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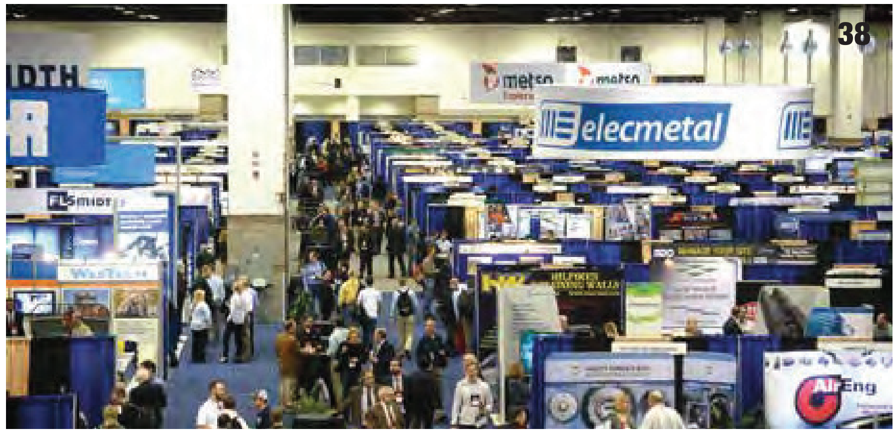
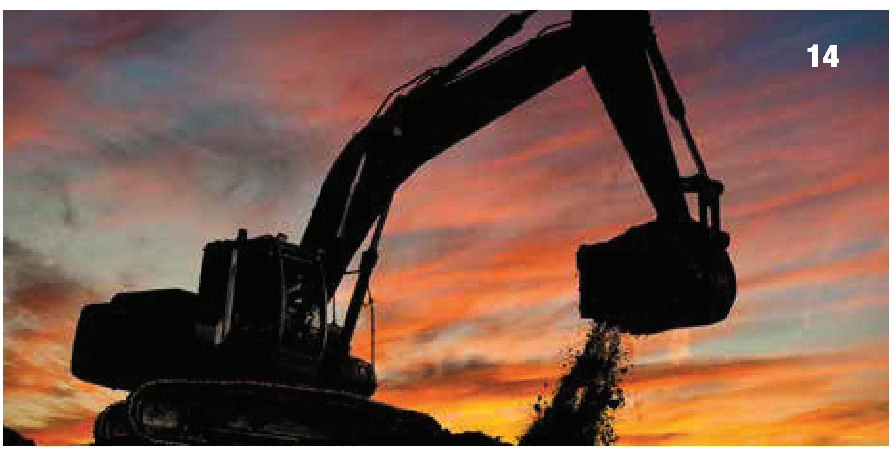


Feature Articles



Technical Papers (peer-reviewed and approved)

Special Editorial Section T&UC

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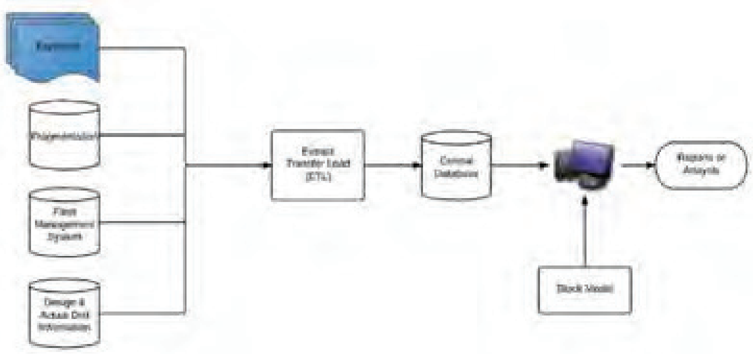
Drill & blast implementation case study at multiple Freeport-McMoRan sites

by S. Gering, C. Calderon-Arteaga, L. Gutierrez and T. White

Drill and blast represent the most important, and sometimes the costliest processes in the mine. The cost of drilling and blasting operations greatly contributes to the "high cost trends of the overall mining operations" (Afum and Temeng, 2015). The use of available information to improve the drill and blast processes can be the difference between a wasteful process and one that is optimized for costs, safety and desired fragmentation. Mining operations have access to several types of data sets that include a variety of different systems. This information can be used to improve, evaluate and apply processes for drilling and blasting. This may include different types of data from the different stages of the process (before, during and after the drilling and blasting operations), such as hole locations (planned and actual), penetration rates, drill operators, fragmentation (expected and resulting), explosive (design and usage), geology, vibration and others. This information can be used on its own or combined for further analysis to reduce costs, improve safety and evaluate results. Fortunately, due to advances in mining software, drill and blast engineers can exploit this data and create reports to evaluate results and improve the drill and blast process. However, as users start combining information from multiple datasets and establishing standard operating procedures for reporting across multiple sites, it becomes valuable to create auditable, automated and sustainable workflows for handling the information.

Figure 1

Data storage flow.



Seth Gering, Christian Calderon-Arteaga and Luis Gutierrez, members SME, are product manager, MineSight specialist and MineSight specialist with Hexagon Mining and **Tayor White,** member SME, is mine engineer with Freeport-McMoRan, email seth.gering@hexagonmining.com.

In some cases, the task of aggregating and standardizing the data formats has already been completed and is available to consumers via the Enterprise Data Warehouse (EDW). A data warehouse team extracts data from the source systems and transforms it so that it is meaningful for decision support (Wixom, Watson, 2007). The author's initial implementation plan for the drill and blast solution included using data stored at the sites on local servers. However, we learned early in the process that much of the work for aggregating and supplying the required data was already completed and was available in the EDW ready for use. This saved time, reduced risk and added value to the system.

The goal for this case study is two-fold: to show how information can be used to make decisions and improve processes, especially highlighting the value of using an EDW for managing drill blast information; and to discuss how technical challenges encountered during the implementations were resolved. This article targets users that want to better manage their drill and blast data or try to set up standardized workflows for using this information.

This case study will discuss the process of implementing a drill-and-blast workflow at multiple sites within Freeport-McMoRan (FMI) using both data at the sites and information available from the EDW.

Project overview

FMI manages multiple mining sites across the world that use a variety of different systems and sensors for supporting the drill and blast workflow. This case study will focus on three North American sites: Sierrita, Morenci and Safford. All three sites are openpit copper porphyry deposits.

The drill-and-blast implementations were completed between 2013 and 2015. Although the eventual solution for each site was different, standardized extract transform and load (ETL) workflows were designed and implemented that utilize the same tools. MineSight software was used for transferring data from the source database to a destination blasthole database and for analysis and visualization of this data.

FMI maintains a comprehensive EDW that provides consumers with the correct permissions and access to standardized data in

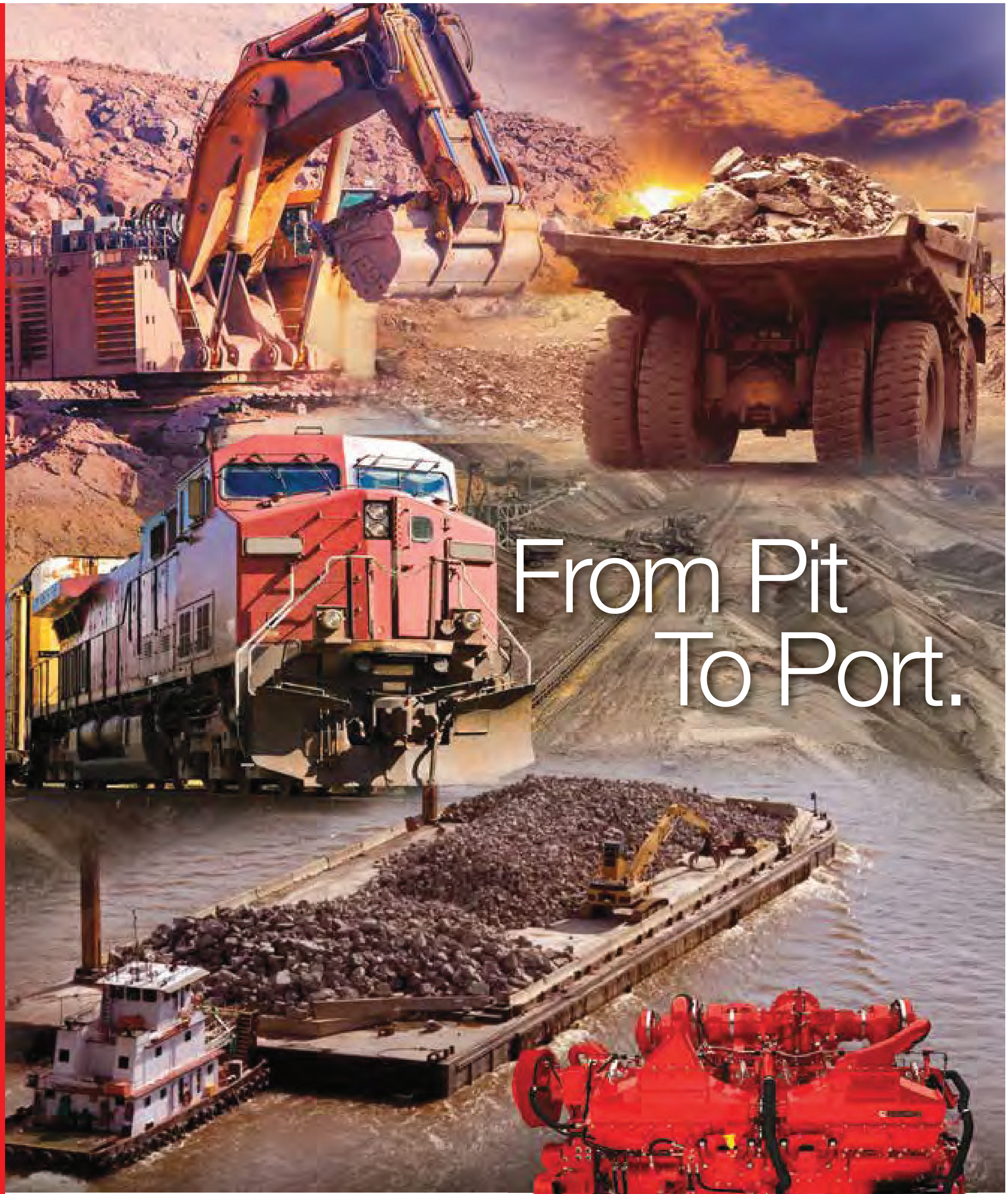


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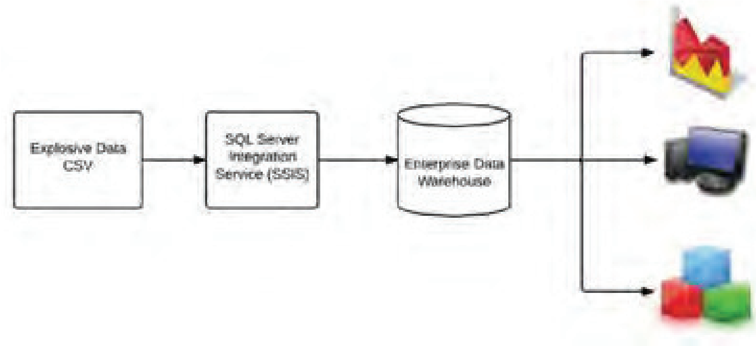
Figure 2

Schematic explosive data flow.



its central repository. For this implementation, fragmentation, explosive and drill systems data were used in conjunction with MineSight for aggregation, modeling and results evaluation. Figure 1 shows how the information from multiple sources systems is combined and stored in the EDW.

Data sources

Explosives data. The EDW is set up to store raw and aggregate data so that engineers can use this information for reporting or as part of the daily workflow. For example, information from the explosives contractor is converted from a csv file to a table in the relational database using an automated SQL Server Information Service (SSIS) routine. This provides the users with information on the explosive, shot, hole profile and water level. Once the information is stored in the database, it can be appended to the actual blasthole record and used for downstream calculations or planned vs. actual shot reconciliation. The schematic and sample attributes from the table are listed in Fig. 2.

Fragmentation data. The fragmentation system includes an image of the muck pile with every bucket load and a timestamp of when that image was taken. The system is set up to automatically capture and analyze the fragmentation image and then store that information into a database once it has been validated by an engineer. However, the actual fragmentation image is not georeferenced to a known spatial location. To obtain the location, processing steps in the EDW links the timestamp from the fragmentation system with the shovel position at the time that image was taken. When joined together, this provides data users with both the tabular and spatial information related to the blast fragmentation. A blasthole model can then be generated with this fragmentation data using MineSight, to conduct analysis based on rock type or other geological characteristics. Thus, joining these two datasets provides a wealth of information that can be used to obtain indicators, such as dig rates and operator efficiency, among others.

Aggregating data and centralizing information in the EDW has multiple benefits. These include:

- All data is in a single database. A single query engine can be used to report data.
  Maintains data history, even if the source transaction systems do not.
- Integrates data from multiple source systems, enabling a central view across the enterprise.
- Improves data quality, by providing consistent codes and descriptions, flagging or even fixing bad data (quality control).
- Organization's information is consistently presented and easily reported.

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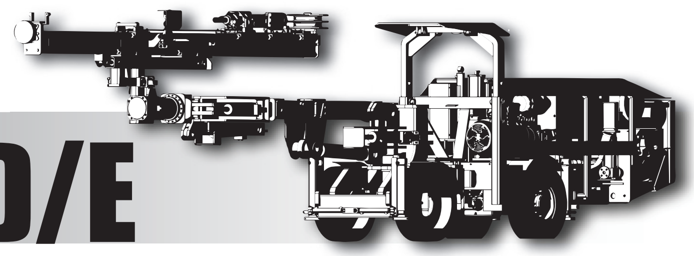

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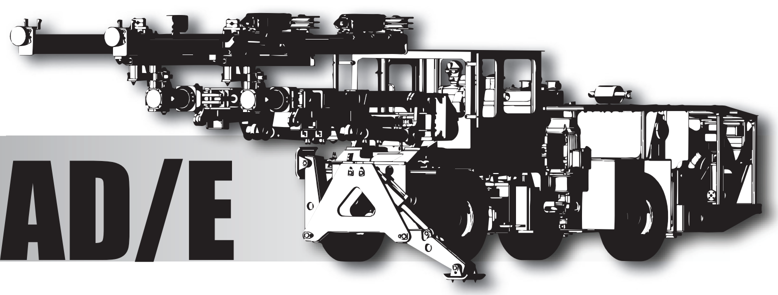

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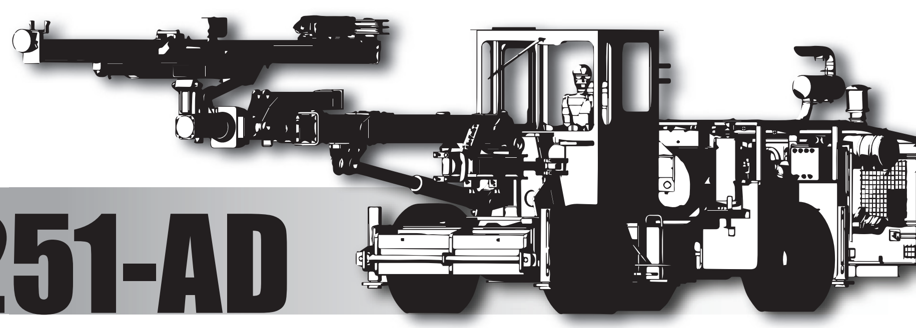

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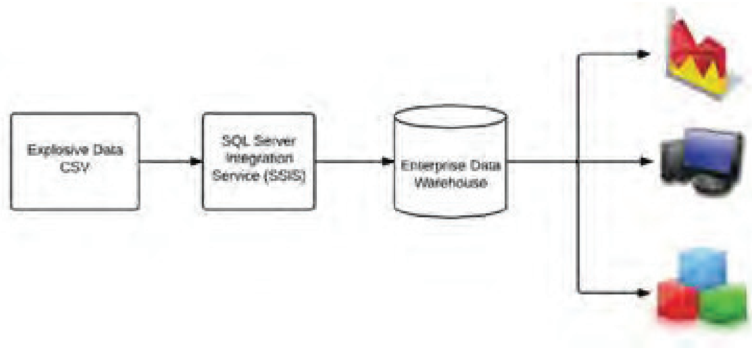
Figure 3

Fragmentation data inputs.



- Provides a single common data model for all data of interest, regardless of the data's source.
- Data structured in a way that makes sense to the business users.
- Database structured to deliver excellent query performance, without impacting the operational systems.
- Adds value to operational business applications, notably customer relationship management systems.

Information usage

The drill and blast workflow varies at each site, depending on the needs of the operation. However, in general, there are a series of steps that each group uses to design a pattern, collect and then analyze the results of a blast. These steps are listed below:

- Drill and blast engineer designs patterns based on rock type and hardness estimated from the bench above.
- Drill and blast engineer exports patterns to the drill fleet management system (DFMS).
- Drill operator uses onboard display to locate and drill planned holes in the field. The actual hole location, operator, and other data are stored back to the DFMS database.
- Drill and blast engineering team visualizes the holes in MineSight and assigns explosive type based on desired fragmentation.
- Explosive contractor loads the holes with explosive based on recommendations from the drill and blast engineering team. The amount of explosive, type of explosive, measured depth, and water level are stored in csv files and then automatically loaded to the EDW.
    - Shot is charged and blasted.
    - Shovel mines out the broken muck and records fragmentation image with each bucket load.
    - Drill and blast engineering team evaluates fragmentation performance and adjusts parameters for the next blast.

Fragmentation data are typically visualized and reported in MineSight using the p80 value from the fragmentation system. The data are first extracted from the EDW and stored in the MineSight blasthole database (MineSight Torque). Once the data is in the MSTorque database, it can be contoured, scaled and visualized along with the blast outlines and explosive data. This provides instantaneous feedback on where the blast has achieved its fragmentation goals and where challenges need to be addressed. Along with the visual inspection, users can further analyze the results by looking at the relationship between the fragmentation, the rock type or other parameters.

The relationship between actual fragmentation and the energy used for

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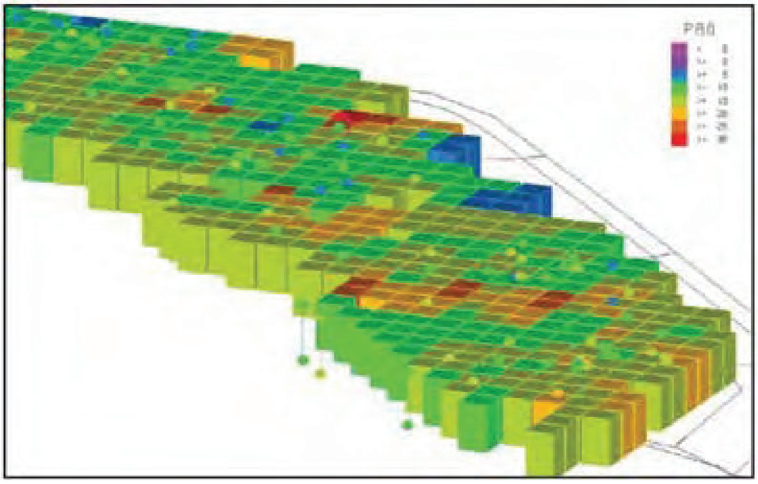
20 ft. Tooling	10 ft. Tooling	Long Stroke Option	Low Clearance Option
24 ft. 6 in. Head Travel	13 ft. 1 in. Head Travel	13 ft. 1 in. Head Travel	7 ft. 8 in. Head Travel

Figure 4

Visual fragmentation analysis.



the blast can be visualized and reported. These data are extracted from the EDW and transferred to a MineSight database for use with the drill and blast system. Although the energy between shots can remain constant, the resulting fragmentation can vary depending on joints, rock types or other factors.

Technical challenges

Although using the EDW provided many opportunities to standardize and streamline the workflow, challenges were encountered while using this data. These included timeout issues when running longer queries, data duplication when running ETL processes multiple times, and the desire to use direct SQL queries instead of csv files exported to the system.

Long transaction times. The initial query against the EDW pulled the fragmentation data directly and loaded that information into the MSTorque database for further reporting and analysis. However, long query times often resulted in timeout or very long transaction times. To work around this limitation, data were extracted from the database view on the server and stored in a local staging table daily using an automated SQL job set up by the system administrator. The transaction includes two steps. The first is to clear out the table, and the second is to populate it with the most recent values from the view. This allows users to work with the most recent information stored locally instead of having to pull across the network. The results were faster transaction times and no timeout issues.

Duplicated records. Another challenge that was encountered related to the blasthole database used for storing and ultimately modeling the fragmentation information. The fragmentation dataset included a window of the past 30 days, so if users run the ETL process multiple times during that period, they ended up with both the new records and duplicates of the existing records already stored in the database.

The first option for handling this was to limit the source data by the current date. However, weekend shifts, and the fact that sometimes days were skipped, prevented this from being a feasible option. The second option was to limit by unique ID. As part of the EDW aggregation, each fragmentation image was assigned with a unique image name that includes the shot, pushback, and other identifying information based on the original blast. To eliminate the possibility of duplicates, we modified the query so that only new records were present in the database. This was done using a subquery to import only new records.

Querying different systems. The final challenge was writing queries from SQL that pointed to a different system. For this option, the authors had to use the OPENROWSET option in SQL or use the csv export from the EDW data online. The data are readily available via csv. However, setting up a semi-automated workflow required pulling data from the EDW directly instead of pulling data from the web service and storing that information as a csv file.

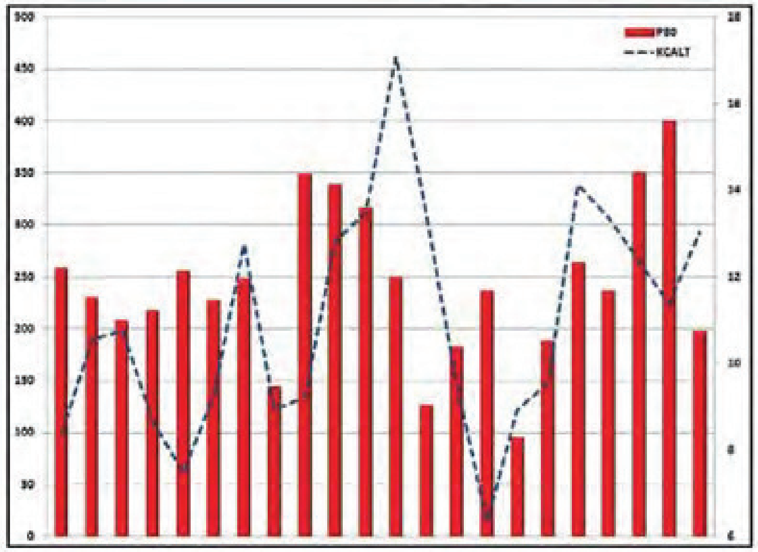
Conclusions

The EDW provided a method for standardizing information across multiple systems and at multiple sites. Once the ETL process worked for a site, replicating that data source at another sister site was straightforward. Using the EDW provides many benefits for the sites, including standardization, script maintenance and ownership and ease of learning.

There are additional opportunities in the future to add value to the system by migrating all the semi-automatic ETL processes and reports to fully automated routines. ■

Figure 5

Actual fragmentation and the energy.



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Drilling news

IBM to partner with Goldcorp

IBM ANNOUNCED entrance into the mining sector with Goldcorp Inc. to bring its IBM Watson technology to the Canadian mining industry for the first time.

Goldcorp is one of the largest gold mining companies in the world. It will initially use IBM's cognitive technology for its exploration targeting efforts in its Red Lake, Ontario mine.

A number of Watson services will be used to analyze vast amounts of data — from drilling reports to geological survey information — to help geologists determine specific areas to explore next, reach high-value exploration targets faster, calculate geological models with more certainty, and interpret the growing volume of data as geologists drive new discoveries. This will improve the ability of geologists to surface new information from existing data and deliver regionalized insights that will assist in the exploration process. ■