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## Peña Colorada iron ore project
## Coeur ready for gold, silver's return
## USGS' iron ore production report

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## SME News



## Departments




**Cover Story**
Technology is what drives modern mining operations. Without new, innovative technology, mines become uneconomic. The Peña Colorada iron ore mine in Mexico was facing declining ore grades. So management installed new technological upgrades at nearly every part of the mining operation to help improve grade and production, page 14. Iron ore is the source of primary iron for the world's iron and steel industries. The U.S. Geological Survey, beginning on page 20, documents the revision of world iron ore production totals to augment historical China iron ore production figures to show both crude and usable ore values. Cover photo of the Peña Colorada Mine is courtesy of Hexagon Mining.

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# Technological innovations that capture project value at Peña Colorada

by J.A. Villa, R.E. Vivas and P. Reyna

Located in the state of Colima, Peña Colorada is one of the largest iron ore operations in Mexico. The project is owned in equal parts by ArcelorMittal and Ternium. Though boasting a production capacity of 4.1 Mt/a (4.5 million stpy) of concentrate per year, Peña Colorada is faced with declining ore grades. In order to respond to this situation, Peña Colorada had to expand production even further. This expansion created various challenges that were overcome by the adoption and application of new technology. Examples of these technological innovations are discussed in detail in this article and include improvements in geo-modeling, mine planning, and mine operations. The successful implementation of these technologies paid for itself many times over, and has led to significant improvements in production and performance, while lowering the operating costs and reducing the variance between planning and execution.

## Project overview

Peña Colorada is a mining company that produces about 30 percent of the iron ore in Mexico. This project generates about 1,200 direct jobs and 3,000 indirect jobs, making a significant contribution to the local economy. Similarly, Peña Colorada invests in its local communities through numerous educational programs, scholarships, university agreements, social development, environmental agreements, etc. Peña Colorada's operations consist of an open pit mine located in Minatitlán and a pellet plant located in the port city of Manzanillo, as shown in Fig. 1:

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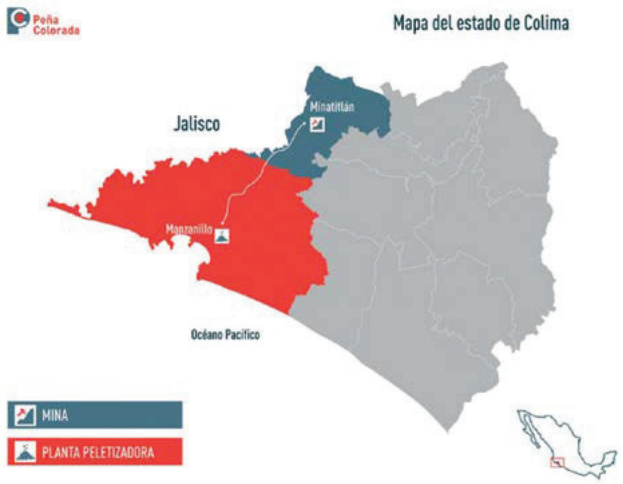
## Technological innovations

Most mining projects around the world typically follow the logic of "mining the next best ore." Consequently, head grades tend to decline over the life of the mine. In the case of Peña Colorada, a decline in head grade combined with a decline in iron ore prices forced the operation to adapt to a new business environment and adopt new technologies to face these challenges. However, the first step along this process was to increase the confidence and reliability of the resource model. This task involved additional drillhole campaigns coupled with more detailed modeling techniques. Once the block model was completed, new optimization studies and production schedules were evaluated with new optimization tools that improved many aspects of the mine plan. The Peña Colorada block model has undergone 3 expansions to reflect additional information not available in the past. The model has expanded to the East and Southwest. The latest model expansion increased the total number of benches to 98 as a result of positive exploration results. Similarly, new geotechnical studies were prepared, which provided new guidelines for pit slope design, and new technology was

## Figure 1

**Location map.**




implemented to monitor ground movement and slope stability. Two sectional block model views in Hexagon Mining's MineSight 3D, along with the pit designs and geologic solids are shown in Fig. 2.

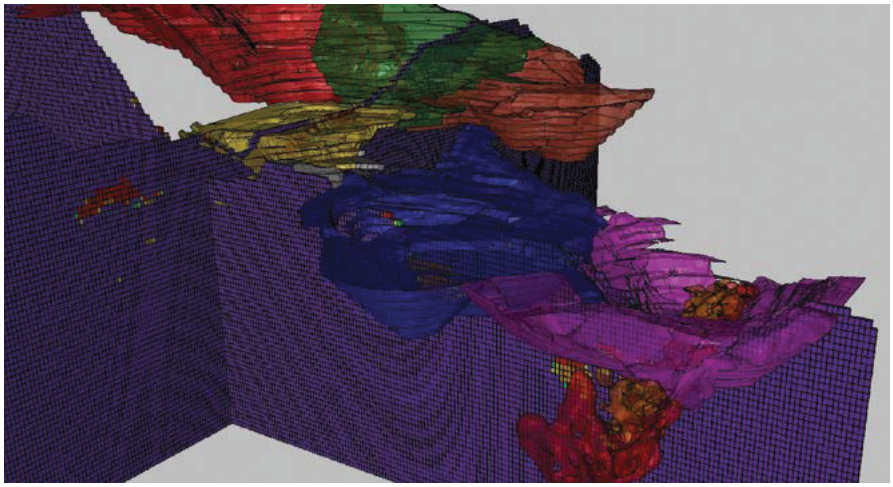
Similarly, Peña Colorada implemented a new fleet management system to monitor the operation and ensure plan execution and compliance, thus capturing in the field the value of the project as forecasted in the mine plan. However, there is always a variance between plan and reality. This has been significantly reduced with the adoption of best-in-class mine planning software and fleet management system. The implementation of these Hexagon Mining technologies narrowed the chasm between what is and what should be; and helped not only shape smart change but also unlock and realize project value.

**Mine planning software.** The Peña Colorada deposit comprises three main structures affected by a moderate fault system, from a mineral resource perspective. These three structures control the geology in terms of minable material characteristics. The mineral resource model was constructed in two stages: 1) construction of the geological model and 2) numerical modeling of attributes. The construction of the geological model involves the processing of the drilling campaign taking into account the minimum scale of geological interpretation and the construction of surrounding solids. The drilling campaign was processed through the use of MineSight Compass, MineSight Torque (tag mineable tool) and MineSight 3D (assay interval editing) tools. The geological envelopes were constructed as geometric solids using the MineSight Implicit Modeling tool to accurately characterize the geological contacts. The numerical modeling of attributes comprises the estimation of grades by localized ordinary kriging. Finally, the classification of mineral resources takes into account the geology of the deposit, different types of drilling campaigns and perforated regions. Because Peña Colorada is an operating project, the mineral resource model was constructed in a way that allows calculation of inventory for both geological and operational material.

One of the technological advances implemented was

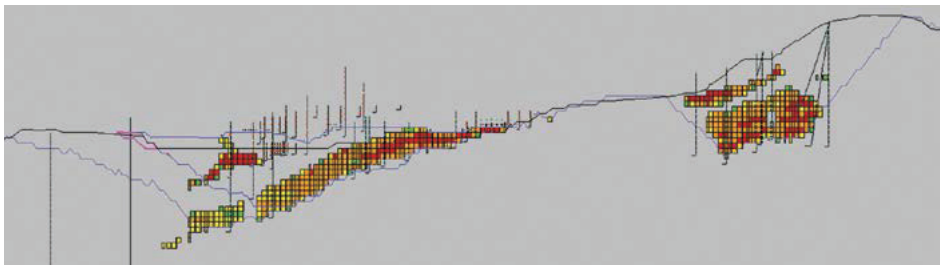
## Figure 2

**Model views in MineSight 3D.**



## Figure 3

**Pit optimization in section view.**



the adoption of MineSight Economic Planner (MSEP). This tool is used mainly to determine the economic pit limits based on the value of the block and the slope recommendations, as shown in Fig. 3.

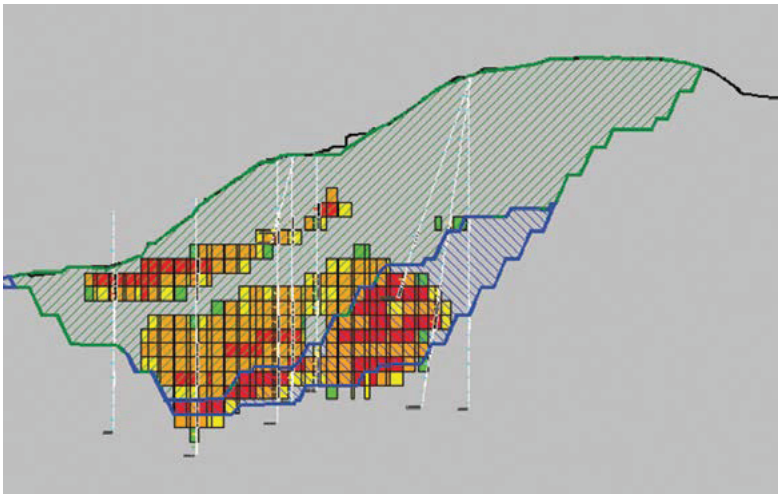
MSEP can model complex slopes by zone and complex slopes by zone and azimuth. This functionality was not available to Peña Colorada in the past, and it allowed the company to follow the slopes recommendations in its pit designs for a safer and more productive operation. Figure 4 shows the pit designs following the Lerchs-Grossmann (LG) pit shells.

One of the issues encountered regarding the pit optimization process, was the time required to run the economic evaluation. This has improved over time with smarter and more powerful engines. However, the Lerchs-Grossmann algorithm that was the standard for many decades has been challenged by the arrival of new algorithms. More specifically, there are pit optimization cases in which the Pseudoflow algorithm can produce the same results as the LG in a fraction of the time.

For more than 40 years, Peña Colorada has faced many challenges, some of which did not represent as much of a risk when the mine was operating at a higher cutoff. Once the mine started to transition into the low grade zones there was less room for error. In the past, Peña Colorada used in-house tools (Rescon & Resc) for generating annual mine plans. These in-house tools were complemented with Excel and AutoCad. However, these manual tools did not optimize the value of the project, so Peña Colorada turned to MineSight Schedule Optimizer (MSSO), which helped the mine optimize the cutoff grade and material routing strategy, meet quality/quantity targets, and integrate the extraction plan with the haul plan and the dump plan all in one tool. All of these aspects of the mine plan have a great impact on the value of the business. For example, after evaluating multiple alternatives with MineSight Schedule Optimizer, it was clear that a mine expansion was required in order to maximize the value of the project. Therefore, the mill throughput was almost doubled, while new equipment was acquired to realize the increased production from the pit. MSSO was used to evaluate this expansion project and the acquisition of bigger shovels (P&H 4100 XPC) and bigger trucks, (CAT 789C & 793F). Mine expansion projects costs are in the order of hundreds of millions of dollars to a few billion dollars. So, investing in an optimization tool like MineSight Schedule Optimizer is easy to justify since it can guide important capital investment

## Figure 4

**Pit designs following LG shells.**



decisions and it costs less than the tires of an off-highway haul truck. MSSO can replicate the schedule of any open pit truck and shovel operation and improve its value and attainability since it has both optimization and manual controls that produce a practical plan. In the past, there were long-term schedules that were optimal, that could not be implemented in operations and there were short-term schedules that were practical but not optimal. MSSO closed that gap and produced strategic and tactical schedules that are practical and optimal for an integrated mine planning vision across multiple planning horizons, providing a clear plan that can be realized in operations.

Similarly, MSSO was used to evaluate and optimize the dump discharge plan. The results of the optimization generated a plan with less stripping required in the earlier periods and a combination of short and long dumps which balanced the truck hours over the life of the schedule and actually reduced the number of trucks required. The estimated gains derived from this optimization study amounted to approximately $35 million in project value.

MineSight Schedule Optimizer has positively disrupted the mine planning landscape. The transformation at Peña Colorada has been significant in the mine planning department. MSSO allows the evaluation of multiple alternatives, blends and mine sequences much faster than before. The program is able to work with multiple material types, scheduling classes, reserve classification, rock types, etc., giving the engineer the opportunity to analyze details that were not reflected before in the plans. The reports are easily created and configured. The truck requirements are calculated based on cycle times obtained from the field and corroborated by the fleet management system. The program reports the haul distances required for fuel consumption and indicates when haul trucks have to be replaced in the schedule. The rich reporting via analytical and graphical results allows for effective communication and understanding between the mine planning and other departments.

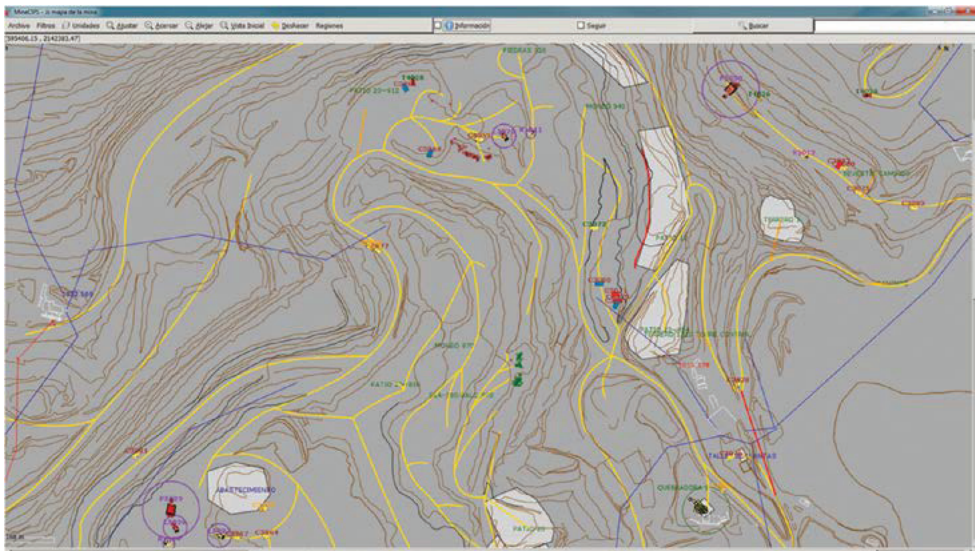
**Fleet management system.** Following the mine plan in operations was a big challenge at Peña Colorada prior to the implementation of the fleet management system (FMS). The ability to monitor in real time the location of the trucks, shovels, dozers, etc., was a significant technological innovation to make sure that the plan stayed on track. Now, the mine planning engineer and operator can communicate and adjust to make changes as needed, thus reducing deviations from the plan. With the adoption of a fleet management system, multiple reports can be created to report key performance indicators (KPIs) and measure performance. It is said that "the observer effect" is particularly true for mine operators. Once the monitoring systems were implemented, people's behaviors changed, because they knew they were being observed and monitored. Prior to the implementation of the FMS at Peña Colorada there was little accountability on the operator side. Multiple delays, extended breaks and missing equipment were not unusual. All of these factors add up and take its toll on productivity and profitability. Asset control and monitoring has made a drastic difference and missing equipment is a thing of the past. The FMS optimizes the haul cycle times and routes the trucks to the best destination based on material type, available routes, mine traffic conditions, etc.

Figure 5 shows in real time a screen capture from the fleet management system showing the trucks, excavators, dozers, haul routes, topography, structures, etc. In total there are five excavators and 26 haul trucks plus the dozers, drills and other equipment monitored at Peña Colorada.

As for the drills, the planners used to have to go to the field to physically inspect the progress

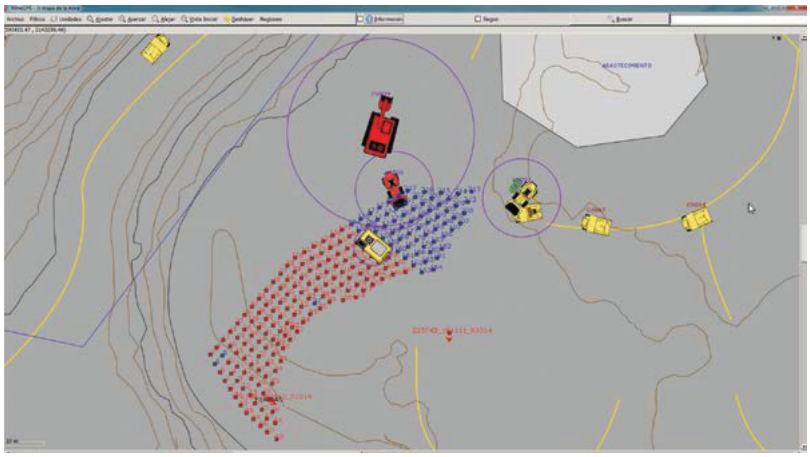
## Figure 5

**Real-time mine monitoring.**



## Figure 6

**Actual drill progress at KPIs.**



and note how many holes have been drilled, how many remain, etc. Now they can see the blast pattern in real time and see how many holes have been drilled, how many remain, they can look at the KPIs of the drill and get metrics on penetration rate, hole depth, hole profiles, etc. Additionally, the drills are equipped with high-precision GPS and this has been very valuable as they have noted an increase in productivity since it is no longer necessary to stake out the collars in the field. Peña Colorada is in a hurricane zone and thunderstorms pose a safety risk. An alert system changes from orange to red if a storm is approaching. In red alert, the topographers could not be in the field staking the collars to be drilled. The alerts could last six hours or more and in many cases the drills would fall behind and production would suffer. Now, the collar coordinates are passed from the planner to the operator digitally with high-precision GPS systems, eliminating the need for the topographers to be staking out the collar locations in the field. Figure 6 shows a capture screen showing the blast pattern in real time, and planners can check the progress of the drill. The FMS displays the holes already done in red, the remaining holes in blue and the KPIs for the drill. Operators and planners can communicate and any deviations can be adjusted as needed in real time.

The high-precision guidance system allows for accurate blasthole location, monitoring of production data and the hardware can be easily installed in the operator's cabin.

Lastly, it should be noted that production reports used to take many hours to complete and required staff dedicated for that purpose. Additionally, the information was communicated verbally and recorded by hand, which resulted in many inaccuracies and errors, compromising the validity of the reports. After the implementation of the FMS, production reports are produced with one click and the information is reliable and in real time (Fig 8).

The production reports generated by the FMS allow the monitoring of the operation and provide metrics to measure performance. Similarly, production reports are reconciled against the planning forecasts to ensure plan compliance. Thus, the variance between planning and execution can be understood, measured and reduced so that maximum project value can be realized according to the business objectives of the organization.

## Figure 7

**High-precision guidance.**


### Conclusions

Over the past few years, Peña Colorada has invested significant resources in technological innovations to improve its business practices. These efforts have resulted in significant increases in production and sales, while realizing lower operational costs. Monitoring the execution of the plans is key to make sure the operation stays on track and that production milestones are achieved. Mine plans have to be flexible and adaptable in order to respond to changes in the operation and the business environment. Lastly, mining technology keeps evolving, often redefining the whole value chain. Aligning mine planning with mine operations is critical in order to realize maximum project value. At Peña Colorada, both planning and operation solutions from Hexagon Mining are used to this end.

### Acknowledgment

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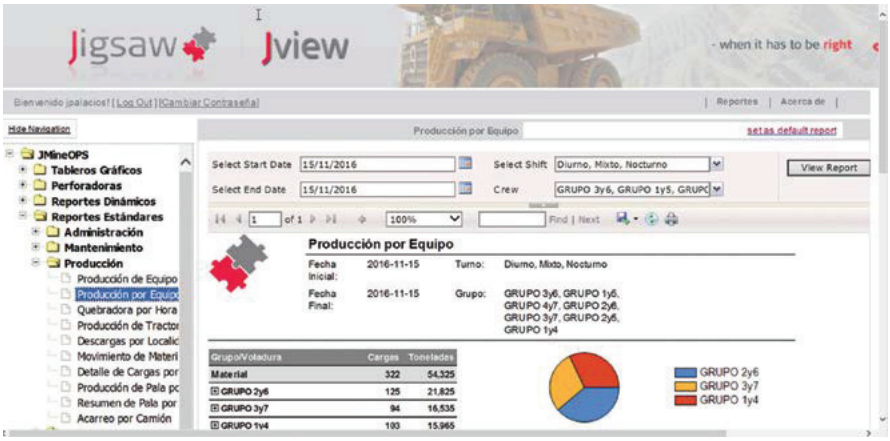
**Figure 8**

**FMS production reports.**




their endless support and continuous efforts to bring about technological innovations at Peña Colorada. Similarly, we would like to express our gratitude to Miguel Cuba, William Cain and Neville Judd from Hexagon Mining for their contributions to this paper.

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