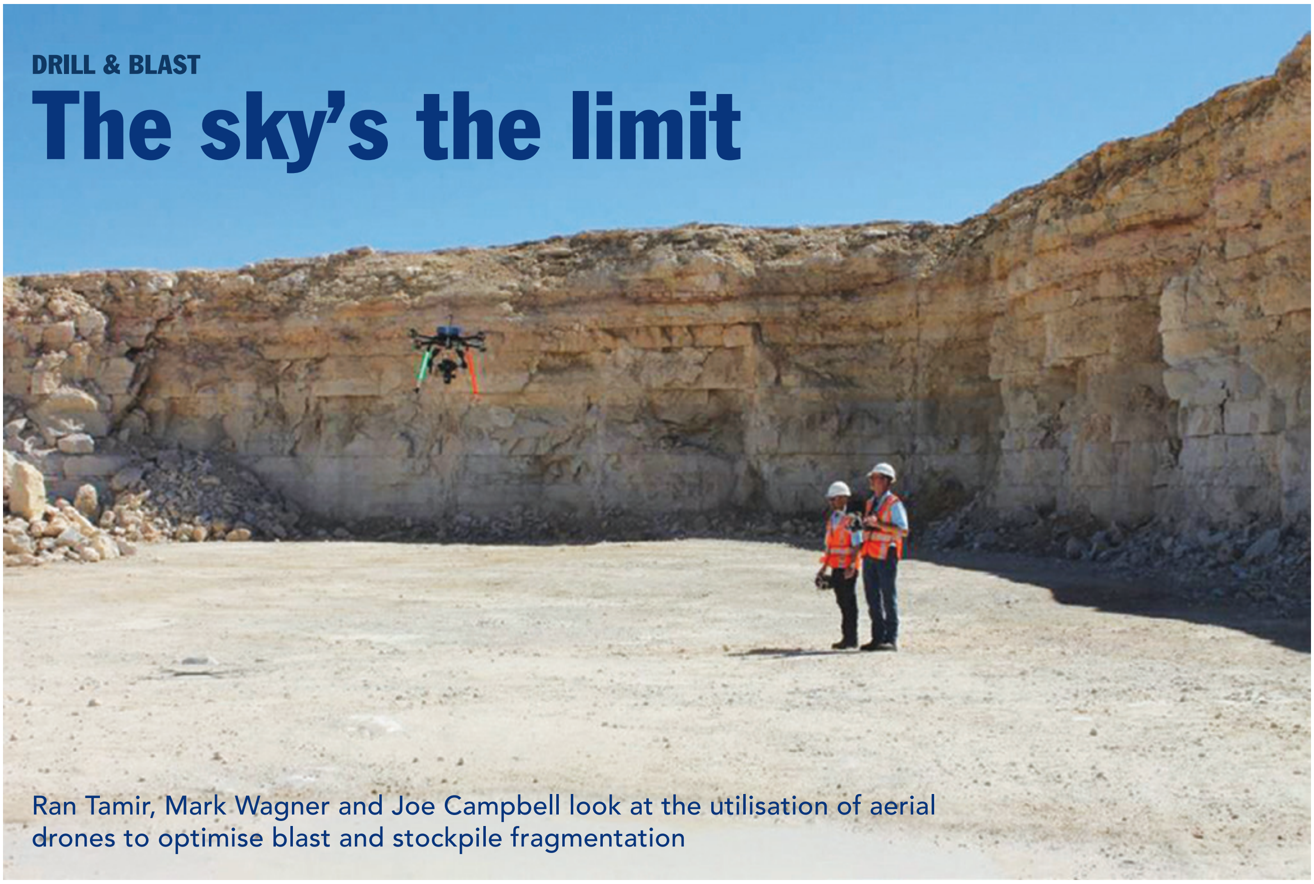
DRILL & BLAST

The sky's the limit



Ran Tamir, Mark Wagner and Joe Campbell look at the utilisation of aerial drones to optimise blast and stockpile fragmentation

Texas Drone Professionals on-site at L'Hoist's Clifton quarry to take drone images for analysis of blast-pile fragmentation

Aerial drones can be used to collect fragmentation data for both blasted muckpiles and post-crusher stockpiles. In tandem with photoanalysis software, drone imaging can give mine and aggregate sites a fast, accurate and economical way of benchmarking and optimising material size throughout an operation.

To maximise potential, mining operations strive to bring ore to the plant's entry point at the most suited state for the process. The higher the compatibility between the ore's controlled variables and the plant's requirements, the better the productivity (and usually quality).

The impact of rock fragmentation on all stages of the process is far-reaching and costly. To overcome the fragmentation's high standard deviation and lack of compatibility 'that can't be avoided', plants compensate by implementing expensive processes.

The goal of producing the ideal feed requires calibration of the pre-process handling of the ore – the blasts. Correlating between geology, blasting parameters such as pattern, timing, explosive load, hole information and measuring the results in place is key to that calibration. The path to continuous improvement is:

- Creating a 'situational awareness' – a 360° picture of the parameters;
- Understanding the fragmentation in the muckpile;
- Making a change (decision); and
- Measuring the impact of the change and comparing it with a benchmark, and adjusting/pushing the performance envelope.

Today, for the first time, we can see the blast fragmentation from overhead by utilising aerial drone photography. Location-specific fragmentation data is one of the most important building blocks in the process of putting together that 360° picture.

With the advancement of unmanned aircraft system (UAS) technologies, operations are realising the benefits of new capabilities including aerial particle-size analysis through photoanalysis, using existing UAS photographs taken for surveying and 3-D profiling. Utilising this tool allows us to make changes that will help us in future blasts, and it can also allow us to react to the current conditions by adjusting the mucking plan.

This is a first step in creating a comprehensive tool that will assist us not just in understanding current blasting and stockpile feeding procedures, but also in making real-time educated decisions based on fragmentation data.

COLLECTING IMAGES AND FRAGMENTATION DATA

Drone configuration

The first step of the drone imaging process is to identify an area for data collection. In this case, leading up to the trial at L'Hoist's Clifton quarry in Texas, US, a six-acre (2.4ha) blast pile area and a two-acre (0.8ha) kiln feed stockpile area were identified as the targets for the flight.

On checking for any safety issues or Federal Aviation Administration (FAA) airspace issues and contacting the appropriate authorities for acceptance, Texas Drone Professionals planned and mapped the flights.

A 3-D image of the blast pile used for fragmentation analysis

Once the company had the needed approvals, the project personnel were ready to proceed to the site.

When on site, the drone supplier confirmed safe flying areas, and configured the drone cameras. Two cameras are mounted to the drone to ensure that backup images are taken in the case of a mishap. In this case a Sony A7R 42-megapixel (MP) camera was used to complete the bulk of the imaging, with a 24MP camera as a backup.

> "Drone imaging can give mine and aggregate sites a fast, accurate and economical way of benchmarking and optimising material size throughout an operation"

In order to take advantage of automated scaling inside the orthomosaic software, ground control using Trimble R8 surveying system capable of offering <1mm accuracy levels was used.

Next, the drone supplier advised the relevant people that there was a mission starting and they determined that the airspace was clear and began a flight. For orthomosaics the flight takes place at about 150ft (45.7m) above the ground, and the flight pattern allows for at least 60% photo overlap. On safely completing the flight, the SD card with images was removed and the images were input into the photoanalysis software.

The photo-stitching took place off-site, and position/scaling was provided via the ground control units. This process results in both a point cloud and an orthomosaic of the data collection area. It is important to note that no physical scaling device is required in the images when completing a drone trial.

Using ground control configurations allows users to remotely impose an accurate scaling device to the photo. This is expected to reduce the amount of risk associated with manually placing a scale on a blast pile, and will drastically improve the speed at which a user can capture images for photoanalysis.

We can now see blast fragmentation from overhead by using aerial drone photography

The photoanalysis process

Sizing analysis of muckpiles has been performed for many years. The photoanalysis process involves capturing images of the fragmented rock in question and uploading these images into the fragmentation analysis software; WipWare's WipFrag 3.0 software was used in this case. Orthomosaic imaging software allows for an overlay scale to be placed anywhere in the image after the flight takes place. This scale is used as a reference inside the image, and is crucial for the analysis to take place.

The photoanalysis software's automatic edge-detection parameters delineate the particles within the image. In this case, it took approximately 10 seconds to run the analysis, and approximately seven minutes of manual edits to these images to ensure an accurate analysis.

After editing, the software outputs the particle-sizing data into a percent-passing format for up to 17 customisable size classes.

Unlike traditional photoanalysis methods where an employee walks to a blast pile, places a measurement device in the blast pile's area of interest and captures images standing perpendicular to the material, drone imaging allows the user to capture aerial images of the same pile, and use orthomosaic imaging to automatically set the scale inside the image. It should be noted that the drone flights can be controlled from approximately 150ft away from the blast piles, further confirming that this method of collecting particle sizing is much safer than other methods that require manually placing scales on the pile in question.

UTILISING DATA

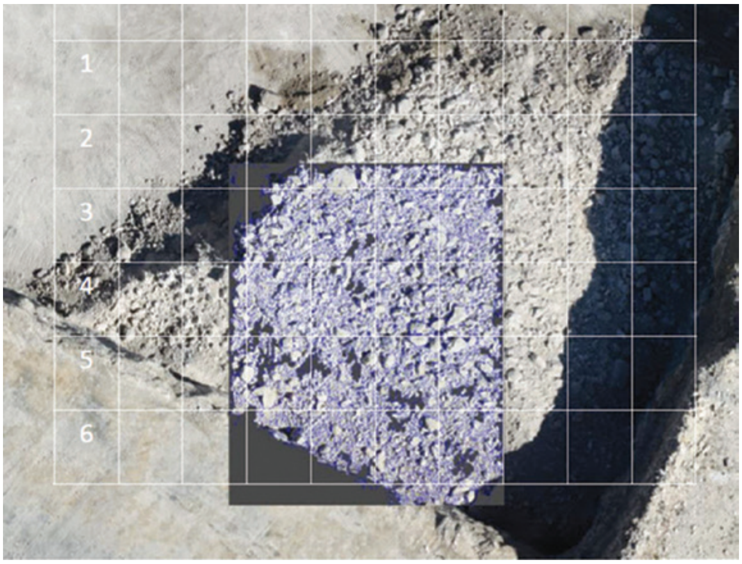
Blast-pile benchmarking and optimisation

Having the fragmentation of the entire blast pile allows an operation to begin benchmarking procedures in the hopes of finding ways to improve performance. To break down blast performance for each shot, it was found to be advantageous to implement a grid overlay when completing the analysis of blasted material. By doing so, the interested parties were able to identify the following:

- What specific zone of the blast provided acceptable fragmentation, and how can we reproduce these results?
- Where are the problem areas inside the blast, and what caused these areas to be coarser (stemming, initiation, hole spacing, etc.)?

Three different grid areas in the blast pile image were identified as having fine, mid-sized or coarse material when visually inspecting the orthomosaic image generated by the drone. Once identified, these areas were analysed with photoanalysis software to get size distributions.

In addition to testing these three areas of the blast pile separately, the particle sizing results could also



The grid overlay used to identify areas in the blast that need attention. The WipFrag fragmentation 'nets' can also be seen

be merged to help get the 'full picture' look at the blast pile fragmentation and a comparison against future blasts.

Using the primary crusher specifications as a guideline, zones could then be created inside the analysis results to track improvements and optimise the material size being fed into the crusher.

In this case, the green area was identified as a 'no-work zone', where the primary crusher does not need to actually crush this material; a yellow 'crush zone' was identified where the primary crusher begins actively breaking down material, and a red 'danger zone' was identified where oversize material is getting into the primary crusher.

Managing stockpile segregation

The drone imaging techniques can be used to calculate the fragmentation size of stockpiles. By separating the stockpile into three distinct zones, operations can use the fragmentation data collected to forecast ideal feed blend and burn rate settings before the material enters the kiln.

An example of how drone imaging can be used to improve performance is with the material size in the 'red zone' as seen in the image (below): now, when an operation wants to start pushing outside material through the process, workers can optimise kiln settings based on the image-analysis data collected.

CONCLUSION

The ability to attribute fragmentation to a location at the muckpile allows a better understanding of the variables contributing to the outcome. The correlation between the shot parameters, geology and fragmentation helps to differentiate between cause and effect and allows an operation to:

- Set better goals;
- Reproduce what worked well; and
- Improve what did not yield expected results.

The more detailed the picture – a fragmentation analysis of each grid block – the better the understanding, giving a wide spectrum of data. The best result, the worst result and the deviation from the standard can be looked for.

The plant's ideal incoming material for maximising both productivity and yield in this case is material above $\frac{3}{8}$in (9.5mm) and below 12in (30.5cm). In cement, the raw mills need a consistent feed, which varies based on the operation, to reduce standard deviation. The grid location knowledge provides the blaster with the ability to relate material size to specific areas in the blast, allowing subsequent blasts to be optimised in line with the operation's goals.

In the case of monitoring the product piles, we work very hard to get the ideal fragmentation curve so that we can supply a consistent feed to the mills and the kilns.

However, building a stockpile comes with a price; the segregation affects both mill and kiln productivity, energy use and product quality. Monitoring the different segregated 'rings' in the pile helps us find the best solution for the consistent feed method by understanding what the segregation looks like and its associated boundaries as it relates to fragmentation. ▼

"The ability to attribute fragmentation to a location at the muckpile allows a better understanding of the variables contributing to the outcome"

Stockpile segregation can now be quantified, and the data collected can be used to forecast what material will be feeding the kiln

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