



# Threshold blasting: the renaissance of explosives in narrow reef mining

by C.V.B. Cunningham\*, T. Zaniewski†, and N. Kernahan\*

## Synopsis

Threshold blasting involves the use of small amounts of high explosive to break and fragment hard rock without having to evacuate mining personnel. The method is easily assimilated and effective in rockbreaking, but requires rigid control on drilling, charging and timing. Current underground trials are aimed at fine-tuning the amount of explosive energy and blast hole geometry to allow the firing of multiple sets of shot holes in a continuous manner. Through correct procedures, the after-blast fumes, dust and fly rock can be contained so as to provide a safe working environment.

Threshold blasting hugely reduces the volumes of explosives used in mining and brings to maturity the potential of the process begun by Alfred Nobel when he introduced nitroglycerine, and later dynamite, to mining. Its key contribution is its enabling of continuous mining operations with well understood and relatively low cost technologies. The use of batch blasting, employing large burdens holds the greatest potential for delivering high flow rates of ore at minimal cost. There is good potential for rapid evolution of the concept.

## Introduction

Rock drilling is a mature technology, which keeps getting better. Drills continue to become lighter, faster and more robust, and therefore represent an attractive technology for hard rock mining. However, the cost of drilling is significant, and it is important to make every hole count.

Placing energetic materials within drill holes and triggering expansion to break the rock makes a great deal of sense, as it is highly efficient in terms of (a) the capital investment required to achieve breakage, and (b) the harsh operating environment, which punishes expensive machinery and often prevents it from operating continuously. Drills and stopping drill rigs are relatively low cost, low mass, adaptable systems which can be kept operating with relative ease, and whose standing costs are relatively light.

Commercial explosives are used with little skill in normal mining, but they deliver results: finely fragmented rock, with reasonable face

advance. The top priorities for the mining crew on the face are,

- ▶ get the face drilled and blasted as soon as possible and get out of the mine
- ▶ the face must break cleanly and not require continual problem solving
- ▶ accidents are unacceptable.

Conventional blasting meets these targets, because large quantities of explosive are used to ensure that as few holes as possible are drilled, and sufficient insurance is provided by the combination of high charge and burden control to ensure that the break is good. Safety is reasonably assured by evacuating the work team while dust and gases are at high levels, and having night shift make safe.

While this system suits the work teams, it often fails to meet the needs of shareholders, who find that the cost of sinking shafts and running them eats unacceptably at the returns from mined ore. The remedy is to increase the ore throughput from the infrastructure without significant running cost increases. This is the environment in which threshold blasting was conceived and launched.

The objective of threshold blasting is to provide what mining work teams and mining shareholders really need: a rockbreaking system which delivers sustainable production from strong, cost-effective technology which is simple, robust, safe, flexible and capable of 24-hour operation.

## Threshold blasting concept

The fundamental theory and evolution of threshold blasting was recently described by Cunningham<sup>1</sup> in 2000. This paper extends the discussion into practical application.

\* *African Explosives Limited, Modderfontein House, Modderfontein, Gauteng*

† *Anglogold Mining Consultancy TDS, Welkom.*

© *The South African Institute of Mining and Metallurgy, 2002. SA ISSN 0038-223X/3.00 + 0.00. First presented at SAIMM, 6th International Symposium on Mine Mechanization and Automation Conference, September 2001.*

# Threshold blasting: the renaissance of explosives in narrow reef mining

## Requirements

High explosives typically release total energy of about 4 MJ/kg, and for 0.7 kg in an 0.7 m charge length, the 2.8 MJ output is released by a shock wave which traverses the charge in 0.25 milliseconds, generating a peak pressure against the blasthole wall in excess of 4 GPa, but rapidly declining to 100 kPa as the hot, compressed gases expand from a density of 1.3 kg/lit to a density of 0.001 kg/lit. It is incorrect to say that the rock is subject to a sustained pressure of 4 GPa; the dynamics of energy transfer and fracture are complex and somewhat obscure, but there is abundant energy to initiate fractures in hard rock.

What happens next depends on the energy concentration in the hole and the rock mass. In normal blasting the burden swells and breaks, being propelled into the stope at velocities up to 30 m/s. This throw can be harnessed for transport purposes, but also results in impacts on the support system, and if units of this fail, loss of support. The combination of low skills in drilling, unpredictable sequentiality of the initiation system and heavy charging, means that damage is often caused to the fresh hangingwall, which brings about excessive stoping width and hence ore dilution.

The recent tendency to seek to utilize propellants (low explosives) rather than high explosives, is interesting in the light of evolution in rockbreaking. High explosives are often portrayed as having ruinously high pressures which are wasted on crushing the much weaker rock, but this argument is not valid for small masses of commercial explosives in jackhammer holes. The characteristics of these products are benevolent for hard rock mining. While it is true that propellants can be made to fracture rock, and are particularly effective for extending cracks, they are less effective at creating fresh cracks, which is why, largely, they are still used in the dimensional stone industry, where the penalty for damaged stone is prohibitive. In addition they are not known for fume properties, as are normally used out of doors.

A 120 g cartridge of emulsion produces about 120 litres of gases. The nature of the gases depends a great deal on the way in which they are confined during expansion, and on the robustness and composition of the explosive, but the main content is water vapour, nitrogen and carbon dioxide. These asphyxiants are of little concern as they are quickly diluted by mine ventilation, but there are usually traces of carbon monoxide and nitrous oxides, which are toxic. Before men can work the air must contain less than about 5 ppm of nitrous fumes and 100 ppm of CO (Regulation 10.6.6). It is thus crucial that the explosive, or propellant, is rigorously formulated and regularly monitored in use. Emulsion explosives are intrinsically the cleanest from toxic fumes, provided they are properly formulated and confined in use.

The technical problems that thus have to be addressed if people are to remain at hand when blasting takes place are,

- ▶ minimization, and dilution, of asphyxiant and toxic fumes so that the ventilation system can deliver healthy air to workers
- ▶ rock particles to be retained at the face and not allowed to fly into refuge areas or to knock out support
- ▶ minimization of damage to hangingwall
- ▶ complete breaking to depth so that full tonnage is achieved with each hole
- ▶ rapid operation to deliver the required flow rate of

broken ore, ensuring short re-entry times.

These objectives are all realizable by threshold blasting, which has the following key elements.

- ▶ Use of the minimum amount of explosive which can fragment the rock. This directly reduces the gas volume produced, and prevents problems caused by high velocity rocks.
- ▶ Use of a rigidly controlled explosive which primes easily, produces minimal toxic fumes, and which delivers consistent performance in small quantities. We have reserved the term 'Tailored Energy Pack', or TEP, to describe this.
- ▶ Effective stemming which prevents any gas from exiting through the collar of the hole. This enables all the available energy to work effectively in rock breaking, and forces the gases toward more complete combustion, hence removing toxic components.
- ▶ A fluid coupling medium against the explosive to improve transmission of energy and cleaning of released gases.
- ▶ Disciplined drill teams, preferably using an appropriately engineered drilling rig, to ensure that holes are drilled parallel, correctly burdened and within the stoping limits. This ensures consistent and economic breaking without dilution.
- ▶ Blasting as many holes as makes sense within the capabilities of the stope system to accommodate the rock in each blast and the volumes of gas and dust created. This promotes productivity, as the process of withdrawing, firing and re-starting takes about the same length of time irrespective of how many holes are fired. Tons per cycle increase with larger batches.
- ▶ Use electronic delay detonators for initiation. This eliminates the fumes from pyrotechnic methods, enables complete checking of the system prior to firing and gives certainty of sequential firing. With threshold blasting, out of sequence firing is fatal to success, as there is no insurance of energy excess.
- ▶ Properly trained and motivated work teams who can underwrite the Basis of Safety of the system and know what to do to solve problems.

## Rockbreaking system

The system is under development and will in due course consist of modular components which simplify the process and ensure rapid and dependable breaking. The regular explosive system in use has the merit of being familiar to miners, who see this as an extension of normal blasting.

## Explosive (TEP)

The threshold blasting concept is well illustrated in Figure 1, which is the outcome of tests done at AEL's Modderfontein laboratories using small masses of different emulsion explosives confined in 50 mm internal diameter steel pipes. The expansion, and rate of increase in expansion of the pipe, are minimal for charge mass from 10 g to 20 g. However, between 20 g and 30 g, threshold conditions develop: expansion for the most energetic formulation increases from about 9% to about 60%, which represents the beginning of bursting of the pipes. Lower strength formulations produce

# Threshold blasting: the renaissance of explosives in narrow reef mining

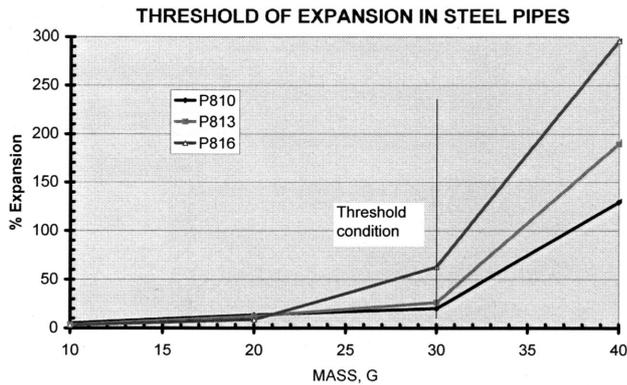


Figure 1—Effect of increasing charge mass in steel pipes

less expansion at the same mass, but show similar trends as the mass increases. The current proving venues use AEL's Magnum™ 365 explosive, a cartridged high sensitivity, high strength emulsion. This is to meet the second requirement previously listed. The charge used is typically one cartridge, either of 25 × 200 mm, or 32 × 200 mm.

## Initiator

It is catastrophic for productivity and efficiency to encounter poor breaking, as this not only upsets face shape and forces reworking of ground, but results in temptation to reduce burdens, increase charge mass and generally abandon threshold blasting. The Smartdet™ electronic detonator system is ideal for proving conditions, as its high robustness, flexibility in programming and full testability eliminate any concerns about performance and fulfil the penultimate condition listed. The Electrodet™ system is also good, as it has full two-way communication, is cheaper, and has a rapid multi-access connecting system. Pyrotechnic initiators will not deliver acceptable results, since they cannot guarantee sequential firing, are not testable, and add toxic fumes to the environment.

## Stemming

A range of stemming materials and methods has been considered, and will continue to be evaluated, since the variety of approaches is almost endless. Table I shows the results of pull-out tests done on various materials. It should be noted that pull-out force does not necessarily correlate with the push-out resistance of stemming. The Max Plug, for example, provided good retention of gases in many blasts, but was vulnerable to changes in hole diameter.

Besides good results achieved with sand stemming, practical issues related to the mechanized and fast placing of the sand in the hole still need to be solved.

## Coupling

Although this aspect is important, and indeed critical where propellants are used, the development of the threshold Blasting technique has not yet concentrated on evaluating it, and the results to date have excluded any coupling material. The reason for this is that it would add to the complexity of the system at a time when the key issue is to improve the cycle time. Many coupling materials are available, and have been tried in early tests, and once a quick and simple system

is complete, it will be introduced. It will have the beneficial effect of reducing an already low charge mass.

## WYSIWYG—A step into continuous mining

The principle that 'what you see is what you get' can be applied in threshold blasting, since the blast is over, and environmental parameters are usually back to normal within 5–10 minutes. The team can then begin making safe, helping with any cleaning operations or installing the support while the miner can inspect the undisturbed blasting results and involve the team in learning about the outcomes of their work, and making decisions on the next blast.

Corrective action takes place when geological and physical properties are changed i.e. if a dyke is encountered, the rock strength changes, or the shot holes to be blasted are tightly confined. The key variables to address are the explosives charge mass, the burden and the hole length, and different situations will dictate which of these is appropriate. A good general guide to the ease of breaking is the powder factor attained: that is, the cubic metres of rock broken per kg of explosive. Figure 2 shows a powder factor plot for a long threshold blast, for top and bottom holes. Since the same charge is in every hole, the fluctuation reflects drilling problems.

## Size of batch to blast

Older, continuous mining concepts were based on the principle of firing propellant-loaded holes two at a time in 4-minute cycles. More recently, some have extended this up to

Table I

### Stemming pull-out trial results\*

Type of stemming	Comment	Pull force
Double washed river sand (wet)	Single load ± 0.5 kg	700 kg
Double washed river sand (wet)	Double load ± 1 kg	> 1000 kg
Double washed river sand (dry)	1 kg	> 1000 kg
Crusher sand (wet)	Single load ± 0.5 kg	
Crusher sand (wet)	Double load ± 1 kg	> 1000 kg
Crusher sand (dry)	(dry) 1 kg	> 1000 kg
Bentamp clay	5 capsules	200 kg
Max Plug		No resistance
Soudal foam		250 kg

N.B. Sand loaded with ANFO loader of 4.5 mm orifice, loading time ±25s

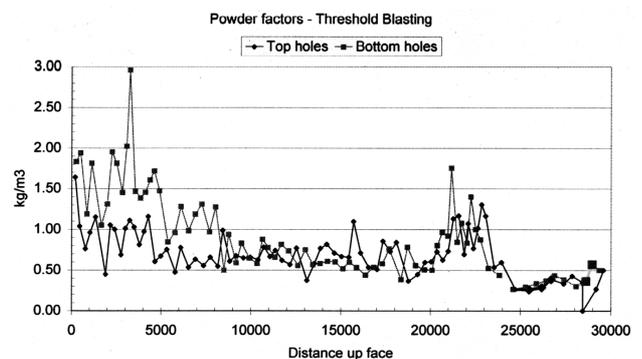


Figure 2—Results of blasting a 30 m panel in several batches. Top holes initially had higher charge masses. The fluctuations are mainly caused by burden variability

# Threshold blasting: the renaissance of explosives in narrow reef mining

6 holes at a time. However, with threshold blasting, using electronic detonators, the batch size is infinitely variable, up to the full stope length. This is a really vital enhancement, as it provides the capability to tailor the work cycles to fit changing conditions and needs.

The following factors must be considered when a decision is made on the size of the blast:

- ▶ *People fatigue*—frequent evacuation of the crew to a safe place can lead to enormous fatigue caused by walking and crawling in the confined space (stopping width 0,9 to 1,2 m) and sometimes through cluttered areas
- ▶ *Cleaning capabilities*—the present scraper cleaning system can clean the face at 15 t per hour, and when assisted by a water jet, at up to 25t/hour. Application of the scraper system will depend on the face shape, configuration and rigging method
- ▶ *Drilling capability*
- ▶ *Explosive system*, relative to the ventilation district conditions and the ability of the ventilation system to dilute gases.

With these points in mind, and following tests and environmental observations, current thinking is that each batch blast should consist of between 25 and 40 holes, depending on the face layout and configuration. However, some mines are attempting to blast 20 to 25 m long panels using threshold blasting ideas. The real danger of threshold blasting is apparent here, and that is the possibility that, in the determination to achieve production goals under stress, the miner may break out of the rules for safe production and begin to blast through the shift without limiting explosive per hole or number of holes. It is vital that controls be put in place to prevent this happening, and AEL is working on a system which will not only facilitate rapid priming, loading, stemming and blasting, but will automatically ensure that agreed threshold energy is used, with the cleanest possible fumes.

## Current constraints

The outstanding feature of threshold blasting is that when applied correctly it breaks rock safely and effectively, doing what it is supposed to do. However, the following vital constraints need to be taken into consideration.

- ▶ The system requires independent ventilation districts.
- ▶ A high quality and efficient local ventilation system must be in place.
- ▶ Personnel need good knowledge of explosives and blasting so as to be able to introduce changes and modification if blasting efficiency drops.
- ▶ There is a lack of suitable narrow reef equipment for mechanized and automatic drilling, charging-up and blasting. This is true for all blasting operations and not just threshold blasting.
- ▶ Legal constraints:
  - re-entry time: DME permission
  - multi-blast conditions permission
  - explosives cutting permission if this is necessary during trials
  - permission to charge up, while drilling operation is in progress

- safe distance from blast where crew can be evacuated
- requirements for design of the temporary waiting place
- alarms and warnings to ensure the zone is cleared.

To resolve the above constraints and requirements will be a time-consuming work and will possibly require some changes in current mining legislation.

## Results

During testing the charge mass was reduced in steps from 200 g of Magnum™ 365 per hole. It quickly became evident that there were two distinct thresholds: the breaking threshold and the movement threshold. At 150 g of explosive, the explosive was breaking and moving the rock. At 120 g however, it was breaking the rock, but the broken ore was lying in a pile against the new free face. These thresholds will be different for different explosives, conditions, hole diameters and burdens.

Currently, thousands of holes have been blasted, and the main effort is now on reducing the cycle time and arriving at an appropriate explosive system. There have been few problems around breaking ground: the main challenge is the normal one of keeping up momentum while stopes and personnel experience change.

## Environmental observations

Blast fumes were closely monitored on two different mines during threshold blasting operations.

- ▶ The levels of harmful gases as CO and NOx were very low and reverted to below legal limit within 5–10 minutes. These measurements were conducted 20 m to 30 m from the blasted face in the return airways.
- ▶ The dust level was higher than expected but reverted to legal limit immediately when sprays were used.
- ▶ The noise level was high but of short duration: proper use of hearing protection eliminates this noise problem.

Average data recorded during 4 batch blasts is presented in Table II.

These results are clearly encouraging, since no special measures were taken to contain the environmental effects. All values could be further reduced with conventional measures.

## Proposed continuous mining system and methods

At present no fully mine-worthy systems have been implemented but teams have been trained and are producing ore while consideration is given to layouts for concentrated

	CO ppm	CO <sub>2</sub> ppm	O <sub>2</sub> %	NOx ppm	SiO <sub>2</sub> dust mg/m <sup>3</sup>	Noise dB
Before blast	nil	700	20.5	nil	0.0613	70
During blast	< 60	2250	20.5	< 3	10.192	114–120
5–10 min after	nil	850	20.5	nil	0.0808	75
<b>Legal limit</b>	<b>100</b>	<b>5000</b>	<b>19</b>	<b>5</b>	<b>0.1</b>	<b>85</b>

## Threshold blasting: the renaissance of explosives in narrow reef mining

and continuous mining under threshold blasting. The following parameters define how it will need to be implemented for continuous mining:

- ▶ Size of the blast to be matched with the cleaning capabilities of the equipment used
- ▶ Times of evacuation of the crew for blasting and distances to be walked shall be limited
- ▶ 24 hour operation
- ▶ The crew change-over needs to be done on the face if possible
- ▶ Panel or panels operating in independent ventilation districts
- ▶ Most of the tasks shall be mechanized and where possible automated
- ▶ Minimum people working on face
- ▶ Multi-skilled crew to allow for rotational changes.

A number of alternatives are under consideration, but the simplest and most readily implemented is to mine on dip.

### Down- or up-dip method

In this method:

- ▶ The face length can equal the spacing between cross-cuts, which depending on the mine design can be between 60 and 90 m. This will allow for separation of the drilling and blasting operations
- ▶ Strike development is limited to one or at most two gullies per raise connection, which significantly reduces time for ledging and equipping
- ▶ Ventilation conditions are also improved as it is possible to cut more independent ventilation districts and optimize dilution of the blasting gases
- ▶ The stope drill rig is powered by compressed air or hydropower, and is rail-bound to foster a straight face.
- ▶ Blasting is in batches of 20–30 holes, with the blast crew retiring to a nearby place of safety
- ▶ Cleaning is by specially designed scraper or scraper scoop.

Figure 3 illustrates a stope layout currently in use.

Envisaged labour allocation is for 8 personnel working in pairs: drilling; charging-up and blasting; cleaning; and support and logistics.

In 3 minutes the rig should drill a set of 2 holes, index to the next position and begin collaring. If this is sustained, it should be possible to drill, charge and initiate a batch of 30

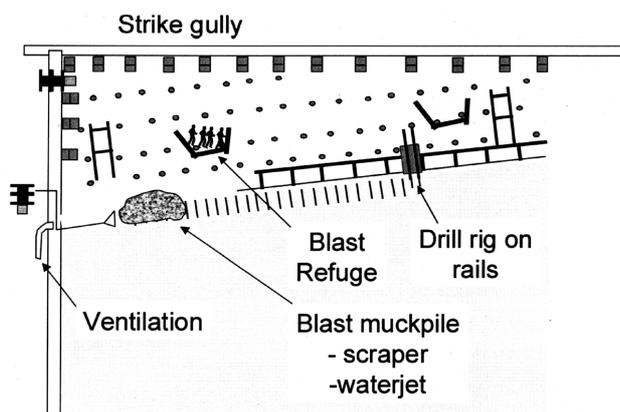


Figure 3—Threshold blasting layout for down-dip panel mining

holes every hour, giving 5m<sup>2</sup> for an advance of 1.0 m and a burden of 33 cm (which is very conservative). In reality, the blasting rate will be slower than 1 hour, at least during system development and with the normal unpredictability of mining operations. If 4 to 5 blasts could be taken in a 6 hour shift, there would be 18 blasts per day for 24 hour operation. If the blasting efficiency is only 75%, ± 70 m<sup>2</sup>/ man can be obtained.

At the time of writing, three blasts per six hour shift are frequently achieved with every indication that this will improve.

### Economics of threshold blasting

The outstanding achievement of threshold blasting, is that it works. There is no question over the ability to break hard rock effectively. The key question is whether this process is economic and profitable.

The viability of threshold blasting will be judged on whether it can produce more net value per day from a given mining area. Value needs to be seen in its most skeletal form: money generated per day, per mining unit (eventually across the mine, but in this case, per stope). Working cost must be aligned with this: the money outflow per day, per stope.

The focus is therefore on two fronts: metal value released per day, and daily cost of supplies and services. The sole determinants of value released per day are the grade, the number of holes fired, and the tonnage per hole. The greater the value released, the better will be the utilization of capital.

### Grade and number of holes

The grade is typically diluted slightly by conventional blasting, through overbreak, the creation of fines and such. These losses are not scientifically definable, but would probably not be less than 5% of what would be won with the tighter control afforded by threshold blasting. This implies that threshold blasting would have the same effect as increasing grade by 5%, or whatever amount would be agreed by those carrying responsibility.

The number of holes fired per day depends on the nature of the drill rig, the drilling technology, the site characteristics, the ability to charge, stem, blast, and make safe, and the motivation of the crew. This will vary from site to site and should improve with evolving capabilities. However, drilling capacity is likely to be a constraint. In addition, the cost of drilling, while not usually visible, is one of the greater components of direct working costs. For this reason every hole needs to count.

### Tonnage per hole: a key economic parameter

Tonnage per hole is controlled by (a) the burden, and (b) the hole length, assuming narrow reef conditions and a full break. Assuming length is not a variable in an operating stope, burden is the sole determinant of value per hole, which is therefore directly proportional to the burden. Thus for a gold mine working at 9 g/t, with 1.2 m stoping width and 1.1 m advance per blast, with 2 rows of holes at 0.3 m burden, the value per hole is R367 for a R/\$ rate of 8. If the burden is opened up from 0.3 to 0.4, the value per hole increases to R489. Figure 4 shows this inescapable relationship.

## Threshold blasting: the renaissance of explosives in narrow reef mining

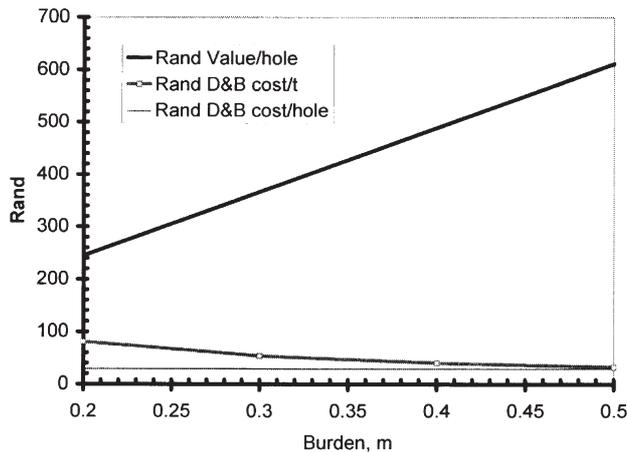


Figure 4—Value per hole and drill and blast cost relative to drilled burden for full breakage

However, there is a second crucial influence of burden on value released, which is its effect on tonnage released per unit of time. In threshold blasting, the drilling rate and cycle time are linked, with the number of holes per hour determined primarily by the chosen cycle time. For a fixed number of holes, the burden determines the tonnage per cycle.

Thus burden not only affects the value per hole, but the value per cycle. Assuming a 50-minute cycle to drill and blast 14 holes, with the system not bottlenecked by cleaning, then for the above example, the Rand value of ore released is R5138 per cycle for 0.3 m burdens, and R6850 for 0.4 m burdens. What is intriguing here is that within a given range, the explosives and drilling cost per cycle does not change with burden, so ability to expand the burden is ability to gain free value.

### Drill and blast cost

Direct costs are also impacted by the burden: the cost per hole is the same, so the more the burden, the less the cost per ton. As burden increases, revenue per hole increases and cost per ton decreases, within the limits of the blasting system being used. The result is a sharp divergence between cost and value released per hour, which can be thought of as the net available value of the broken ore on the stope floor. This is illustrated in Figure 5.

In regarding this scenario the key assumption is that as burden increases, full breaking takes place and there are no negative effects. Clearly, if the full advance is not pulled, things go in the opposite direction: the costs per ton escalate, the cycle time increases owing to remediation, and value per hour sinks. It is therefore absolutely critical to have complete control over the blasting operation, and this requires the following:

- consistently accurate drilling, which ensures that the average burden is not much different from the maximum burden achieved
- consistent energy output per hole, which is dependent on the type of explosive and stemming method
- entirely dependable initiation of the holes, which means no misfires and no out of sequence firing. In practice, this means dependable electronic detonators

(it should not be assumed that all electronic detonators are sufficiently dependable for this application).

These requirements do increase the cost per hole relative to conventional blasting, but by an amount which is insignificant in relation to the value generated. If any requirement is not met, it will result in having to reduce the burdens, and this will send the economics of the operation into reverse.

These are the fundamentals of the economics of threshold blasting: the need to break the maximum burdens, and to blast the correct tonnage to achieve the most efficient cycle time.

### Conclusions and recommendations

Not only is the explosive consumption in threshold blasting a fraction of what is normally used, but the breaking results are what the industry have always sought: low overbreak, full advance and minimal ore fines. One of the most common reactions when observing the success of this process, is to question why conventional blasting has continued over the years. There are a number of components in the explanation. Chief amongst these is the lack of control in conventional underground blasting operations. Threshold blasting does not work if the drilling accuracy is poor, if initiation is out of sequence, or if the stemming is not conscientiously undertaken. These technical issues can be overcome, but the need for a trained and willing work force remains.

A second issue is that explosives costs are a small portion of operating costs and therefore have always had a low priority relative to the need to get the tonnage out every day. There is also the need in many mines to throw the rock into the gully, which requires significantly higher loading.

An endemic problem, is the pressure on managers to deliver tonnage daily with increasingly scarce resources. Threshold blasting is possibly the cheapest and most easily assimilated of all new rockbreaking technologies, but it cannot work safely and efficiently unless it is implemented with an orderly and patient determination, without suffering attempts to reduce costs before it is established, transferring trained personnel away and moving the project around the mines so as to not 'get in the way of production'.

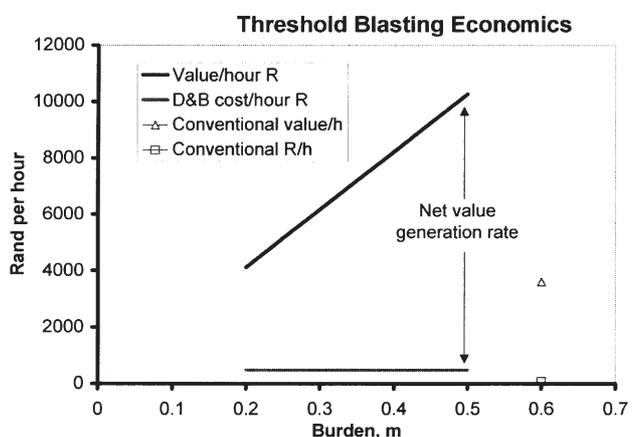


Figure 5—Effect of burden on hourly value release rate and cost. Approximate equivalents for conventional blasting, once per day, are included

## Threshold blasting: the renaissance of explosives in narrow reef mining

The key to implementing the technology is firmly to hold in view two things, and not to waver:

- ▶ the economic justification, which is easily understood and is compelling
- ▶ the fact that threshold blasting has the best intrinsic capability of any method: clean gases, outstanding breaking capability and natural affinity for mining teams. If this cannot work, it is hard to imagine what can.

It is particularly crucial to understand the importance of sustaining a wide drilled burden, so as to maximize the rate of ore production and to minimize the cost per ton.

It is also vital not to permit the technique to degenerate into conventional blasting with personnel present.

The development road ahead is long and rising, but we have a technique which requires relatively small investment and which can be adopted by any small- or

large-scale operation.

### Acknowledgements

The authors thank the management of African Explosives Limited and AngloGold Limited for permission to present this paper. A large number of people in both organizations have been involved in the work, which is proceeding with interest from the wide mining industry, and reports direct from operating mines are likely to be published in the immediate future.

### References

- CUNNINGHAM, C.V.B. Threshold Blasting: reinventing the application of explosives for narrow reef mining. *NIXT conference on new developments*, Modderfontein. Van Rooyen, F. *National Institute for Explosives Technology*, 23 November 2000. pp. 63–68. ◆

## XIV INTERNATIONAL COAL PREPARATION CONGRESS AND EXHIBITION

### Invitation to Members of the SAIMM

The SAIMM and the South African Coal Processing Society are hosting the XIV International Coal Preparation Congress from 11 to 15 March 2002.

South Africa is a coal country with reserves of 55 billion tons, mining some 300 million tons per annum and exporting some 66 million tons in 2001. We rank third as a coal exporting nation and as the fifth-largest coal mining country. It is therefore appropriate, besides being a great honour, for South Africa to host the Congress and to be able to showcase our industry.

Our industry is an industry in change. We are experiencing rationalisation in ownership of the mines, while at the same time we see the emergence of smaller Black empowerment operations. Legislation in respect of ownership of mineral rights is undergoing reform. Export capacity is growing. We are experiencing competition from gas from Mocambique for the first time. More and more mines are becoming multi-product mines as the quality Witbank-Highveld reserves are depleted. Our anthracite and coking reserves are small yet there is strong demand for these special coals.

These changes present numerous challenges to the industry especially in the area of coal preparation. The collaborative research programme Coaltech 2020 has as one of its objectives the extension of the life of the Witbank-

Highveld coalfield using input from a number of disciplines. The Coal Preparation Engineer has an important role to fill in this research programme.

The Congress will be addressing many of the issues pertinent to the changing coal industry in South Africa.

Members of the SAIMM with interests in this important industry are invited to attend the Congress in order to gain first-hand knowledge, from international experts, on up to date developments in coal beneficiation, the use of flotation and spirals for the recovery of fine coal and the use of new generation jigging and laboratory technologies. Other topics include the environment, power generation, dewatering of fine coal, modelling and quality control, analysers and research programmes.

A large contingent of Coal Preparation Engineers from the thirteen participating countries will be attending. Members will have the opportunity to meet with these delegates in order to gain further knowledge of this international industry and to establish and exercise network opportunities.

For more details please contact the Manager Ms Sam Moodley at the SAIMM offices on 011 834 1273 or sam@saimm.co.za

A.A.B. Douglas  
SAIMM, President

