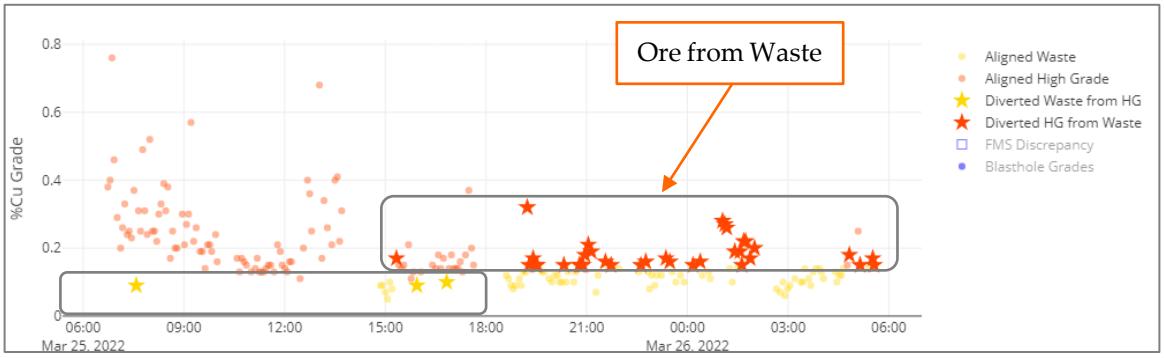

Figure 5 Grade truck diversion client portal view at Copper Mountain mine in a day.

Figure 6 below show the correlation between the blasthole grades in comparison to the ShovelSense® grades for a specific shovel during the day shift and night shift of 25 March 2022, at Copper Mountain. The figure can be compared to Figure 4 above which show the truck diversions on the same data. It is clear from the chart that when material is homogenous there are not a lot of diversions. In other words, where big volumes of material of the same classification are present and not have a lot of sharp transition zones where material are quickly changed from one classification to another. In contrast, when material is heterogenous i.e., where a lot of ore-waste boundaries are present we generally see a lot of diversions. Thus, the shovel started in a homogeneous area and were later operating in a heterogeneous area from around 15:00 for the rest of the day's activities.

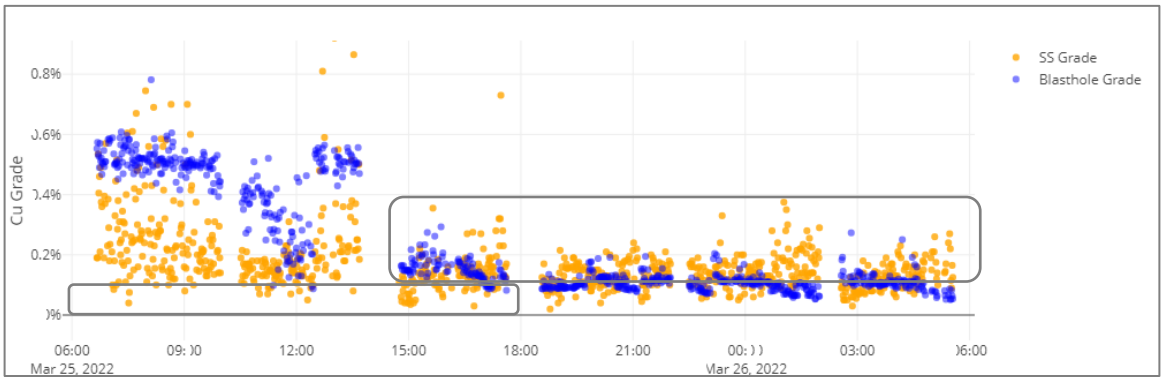

Figure 6 Blasthole grade vs ShovelSense grade in the client portal view at Copper Mountain mine in a day.

Since the first installation at Copper Mountain in 2020, ShovelSense® has proven its effectiveness and has now been installed on all 5 of the loading units. BeltSense®, MineSense's conveyor belt solution, has also been installed and is currently being trialled. BeltSense® can be used for diversion on the conveyor or for grade reconciliation purposes.

4.2 Advantages of material sorting at the extraction face

It is evident that MineSense's ShovelSense® technology provides enormous value to mine operators by identifying ore and waste and classifying ore at the earliest stage possible and in its rawest state in the full mining value chain, the extraction face. The following list offers the advantages of sorting material at the extraction face using ShovelSense®:

- **Real-time data collection** – Millisecond mining is introduced with ShovelSense® when data is collected in real-time at the extraction face. The traditional time delay of gathering the orebody knowledge and operational data is eliminated and allow instant decision making and haul truck diversions.
- **Accurate dig line** – The blast heave can have a significant impact on the ore loss and dilution. The granularity of a bucket with ShovelSense® technology, in comparison to the smallest mineable unit, allows for the dig line to be accurately delineated between ore and waste.
- **Improved efficiency** – Integrating real-time grade data into the existing fleet management system that automatically diverts high-grade and waste trucks when ShovelSense® grades deviate from the mine plan.
- **Increase in feed head grade** – By recovering ore from waste (ore loss) and removing waste from ore (dilution) using ShovelSense®, the mill feed grade is increased.
- **Ore feature visualization and value creation** – Each measure of a shovel bucket scoop using ShovelSense® technology is paired with the precise bucket location enabling reconciliation of grade information and updating the mine plan with actuals and new improved information.
- **Improved orebody knowledge** - The geological trend knowledge can be verified and adjusted for better interpretations using ShovelSense®.
- **Increased profits** – Improved return on investment is enabled with ShovelSense® when more ore is extracted, and a higher revenue is generated. Costs are also reduced by removing dilution, in other words waste from ore.
- **Sustainability performance improvement** – With ShovelSense®-supported ore sorting, the site uses fewer water and energy resources to extract and process each unit of copper.

5. CONCLUSION

Considering the full mine to mill process, the first opportunity to decide on what to do with the orebody after blasting is when the shovel start loading the material. If you decide to haul the material first and the material gets crushed, you will end up with homogenizing the run of mine material. Thus, the opportunity to maximize ore sorting will be where the material is in its rawest state. By sorting the material in its most heterogeneous phase you will be able to reduce dilution in ore and recover ore losses that would've been sent to the waste dumps. In return you will increase your profits and improve sustainability. The copper mountain case study proves the instant collection of data within the shovel bucket at the mining face will certainly provide a considerable advantage to mine operators. Thus, the single biggest advantage of ShovelSense® has, is the recovering of ore that would've been categorised as waste which has a substantial effect on the revenue. Not only is the ore loss improved but new orebody knowledge is obtained, and dilution is reduced. Both ore loss and dilution improve processing efficiency, reduce water and energy consumption, and limit the amount of acid mine drainage.

6. REFERENCES

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