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Pillar recovery with WebGen™ 100 wireless technology, Nexa Resources Vazante – Brazil

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Abstract

Vazante is an underground mine owned by Nexa Resources group that uses VRM (Vertical Retreat Mining) as predominant mining method, which involves leaving ore pillars in the mined stopes. These pillars have the function of stabilizing the open stope and minimizing dilution by limiting the hydraulic radius. The recovery of these pillars is financially desirable but making it operationally feasible is not simple and involves extra costs and cycles with scalling, backfilling the open stope, reinstalling infrastructure needed, accessing previous blasted areas, drilling, charging with explosives, and subsequently firing and then mucking out the blasted material out. The first wireless blasting system, WebGen™ 100, allows the mine to preload the pillar with explosives, which is initiated after the block is mined, without the need for the extra cycles described previously. The initiation systems available so far did not allow such a feat, since their operation is based on the principle of physical connection between detonator in each blasthole and ignition source (via blasting cable or shock tube). The WebGen™ 100 system is based on magnetic induction communication, and its signal is capable of overcoming rock, water and air. With WebGen™ 100 it was possible to safely preload the pillar together with production blasts, a technique named as Temporary Rip Pillar (TRP). Thus, it was possible to reduce the exposure of people and equipment, reduce operational cycles and increase mineral recovery, directly contributing to anticipate the ore production while guaranteeing the safety of the teams involved.

1 Site Profile

Vazante is a zinc/lead mine located in the northwest of Minas Gerais state, Brazil, and owned by Nexa Resources, a company formed from the merger between the Brazilian Votorantim Metais and Peruvian Milpo. The mine currently stands for 28% of the company's equivalent zinc production, delivering and beneficiating 374 and 35 kton in Zn and Pb concentrate, respectively. All the ore production is concentrated at the mine site and transported to Três Marias, where the metallurgical concentration takes place in a smelter.

Vazante is inserted in a karstic context associated with high rates of hydric circulation and its relationship with the terrain's morphology (high outflow rates associated with geological structures, presence of sinkholes and caves), which brings extra concerns to mine operation.

The mine operation started in 1969 as an open pit mine and developed to an underground operation in 1982, with Vertical Retreat Mining (VRM) and Long Hole Open Stope being used as main methods for ore extraction. The method of choice is dictated by the ore block geometry, and continuity and angle.

The VRM is a variant of Sub-Level Stoping, consisting of opening two parallel galleries (drifts) at the base of the ore panel, the first is developed in the orebody and the second in waste, which is used for access and transport. Both lower galleries are connected approximately every 60m by a crosscut. On the top of the orebody panel another tunnel is developed.

The deposit is controlled by a large shear zone, from where the Willemite mineral (zinc silicate) is extracted from hydrothermal veins embedded in a breccia main body. This shear zone has a main NE / SW direction, with dips ranging from 30 to 85° to NW and veins width of approximately 4,5 m.

2 Situation

Where the VRM method is used, a roughly 15m wide pillar is kept between each designed stope to enhance the stability of the rock mass and maintain operational dilution at a manageable level. The recovery of the ore contained in these pillars is dependent on a number of discreet operations required after the entire stope is blasted and mined out, which involve resources and time that could have being used for primary production. Most importantly, it requires exposure of people to areas that have already suffered damage due to very close blast cycles performed during the mining of the stope. The reentry for blasting the pillar is accomplished for several roof-supporting steps, such as shotcrete, rock bolting and cable bolting after completing backfill.

In order to control dilution, the site performs individual stope stability analysis under the methodology introduced by Potvin, 1998 and ELOS (equivalent linear overbreak/slough). The analysis results indicated the necessity of introducing an island pillar into the mining sequence of the stope to reduce hydraulic radius during its operational stand-up time.

Figure 1 shows the layout and mining sequence for the stopes 255 BL1 12300 and 255 BL1 12400 which were mined using the current blasting technology applied on site (bulk emulsion and i-KonTM III electronic detonators), and the island [rib] pillar (number 5) extracted using WebGenTM 100.

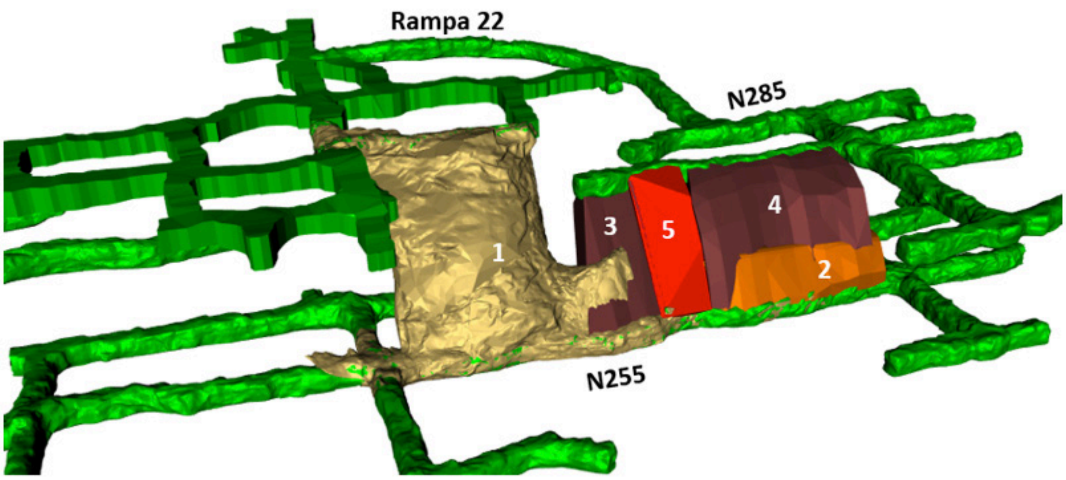

Figure 1 Layout and mining sequence for the stopes 255 BL1 12300 and 255 BL1 12400

The recovery of 255 BL1 12300 island [rib] pillar using wired detonators would be dependent on rockfilling the adjacent open stope, reinstalling ground control where needed, scalling, and managing the risks associated with personnel exposure to previously blasted rock mass. This incurs additional costs and time delays. All these operations aim to allow the safe re-entry to the upper level in order to load 110mm downholes, program the electronic detonators and fire the shot. The ore would then be extracted from the lower level with 60% expected recovery and dilution caused by the contact with the backfill material.

3 Value proposition

Using WebGen™ 100 wireless technology, Orica presented the possibility of recovering 255 BL1 12300 island [rib] pillar minimizing people's exposure and allowing the mine to improve operational productivity safely and efficiently by keeping two mucking access for the main stope.

The pillar was preloaded with WebGen™ 100 wireless detonators before losing the access to the upper level due to the blast events on the main 255 BL1 12300 ore body. After all ore from the block was extracted and the pillar had completed its requirement to provide regional stability and dilution control, the island [rib] pillar was remotely initiated.

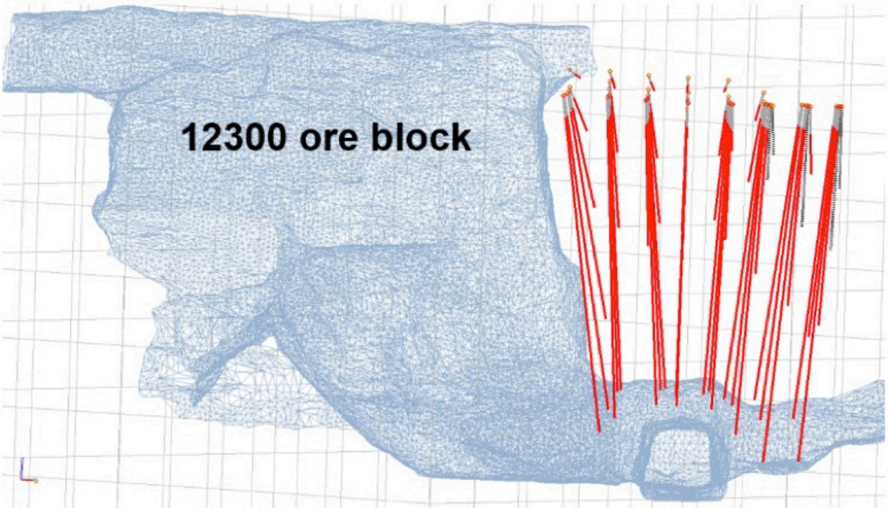

Figure 2 Temporary pillar preloaded with WebGenTM 100 with longest holes being 30m

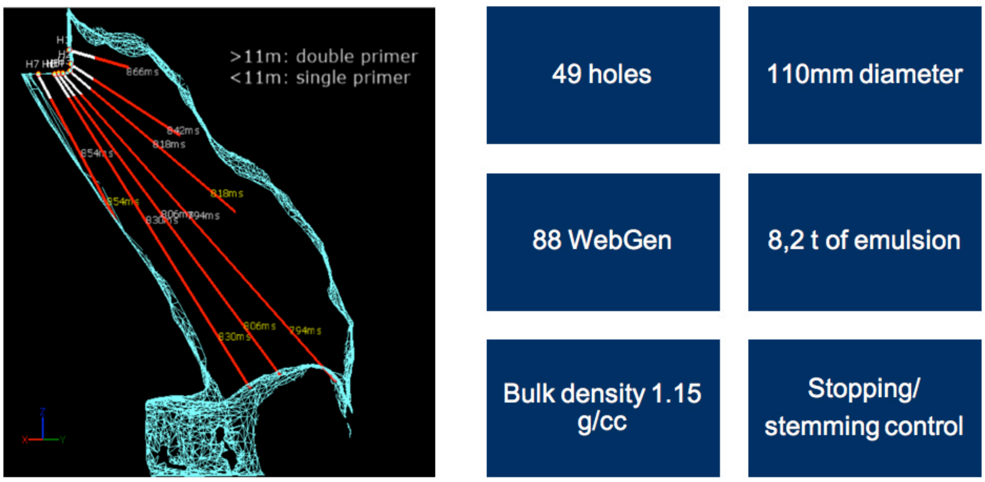

Figure 3 Summary from the blast

This way was possible to recover the ore contained in 255 BL1 12300 island pillar without the need to complete all the steps described in the Situation session, minimizing crew exposure, and improving mine productivity.

4 Results

While there was still access to the top of the island pillar, Orica and Nexa's crew conducted extensive site signal surveying and followed the best practices to guarantee all the drill pattern in the pillar area was correctly loaded and all 88 WebGen™ 100 units were encoded and positioned as planned. This blast was kept sleeping for 32 days. In the meantime, several ore blasts took place beside the preloaded pillar to release ore to be mucked from the main 255 BL1 12300 stope. Shotcrete was applied at the lower level to eliminate the risk of slumping blastholes interacting with bogging operations, and as an additional safety precaution for all operations and people working under the sleeping shot. Without this safe spot, the tele remote operation mucking process would have to be done over 90m due to the size of the open stope, what would result in significantly lower productivity, this situation is avoided by using WebGen. After all the ore material from 255 BL1 12300 main stope was mined, the wireless detonators were safely fired using a magnetic inducted signal traveling through the rock.

A special blast sequence was also used for this specific application with the intent to lower blast vibration levels. A seismograph was installed to verify the initiation of the charges.

Figure 4 Blast outcome

The preloaded pillar had dimensions of approximately 25x30x6m, generating 18.8 kton of ore accounting for 12% of zinc production for the month, achieving an overall average Zn content of 9.19%. Applying WebGen™ 100 enhanced pillar recovery enabled the mine to improve its productivity without exposing people to areas previously damaged due to prior blast cycles. The process was completed with no misfires, adequate fragmentation, allowing 88% recovery of the pillar with operational dilution kept under desired levels, resulting in a net benefit of US$1.59M for Nexa Resources Vazante.

The following outcomes were achieved using WebGen™ 100 for pillar extraction:

- Increased expected ore recovery from 80 to 88% for the pillar;

- Cycle time reduction of approximately 70% achieved for the extraction of pillar (from 90 to 20 days);

- Decreased dilution of 255 BL1 12300 main stope from 27% to 20% due hydraulic radius reduction and less standup time.

A second application currently being studied at the mine site will allow to preload an entire stope, which will reduce operational risk, number of cycles which would enable to increase ore production and therefore profitability.

5 Conclusion

WebGen^{TM} 100 is an enabler technology paving the way for Drill and Blast to move into the automation of its processes, along with all the mining industry. In that sense the wireless initiated booster allows mines to rethink new ways to extract ore, bringing to the market new mining methods as the TRP (Temporary Rib Pillar) presented in this case study, and the possibility to safely pre-charge areas that can then be fired at the convenience of the operation while removing people from hazardous situations such as working near open stopes, at the brow or the need to re-enter areas previously blasted or in poor conditions to hook-up the shot and program detonators.

Acknowledgements

Orica appreciates the opportunity to partner with Nexa Resources to develop this case study. We thank all Vazante crew for the trust and partnership during the tests and application of Orica's newest technology WebGen^{TM} 100 wireless detonator.

Figure 5 Blast crew responsible for the blast. Left to right: Italo Jeferson, Luciano Santos, Fabricio Santos, Francisco Biulchi, Mateus Gomes and Wesley Andrade

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