High technology for improving safety

Introduction

During the last 10 years, blasting industry in Senegal has known an important change. It's not just a revolution of technics but a deep evolution. Blasting has gone from an artisanal practice to a known-how focused on new technology with more concern about safety and environment.

Awareness of actors of the sector about the global environmental impact of mining and quarrying leads operators to pay more attention about safety.

Mineex, Senegalese subsidiary of EPC Group has obtained on April 2019 a triple certification ISO 9001, ISO 14001 and OHSAS 18001 in an African country where mining activity is recent and where safety reflexes barely appear in the local culture. In 2021, the OHSAS 18001 has been upgraded to ISO 45 001.

Benchmarking with practices in other EPC subsidiary in mining countries where technology and increased regulation led to improvements in mine safety helped us make mining, in Senegal, a less hazardous profession.

Why mining is considered as dangerous in the first place?

One of the most dangerous effects of mining comes from the blasting activity. It appears that all the energy that is not used for the fragmentation of the rock goes in the environment as nuisance (vibration, flyrocks, noise, etc.). By improving the blasting result we can control the effect of the blast in the environment.

It is very difficult to get a general view of all the rock formations, and while 3D mapping technology does help to get a better understanding of a mine or quarry, more advanced mining technology is needed to better understand the impact of drilling and explosions on rock structures, so that accidents can be avoided.

To have a control of the safety during it operations, EPC chose to develop and adapt tools to the ground conditions and constraints by using possibility offered by new generation drones and probes.

Our case study is based on a 12 Ha basalt quarry in Ngoundiane (100 km of Dakar _ Senegal) where Mineex provides the drilling and blasting service.

The specificity of this quarry is the heterogeneity of the rock and also that 4 other quarries in activity surround it, all using blasting operations to extract the rock.

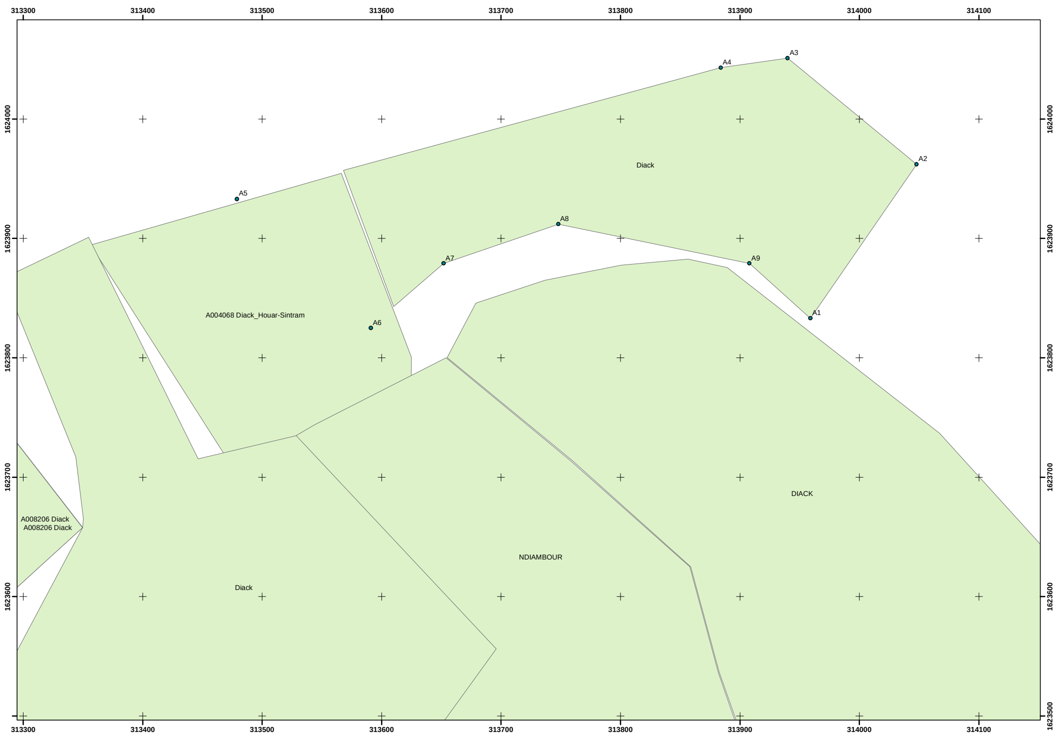

Fig.1 : Location of the quarry (image à changer en attente du service des mines)

Thus, it is very sensitive to operate in such environment and take into account all constraints to blast safely.

Many incidents and accidents occur in this area. The last one dated on October 2020 destroyed windscreen of trucks parked nearby and was due to fly rocks caused by:

- bad design of the pattern leading to production of more energy than necessary
- setting out that does not match with the original design
- deviation of the blasting holes

Many controls can be implemented to reduce the likelihood of accidents arising from these causes.

This paper highlights the different steps of the drilling and blasting services that includes arrangement made to improve safety concerns:

1. Modeling of the quarry and design of the blasting pattern
2. General surveillance of the quarry (slopes for the security of trucks, control of hazards): using drones to correct the mining design on a security point of view
3. Visibility of the exploitation by modeling the evolution of the quarry and the impact in the environment.
4. Video of the blast to analyze and improve results.

I. Modeling of the existing quarry and design of the blasting pattern

Pictures obtain by drone are treated and integrated into EPC blasting design software Expertir.

With the precision of drone images, almost all parameters around the blast are taken into account including:

- The neighboring quarries
- the real shape of the quarry face
- slopes of access tracks
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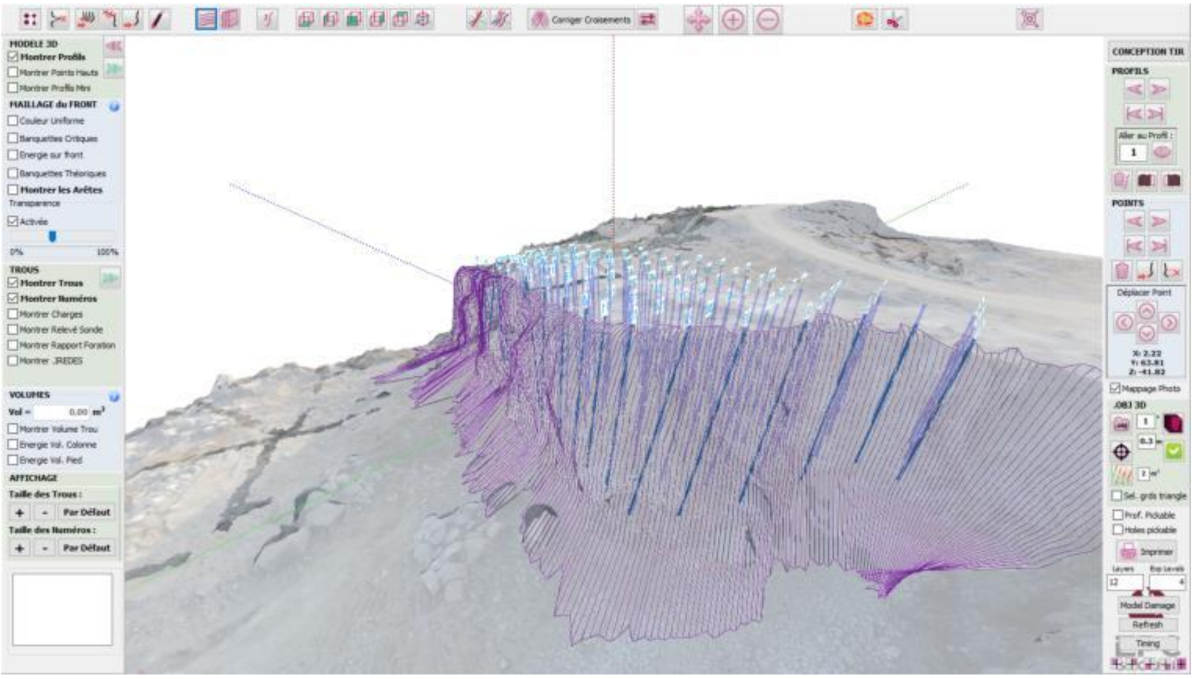


Fig.2 : Mapping of the quarry face combined with probe results

Combination of information of the quarry face mapping given by the drone images with possible deviation control information given by EPtraC (in-house probe developed by EPC Groupe) ensures to have a real burden value.

This fundamental information helps to avoid under-loading (generating blocks that are complicated to process then, and above all dangerous) or overloading (with high risk of projections)

EPtraC is an ultra- compact manual probe accompanied by an adapter to measure holes of different diameters with no depth limit other than the rope used to lower it! There is no need for a communication cable during the measurement operation:

- the information is stored in the probe that communicates it when it is brought to the surface via Bluetooth on a dedicated EPC Android application.

- This system is intended to be lighter and more flexible than current probes. Its extreme precision was validated by photogrammetric measurements during several tests under real conditions. This probe very light is a plus for the users and made them the job safely.

All data (drone images and EPTraC information) are directly treated by Expertir, which is the EPC tool for blasting design. Explosives per holes are adjusted accordingly and it considerably minimizes risk of error. In addition, analyze of video taken during each blast helps to improve results and control projections.

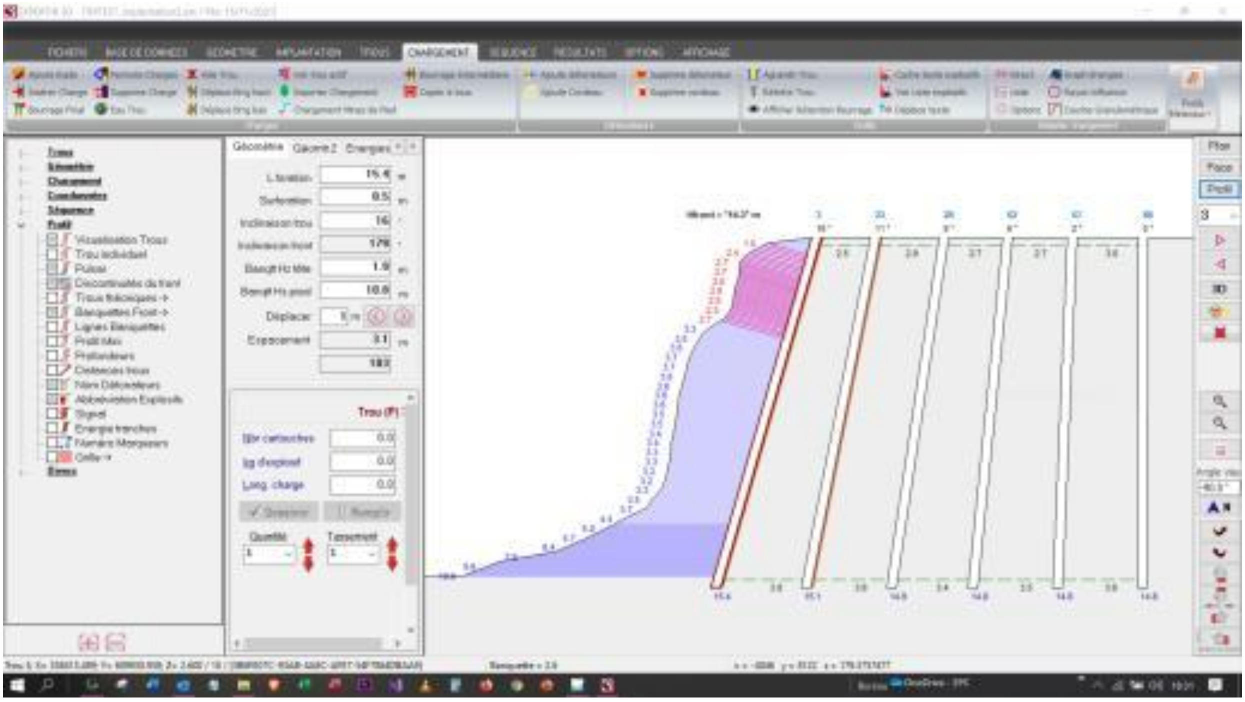


Fig.4 : Design of the blasting pattern with Expertir

The implementation of appropriate controls with this probe helps to reduce risks to a lower level and constitute an important component of the safety management.

Date	Resume	Causes	Proposed solutions	Date of implementation
03/06/19	On 04/02/2020 after loading the holes the blastman feels safe in a shelter and proceeded to the blast. His other colleagues noticed a flyrock coming in his direction, they warned him without success. The rock then felt on the blaster helmet. The violence of the impact caused a head injury despite the presence of the helmet.	Overloaded hole	Verification of holes	17/06/19
		Bad appreciation of the safety perimeter	Awareness of the importance to respect the safety perimeter	Awareness session on 19/06/19
08/08/19	After they finished to load the blast, the team left the blaster on the site. After all safety procedures the blaster proceed to the blast around 6 p.m. as usual, there were projections and two large blocks felt on the blaster's metallic shelter. At that moment the blaster fell down and saw that his foot was stuck under the metallic cover and there was nothing more he could do. After the shot, his teammates had to bring in an excavator to lift the cover to free his foot and then take him to the hospital He was diagnosed with a fractured fibula.	Flyrocks due to light burden	Verification of the quarry face and increase of the stemming height	14/01/2020
		Cover too heavy to be moved easily from the quarry face	Find a safe place away from the security perimeter to install the metallic cover	Immediate action on 10/08/19
23/10/19	On October 23, flyrocks from a blast reached the roof of the driver's building and on the windscreen of a truck	Proximity between the blasting area and constructions	Verification of the quarry face and increase of stemming height	14/01/2020
29/10/20	A flyrock from a blast reached the roof of a bank nearby the quarry	Proximity between the blasting area and constructions	Control of blasting parameters	09/11/2020
			Optimization of the stemming	09/11/2020
04/03/21	On March 04, 2021 in our client's quarry we were surprised by flyrocks from the neighboring quarry at 5 p.m. whereas blasts were normally operated at 6 p.m.	Lack of communication between quarries	Whatsapp group with all quarry operators to inform their neighbors	15/03/2021
		Problem of blast design by the other quarry	Not enough information on the blasting design procedure of the concern quarry	Not enough information on the blasting design procedure of the concern quarry

Tab. 1 : Flyrock incident record

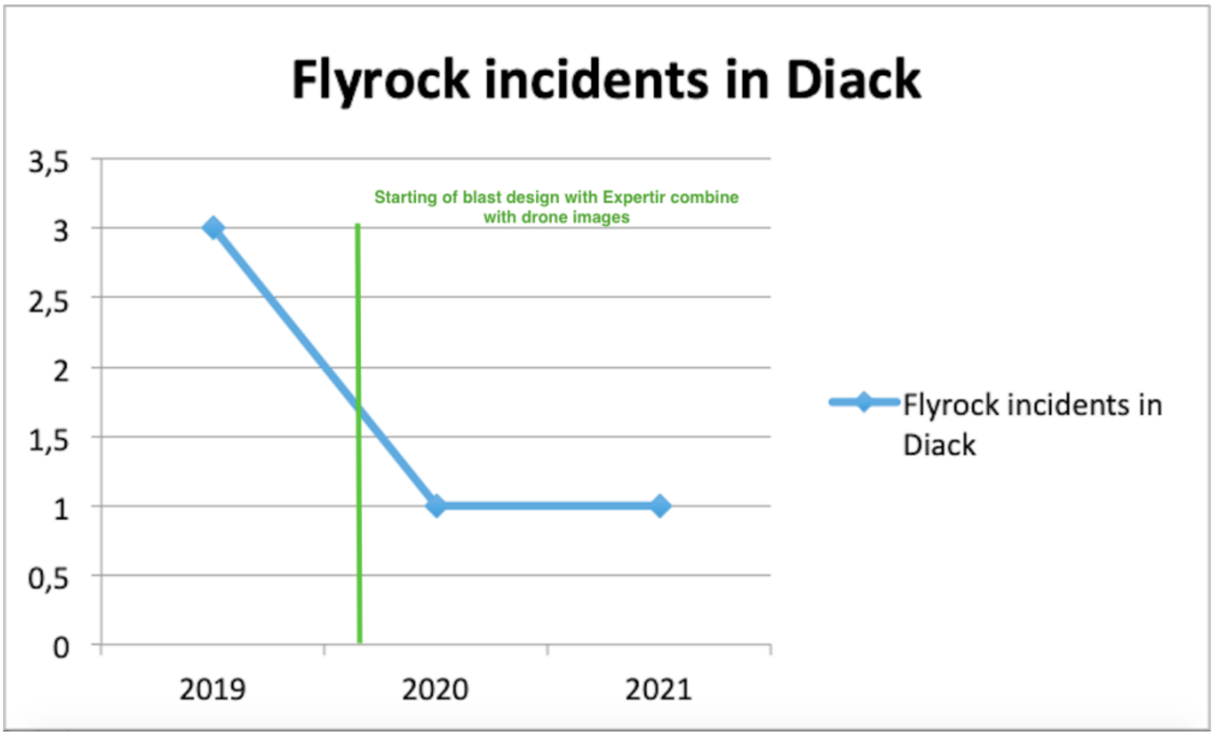


Fig.6 : Evolution of flyrock incident in Diack quarry 2019_2021

The table above lists the flyrock incident recorded from 2019 to 2021.

It highlights the fact that major incident are due to overloaded holes because of:

- deviation during the drilling process: the bottom hole burden receive the more energetic explosive (emulsion cartridges as booster) for a lighter burden and then provoke important flyrocks.
- irregular front face: The explosive column height is too loaded at some point of the quarry face (fig.5)

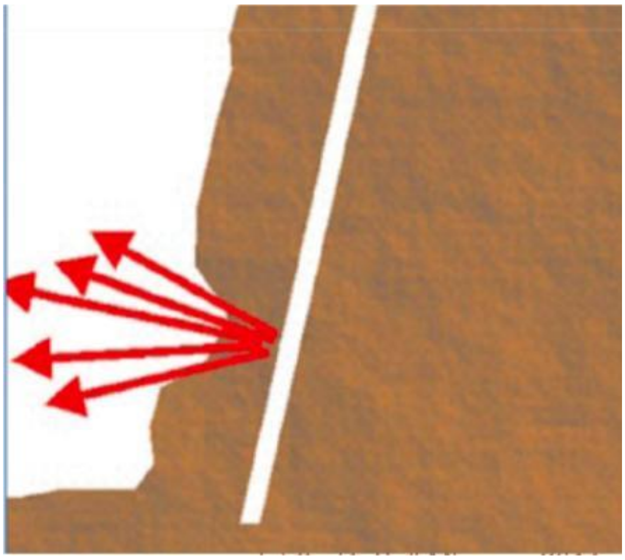


Fig.5:

The deviation issue is handled by the using of EPtraC. When the probe detects a position of a hole different from the original design the explosive charges are calculated accordingly to avoid a higher powder factor than necessary.

The mapping of the quarry face with drone images allows us to readjust the powder factor.

Since May 2020, date on which these measures were put in place, we can note a decrease of incidents due to flyrocks from our blasting.

The flyrock reported in March 2021 was coming from the blast of another quarry just on the boundary of the 2 sites. We haven't reported all flyrock incidents from those quarries, which are numerous, but this one impacted directly our equipment and almost one of our blaster.

This means the risk will remain unresolved until we can replicate our conclusions to neighboring quarries.

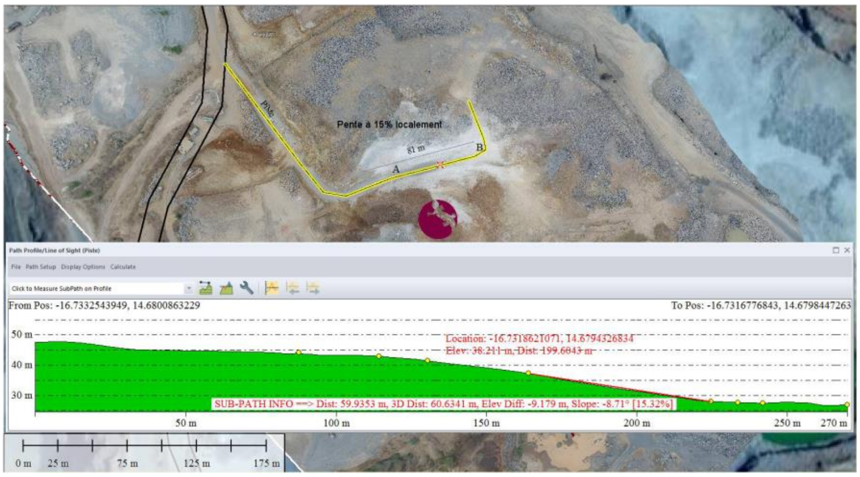
This will require:

- discussions with other quarry operators,
- coordination of blasting program of each operator (a whatsapp group with all quarry manager has been setup since the incident of 03/21)
- training program for their staff,
- but also a significant investment in modern tools (probes, drones, software, etc.). This point can be problematic because companies doesn't have the same level of development and safety management

II. General surveillance of the quarry

Safety concerns may not only occur during blasting operations. This has once again been proven by the drone images of this quarry. After their treatment by a GIS software (Global mapper) it appears that the existing slop was up to 15.32%, which is too high to insure safety traffic in the site.

In this case, our proposal was to provide the client with an access track with an acceptable slope of 10% (10m for 100m in length) so that the vehicles circulate safely (without consuming too much energy or causing accidents).



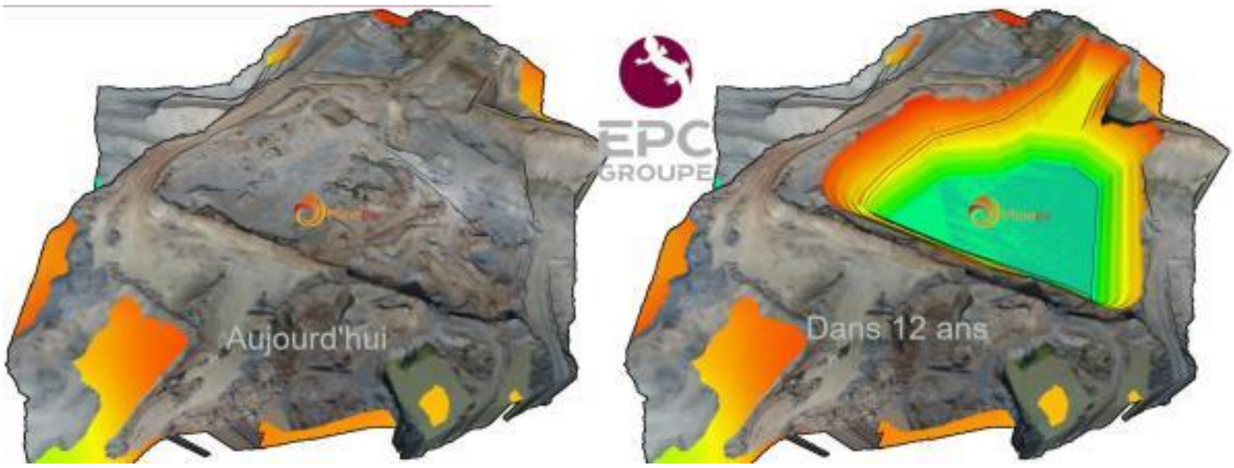
The main issue is to follow the evolution of the quarry with the client who regularly have tight production requirement to meet and most of the time it is done to the detriment of the attention they have to pay to security issues.

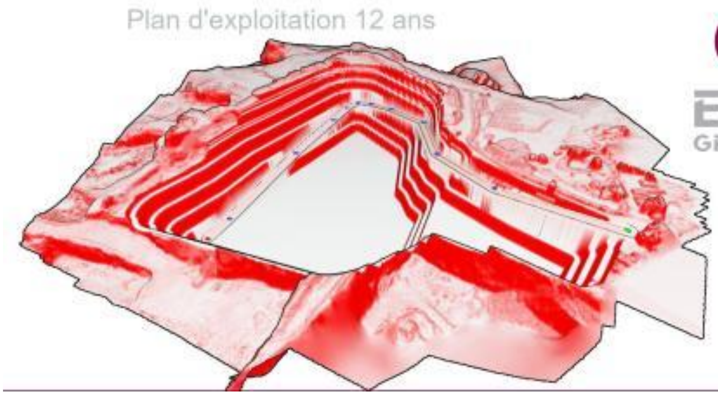
For example during the rainy season 2021 the client cut a regular ramp to use the rock for production because of problem of access to the main quarry face, full of water. Since then they are using a ramp that was abandoned because of the high slop (17,9%).

Fig. 4 : Control of access slopes

III. Evolution of the quarry

Pursuing the exercise of securing the quarry, we provided to the client an operating plan for the next 12 years, which plan for the gradual construction of slopes and berms so that they meet safety standards at any time of its development.





Conclusions

This Paper titled “High technology for improving safety” has explained how technology is used to improve safey meanwhile improving blasting results.

Drones not only scan the mines from perspectives that are dangerous and -inaccessible to humans, they also communicate any information inside the quarry. This makes a more detailed analysis of the mine slopes in a short time without having to deploy skilled surveyors into an inherently hazardous environment or affecting production.

It’s demonstrated also that whatever the solution is, to be efficient, it has to be implemented at a larger scale to guarantee safety of company’s staff and equipment.

A solution can be for quarry operators to invest together on adequate tools, pool them and organize training sessions together to reduce costs.