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The application of short-delay electric blasting in an up-dip stope

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SYNOPSIS

A series of blasting experiments was carried out in an up-dip stope of a gold mine using short-period-delay electric detonators. The main object of the investigation was to show the interactive effects of short-delay blasting.

The delay range over which observations were made was restricted to between 10 and 200 ms. To quantify the blast results, data were collected on fragmentation, throw, position of muckpile, and ground vibration. For comparative purposes, blasting parameters for conventional pyrotechnic sequential firing were also measured.

The paper describes the most relevant parts of the study and gives the experimental results. The interactive effects of short-delay blasting are analysed, and some aspects of the breaking mechanism are discussed.

SAMEVATTING

Daar is 'n reeks skieteksperimente in 'n styghellingafbouplek van 'n goudmyn uitgevoer met gebruik vn elektriese kortvertraging-springdoppies. Die hoofdoel van die ondersoek was om die wisselwerkende gevolge van kortvertraging-skietwerk te toon.

Die vertragingsbestek waaroor waarnemings gedoen is, is beperk tot tussen 10 en 200 ms. Ten einde die skietresultate te kwantifiseer is daar data oor fragmentasie, valafstand, posisie van die laaihoop, en grondvibrasie versamel. Met die oog op die vergelyking is die skietparameters vir konvensionele pirotegniese opeenvolgende afskieting ook gemeet.

Die referaat beskryf die mees toepaslike dele van die studie en gee die resultate van die eksperimente aan. Die wisselwerkende gevolge van kortvertraging-skietwerk word ontleed en sommige aspekte van die breekmeganisme word bespreek.

Introduction

Rock breaking as practised in the stopes of South African gold mines is an important element of the production cycle. Depending on the layout of stopes and the stoping method used, from 20 to more than 100 shot-holes may be blasted during rock breaking in a single stope. In order to achieve an acceptable breaking efficiency, these shot-holes must be detonated with certainty and in strict sequential order. This sequential firing is achieved at present by the combined use of safety fuses and igniter cord, and is generally referred to as a pyrotechnic sequential firing.

Investigations carried out by both the Research Organization of the Chamber of Mines[1] and AECI Limited[2] have shown that misfires and out-of-sequence firing can result in disruption of the production cycle, a loss of 20 to 30 per cent in potential planned production, and damage to support, hangingwall, and scatter barricades. The causes of failures and out-of-sequence firing were found to be the different performance of blasting accessories in an underground environment compared with their performance on surface, variations in the specific characteristics of the accessories, poor face and hangingwall conditions, and bad blasting practice.

With continued research, the effects of some of the above causes may be reduced. However, there are some causes inherent in the fuse–igniter cord system that are not likely to be eliminated. The most important of these is that the time interval between adjacent detonations is extremely variable. Furthermore, to eliminate out-of-sequence shots as far as possible, the nominal delay between individual shots is of the order of several seconds, thus eliminating any dynamic interaction between individual shots.

From development and opencast blasting it is known that significant benefits can be obtained if the time interval between individual shots is short enough to allow for dynamic interactions. These interactions can affect a number of parameters that characterize the blasting results. In view of the potential advantages of short-delay blasting, a study was conducted to identify the critical parameters and to assess the benefits that are likely to be obtained.

This preliminary study covers only the most important aspects of short-delay electric blasting in stopes, and was designed primarily to test the experimental method used. It was expected that the study would yield information regarding the application of short-delay electric blasting in stopes and results that could be useful in the planning of further experimental investigations.

Details of the Experiments

The experiments were designed to be carried out in a stope where the relevant blasting parameters could be studied under reasonably controlled conditions. To this end, a stope was made available for the experiments at Two Level (180 m below surface) of the West Shaft at West Rand Consolidated Mines. The layout of the up-dip experimental stope is shown in Fig. 1. The length of the stope face was kept at 15 m and the stoping width at 1 m throughout the experiments. For each advance, approximately forty-five holes each 1,2 m long were drilled at an angle of 70 degrees to the face of a staggered pattern. The accuracy of drilling was ensured by the use of a drill rig.

The whole face blast was completed in five steps, as shown in Fig. 1. During the first step, the first 3 to 5 holes

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at the loose end were blasted by conventional methods to remove the weathered and loose rock. The blasts in the second, third, and fourth steps were designated to be the experimental blasts. Each step, corresponding to a bench, consisted of the blasting of ten holes over a 3 m length of the face. During the fifth step, the remainder of the face was blasted conventionally to give a 4 to 5 m clearance for the positioning of the connection board.

The BM 125 instrument is a sequentially controlled capacitance discharge-type precise timer with ten individually controlled circuits. It is capable of providing twelve different delays in the range 10 to 200 ms.

So that the results of conventional and short-delay electric blasting could be compared, and the type and degree of interaction that takes place during short-delay blasting could be studied, the parameters fragmentation, throw,

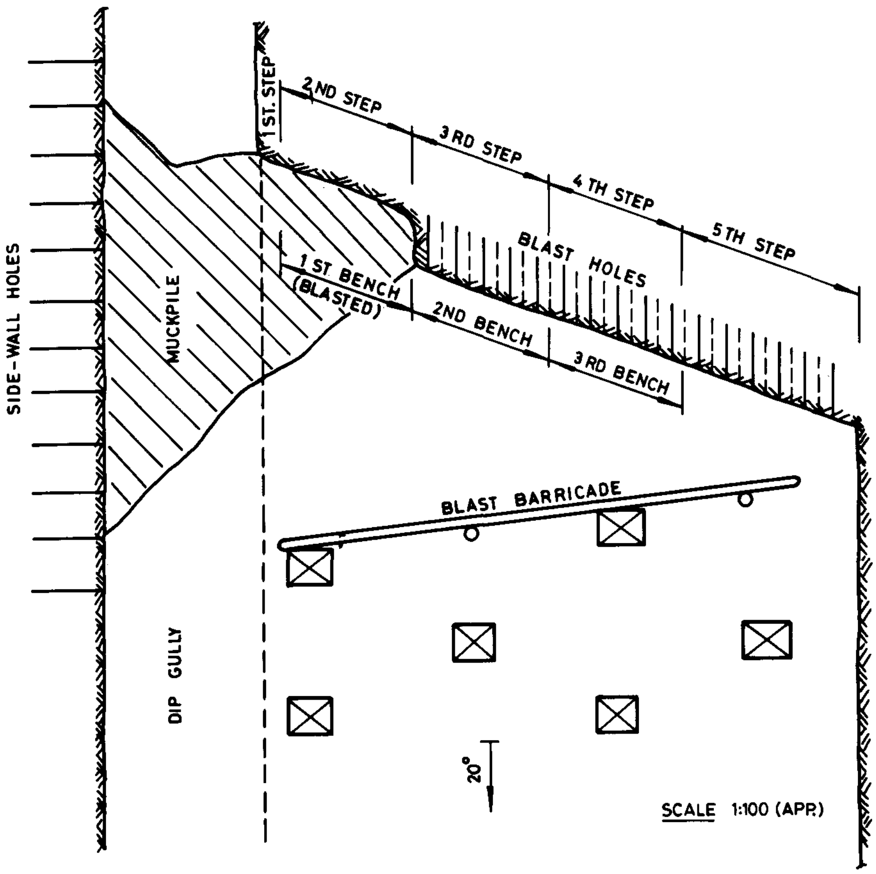

Fig. 1—Details of the experimental stope

Throughout the experiments, the various elements of blasting, excluding the delays, were kept constant and the blasting standards of the mine were adhered to. Benches 1 to 3 were advanced twice by blasting with conventional methods, and ten times by short-period-delay electric blasts (Table II).

Since the number of different electric short-delay detonators that were available immediately was very limited, a BM 125 sequential timer, in combination with short-period-delay electric detonators (Table I), was used for initiation in the short-delay blast experiments.

position of muckpile in the gully, and ground vibration were measured for each blast. In addition, information was gathered by an inspection of the length of sockets left after each blast, the degree of overbreak, and the damage to the hangingwall, support, and barricade. The methods of measurement used are described below.

Fragmentation

Screening was used for the size classification of blasted rock. Samples taken systematically from both the stope and the gully were passed through a set of four screens

TABLE I
DELAYS AND TYPES OF DETONATOR USED DURING THE EXPERIMENTS

Experiment no.	1			2			3			4			5			6			7			8			9			10		
Bench no.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Nominal delay — BM 125, ms	200	200	200	150	150	150	100	100	100	80	80	80	60	60	60	50	50	50	40	40	40	30	30	30	20	20	20	10	10	10
Type of detonator	16	16	16	14	14	14	11	11	14	9	9	9	9	9	–	5	5	5	4	4	4	3	3	3	0	0	2	1	1	0
Nominal delay — electric detonators, ms	615	615	615	470	470	470	310	310	470	235	235	235	235	235	175	115	115	115	90	90	65	65	65	0	0	0	45	25	24	0
Average distribution	67	27	27	8	3	4	9	5	8	2	4	2		4	4	4	2	5	20	22	28	5	5	5	0	0				0

with apertures of 115, 65, 25, and 12 mm. Screening carried out after each bench blast yielded mass percentages from which average mass percentages were calculated for each face advance.

Throw

To compare the quantity of broken rock thrown into the gully with that left in the stope for each blast, the following procedure was used. The total volume and mass of the rock to be blasted was calculated from the data received from surveying of the face prior to that particular blast. After the blast, the survey of the muckpile provided information on the three-dimensional profile of broken rock in the gully. From this information, the volume and mass of blasted rock thrown into the gully were calculated. The density of the broken rock was derived from the mass of blasted rock collected in a pan (dimensions 1 × 1 × 0,2 m) placed in the gully before the blast.

For the throw, the distances between the gully and the centre of the bench for each bench blast were measured. The angle between the face and the line that confined the broken rock in the stope was recorded for each bench as the throw angle.

Position of Muckpile

The spatial distribution of broken rock in the gully was measured as follows. Holes 1 m apart and 1,5 m above the floor were drilled into the gully side-wall (Fig. 1), and a steel rod with chains hung at 0,25 m intervals was inserted into each hole. The differences in the length of the free chains before and after the blast were recorded, and the distribution of the broken rock was plotted on the plan of the experimental area.

Ground Vibration

A Sinco S-2 ground-vibration monitor was used to measure and record the degree of ground vibration caused by the short-delay blasting. The monitor consists of two transducers and a control unit incorporating a seven-channel recording oscillograph. Each transducer contains three orthogonal velocity-sensitive geophones orientated vertically, longitudinally, and transversely. The transducers were installed at distances of approximately 8 and 60 m to the blast, respectively.

Results of the Experiments

A summary of some of the experimental results is given in Table II. The most important results are discussed in more detail below. It should be noted that no damage to the hangingwall was noted throughout the experiments.

Fragmentation

The size distribution of the broken rock resulting from various delay blasts is presented in Table III. It is difficult to deduce characteristic trends from these results, on which geological discontinuities may have had an influence. However, there appears to be a decrease for particles larger than 115 mm, and at least not to be an increase for particles smaller than 12 mm as the delay interval reduces.

Throw

The mass percentages of the broken rock in the gully after various delay blasts are depicted graphically in Fig. 2. As seen, the effect of short-delay blasting on throw started around 150 ms. At a delay interval of 80 ms, the effect was more pronounced. Beyond that point, the effect of shorter delays on the overall throw became less significant.

Position of the Muckpile

Figs. 3 and 4 show two representative muckpile formations in the experimental area. The diagrams show how the position of the broken rock in the gully changed with delay interval. At longer intervals, the broken rock formed a pile with a uniform height across the gully, its distribution along the gully being limited to a length of 9 m. With a reduction in the delay interval, the scatter of the broken rock became larger along the gully, and the pile became higher towards the side-wall of the gully. In the stope, the angle between the line confining the broken rock and the stope face became smaller.

Ground Vibration

The peak particle velocity was found to be independent of the delay intervals that were employed during the experiments. Fig. 5 shows that the measured duration for the peak particle velocity did not exceed 10 ms, even 8 m away from the blast. The small changes in the amplitudes are due to changes in certain parameters such as stemming, burden, explosive, and rock conditions.

By use of the records of individual shots with the same charge and distance, the following average values were established for peak particle velocities:

Velocity	7,41 mm/s
Displacement	7×10^{-3} mm
Acceleration	1,36 g
Duration	10 ms
Frequency	286 Hz.

Efficiency of the System and Accessories

Compared with conventional blasting, the system used for short-delay blasting resulted in fewer malfunctions such as cut-offs, misfires, and out-of-sequence shots. From 33 short-delay bench blasts, only two cut-offs, due to break-offs in the circuits of the connection board, were experienced. It should be noted that only ten holes were blasted at a time during the experiments on short-delay blasting, and this may have had an influence on the performance of the system. Experience has shown that the system used for short-delay blasting needs improvement for repetitive use underground.

The deviations in the timing of short-period-delay detonators were found to be greater at longer delays. The average deviations are given in Table III.

Discussion

The experimental results show that the delay interval does not affect the fragmentation, throw, and muckpile shapes for conventional blasts and blasts of 200 ms delay. This implies that each shot completed its breakage without being affected by the other shots in the sequence. A change in the blast results was noted first around 150 ms, and continued as the delay intervals were reduced. Therefore, the minimum firing time interval at

TABLE II

SUMMARY OF BLASTING EXPERIMENTS

Experiment no.	1			2			3			4			5		
Nominal delay, ms		200			150			100			80			60	
Face angle, °		79			71			70			70			70	
Bench no.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Blasted length, cm	304	303	274	350	335	270	315	300	290	295	310	290	300	300	310
Av. stope width, cm	100	98	100	98	100	100	100	100	97	100	100	100	98	100	100
Av. hole length, cm	112	110	109	117	120	120	115	120	120	115	120	120	115	118	119
Av. socket length, cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Av. burden, cm	30	30	27	35	34	27	32	30	29	30	31	29	30	30	29
Av. spacing, cm	47	49	49	48	50	50	51	48	50	51	50	48	50	48	49
Throw distance, m	4,5	7,7	10,4	4,6	7,9	10,4	4	6,9	9,7	4,2	7,7	9,9	4,2	7	9,8
Mass of blasted rock, t	9,2	8,8	8,1	10,8	10,8	9,7	9,8	9,7	9,1	9,1	10	9,4	9	0,5	3,1
Mass of thrown rock, t	6,2	5,5	0,6	6,9	7,4	2,1	7,3	4,7	3,3	7,2	7,5	4,9	4,8	3,8	3,8
Mass of thrown rock %	68	63	8	63	68	21	75	49	37	79	75	51	53	40	38
Throw angle, °	51	60	56	55	58	68	48	44	44	42	41	40	40	44	40
Overall throw, %		48			52			54			68			57	
Down-dip throw	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Av. back break per hole, cm		30			10			15			–			12	

Experiment no.	6			7			8			9			10				
Nominal delay, ms		50			40			30			20			10			
Face angle, °		74			70			69			68			72		71	67
Bench no.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		
Blasted length, cm	305	300	295	300	294	291	305	295	300	300	295	290	300	300	300	1500	1200
Av. stope width, cm	98	100	100	100	98	95	100	100	100	100	100	100	100	98	95	100	110
Av. hole length, cm	140	125	115	150	150	150	125	128	129	127	127	129	120	120	120	118	121
Av. socket length, cm	–	–	–	19	10	–	–	–	–	–	–	–	–	–	–	5	12
Av. burden, cm	30	30	30	30	30	29	30	30	29	30	30	29	30	30	30	30	30
Av. spacing, cm	49	50	50	44	48	48	49	53	50	49	51	48	48	48	47	49	51
Throw distance, m	3,2	6,5	9,3	2,8	5,6	8,3	4,2	7	9,7	3,8	6,5	9,2	4,1	7	9,8	15	12
Mass of blasted rock, t	11,3	10,1	9,1	10,6	10,9	10,4	11,9	11,4	10,9	11,3	11,5	10,9	9,7	9,2	9,5	47,8	43,1
Mass of thrown rock, t	8,7	6,7	4,5	6,9	6,9	2,4	10,5	7,4	5,8	9,5	8,6	5,5	7,6	4,1	2,3	22,5	21,1
Mass of thrown rock %	77	66	49	65	63	23	88	65	53	84	75	50	78	44	26	47	49
Throw angle, °	46	47	44	42	50	48	40	40	40	40	40	40	41	43	43	70	75
Overall throw, %		65			51			69			70			50		47	49
Down-dip throw	–	–	–	X	X	X	–	–	–	–	–	–	X	X	–		
Av. back break per hole, cm		7			6			6			–			20			

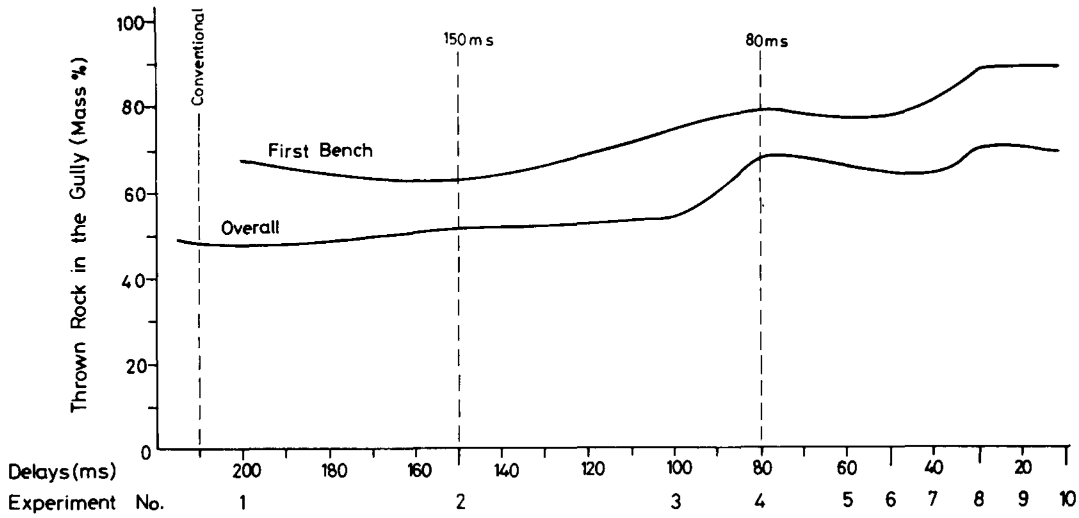

Fig. 2—Change in throw with changes in delay intervals

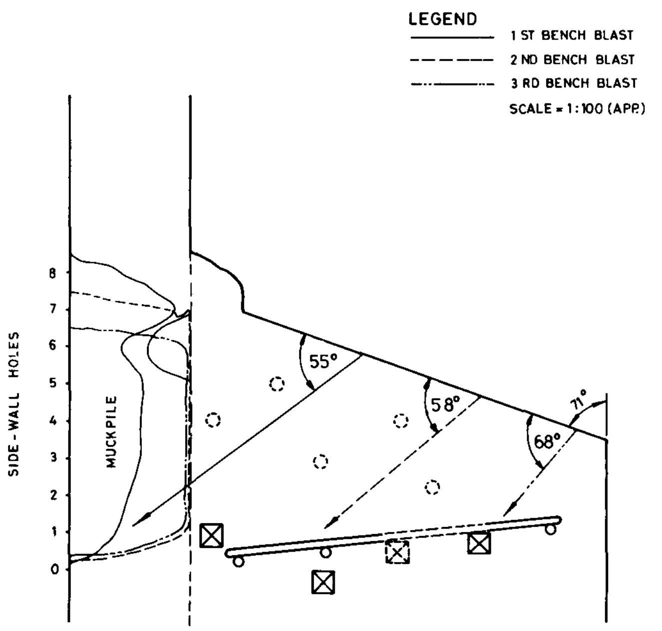

Fig. 3—Position of the muckpile and conditions of the support and barricade after a blast of 150 ms delay (the broken lines represent damage)

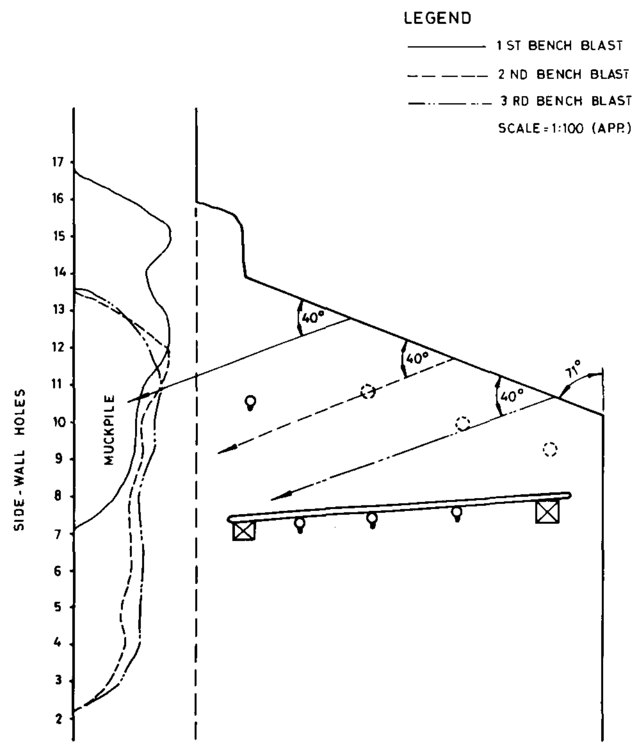

Fig. 4—Position of the muckpile and conditions of the support and barricade after a blast of 30 ms delay (the broken lines represent damage)

which substantial dynamic interactions do not occur between adjacent holes can be estimated as 150 ms under the conditions of the experiment.

It is expected from the research[3-5] that the 'burden escape time' in stoping will be less than 10 ms. By that time, the *in situ* fragmentation process is complete, the cracks have reached the free face, the burden has begun to move, allowing gas to escape from the borehole-crack system, and the stress in the freed rock has decayed to insignificant levels. Any effects of one shot on another at longer time is therefore a 'post-escape' phenomenon, and must be connected to the influence of the air shock or flying rock from later holes on the still-moving rock fragments from earlier holes.

Effect on Production

An increase in the velocity of flying rock fragments was observed in the throw values and muckpile shapes as increasing throw percentages and broken-rock piles close to the side-wall that were longer, narrower, and higher. As the length of face broken increased, the throw angle was observed to decrease, i.e. the throw became directed more into the gully. In up-dip stoping, the changes in throw and muckpile shape can be regarded as favourable. The quantity of broken rock left in the stope was reduced, and consequently the supports and the blasting barricade were protected from the direction of throw. However,

TABLE III
THE DISTRIBUTION OF FRAGMENTS INTO VARIOUS SCREEN SIZES FOR VARIOUS DELAY INTERVALS

Screen sizes, mm	Fragments, % (by mass)										
	Con.	200 ms	150 ms	100 ms	80 ms	60 ms	50 ms	40 ms	30 ms	20 ms	10 ms
+115	51	49	53	67	30	52	47	40	25	50	28
−115 +63					14	16	21	26	33	27	31
−63 +25	22	20	19	15	22	16	23	16	21	14	19
−25 +12	12	14	16	9	19	10	5	11	13	6	13
−12	15	17	12	8	15	5	4	6	8	3	9
Total sample mass, kg	3×400	351	369	362	133	360	386	417	357	513	433

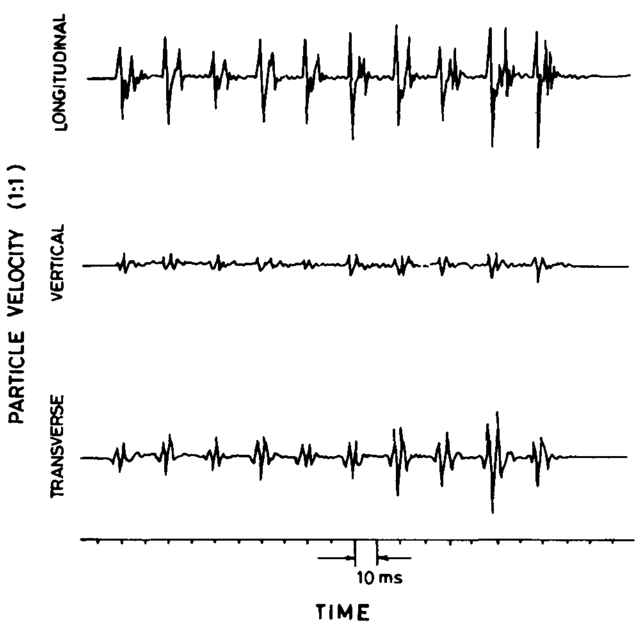

Fig. 5—Records of particle velocity for a blast of 20 ms delay 8 m away from the face

for breast stoping, short-delay blasting may not be favourable. As known, and also as observed during the experiments at longer throw distances, flying rock fragments are trapped by the hangingwall and footwall, and do not reach the gully. The blasted rock in the stope becomes a second obstacle for the throw from the inner part of the face, and consequently the throw percentage is greatly reduced. On the other hand, even at the minimum throw angle (40 degrees at 30 ms), there would be a limiting throw distance beyond which the blasting barricade and the support could not be saved. The damage in that case would be expected to be heavy because the blasting barricade and the supports would be exposed to a large mass of high-velocity rock fragments.

With the suitable geometry of up-dip stoping, the following improvements in mining productivity can be expected from the use of short-delay blasting:

(1) less labour and time are required for the cleaning operations;
(2) the time spent on some of the preparatory work, such as repairing the damaged supports and rigging the scraper rope, could be reduced; and
(3) the even distribution of muckpile along the gully provides better ventilation and reduces operational problems such as access to the gully face.

Alternatively, lighter charging can be employed with short-delay blasting to produce 'conventional' results. In deep-level gold mining, the use of lighter charges has a vital importance for the following reasons.

(a) Heavy charges cause overbreaks and backdamage, resulting in a second set of fractures in the rock, which can cause a deterioration in hangingwall conditions.
(b) Unnecessarily fine fragmentation produced by heavy charges frees more gold, which can be lost during cleaning and haulage.
(c) The contribution of light charges to the ratio of charge/burden could potentially improve the mining productivity by reducing the costs of drilling and explosives.

The fragmentation results of intershot delays do not show characteristic trends that can be attributed to the influence of geological discontinuities on fragmentation. However, it is important to note that the intershot delays did not produce more fines than those produced by conventional blasting.

Dynamic Effect on Ground Control

In the delay range of these experiments, the particle velocity as a result of ground vibration was found to be independent of the delay interval. The characteristics of the particle velocity, such as frequency, duration, and amplitude of short-delay blasting, appeared to be the same as those for conventional blasts. The duration of particle movement was found to be a function of distance from the face. However, for a peak particle velocity of 20 mm/s, the duration was less than 10 ms 7 m away from the shot. This implies that the interaction of ground vibrations is not possible at delays longer than 10 ms, regardless of the number of breaking front holes in the sequence. The important conclusion that can be drawn from this is that short-delay blasting at intervals down to 10 ms should not be expected to cause more vibration damage than conventional blasting.

Conclusions

The investigation showed that the interactive effect of short-delay blasting started at a delay interval of 150 ms. At shorter delay intervals, the interactive effects resulted in the following improvements:

(i) better rock breakage and fragmentation, and
(ii) favourable throw and position of the muckpile under the conditions of up-dip stoping.

The measurements of ground vibrations indicated that the duration of peak particle velocity did not exceed 10 ms at about 7 m from the blast. From this fact it can be concluded that, at a delay interval of more than 10 ms, short-delay blasting does not cause more damage due to ground vibration than conventional blasting does.

It was also observed that the malfunctions that are inherent in a conventional pyrotechnic initiations system occurred less frequently during the short-delay electric-blasting experiments. However, improvements in the electric initiation system and the accessories are essential for production-face blasting.

Acknowledgements

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Residual stresses

An International Conference on Residual Stresses (ICRS) will be held from 15th to 17th October, 1986, at Garmisch-Partenkirchen, Federal Republic of Germany.

The Conference is being organized by

- Deutsche Gesellschaft für Metallukunde
  in association with
- Arbeitsgemeinschaft für Wärmebehandelung und Werkstofftechnik
- Deutscher Verband für Materialprüfung
  and sponsored by
- American Society for Metals
- The Institute of Metals, U.K.
- The Metallurgical Society of AIME
- Société Francaise de Métallurgie
- Society for Experimental Mechanics, U.S.A.
- The Japan Institute of Metals.

The modern design of technical components subjected to static and/or cyclic loading requires consideration and assessment of residual stresses. In previous national and European conferences (1979, Bad Nauheim and 1983, Karlsruhe), fundamental and applied aspects and problems from the multiparametric field of residual stresses were emphasized. In accordance with the aim of the earlier conferences, ICRS will provide an up-to-date comprehensive assessment of recent progress and unsolved problems in the field of residual stresses regarding engineering and materials-science aspects. The Conference will apply a unified approach to all important areas of residual stresses in metals, ceramics, polymers, and composites. The topics of the Conference will be as follows.

(1) Modern methods of measuring residual stresses.
(2) Calculations of residual stress states
(3) Effects of heat treatment, forming, surface treatment, casting, coating, machining, welding, brazing, vapour depositing, and chemical depositing on residual stresses
(4) Effects of residual stresses on fatigue and fracture
(5) Optimizing the benefits of residual stresses in manufacturing processes and design
(6) Safety and reliability problems involving residual stresses
(7) Modern developments in the engineering utilization of residual stresses.

Those who wish to present papers should submit two copies of a photoready-typescript extended abstract (one page 16 by 24 cm, beginning with the title, the author's name and location, including figures and tables) in English to the Conference Secretariat by 10th September, 1985. Authors will be notified of the acceptance of the papers and of further information for the full papers as soon as possible. The abstracts of the papers accepted for presentation at the Conference will be preprinted.

Both oral presentation (25 minutes including discussion) and poster presentation will be provided. Authors are requested to indicate the type of presentation they prefer. The Organizing Committee will be reponsible for the final decision.

English should be used for abstracts, papers, posters, and oral presentations.

The authors of papers selected for presentation will be asked to submit the final verison of their papers by 15th November, 1986 (8 pages including figures and tables photoready). Detailed instructions will be given later.

Enquiries should be directed to

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Adenauerallee 21
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Platinum-group metals

The International Precious Metals Institute (IPMI) announces the Platinum Group Metals Seminar II, which is to be held in Washington, D.C. from 6th to 9th October, 1985.

The following five sessions are planned:

- Mining and Recycling
- Economics
- Automotive Catalyst (Worldwide)
- Applications I
- Applications II.

Table-top mini-exhibits are planned for corporate exhibitors.

The seminar co-chairmen are Mr Juergen Schroeter, Engelhard Corporation; Mr David Fenton, Johnson Matthey; and Mr J. Michael Sharratt, Manville International.

Further programme and registration information will follow in the IPMI *News & Review*, or can be obtained from IPMI, Government Building, ABE Airport, Allentown, Pa 18103, U.S.A. Telephone: 215/266-1570.

Control in hydrometallurgy

Preparations are being made for the International Symposium on Iron Control in Hydrometallurgy, which is to be held in Toronto from 19th to 22nd October, 1986. This Symposium will create a forum for the thorough discussion of the problems and opportunities for iron control in hydrometallurgy. The Symposium is being organized by the Hydrometallurgy Section of the Metallurgical Society of CIM as its 16th Annual Hydrometallurgical Meeting. The Symposium is being organized in association with The Institution of Mining and Metallurgy (U.K.), the Metallurgical Society of AIME (U.S.A.), and the Gesellschaft Deutscher Metallhutten und Berleute (Germany).

This will be a truly international symposium as papers have been received from all six continents. These papers have been organized into sessions featuring

- Process Selection for Iron Control
- Chemical Aspects of Iron Control
- Precipitation Processes
- Impurity Behaviour in Iron Precipitation
- Pickle Liquors
- Iron Solvent Extraction
- Residues and Residue Removal
- Fundamentals of Iron Precipitation.

In addition, other interesting papers will be incorporated into a Poster Session.

The Symposium will offer a choice of two technical tours:

- Kidd Creek's Zinc Plant and INCO's Carbonyl Residue Plant (Timmins, Sudbury)
- Metalcoating (Iron IX), Dofasco's new pickle-liquor circuit, and INCO's new Cobalt Refinery (Toronto, Hamilton, Niagara Falls).

A trade show held in conjunction with the Symposium will feature new iron-precipitation processes and equipment for liquid–solids separation.

Further information can be obtained from
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Sheet metal

Sheet-metal experts are invited to contribute papers to the 14th Binennial Congress of the International Deep Drawing Research Group (IDDRG), which is to be held in Cologne from 21st to 23rd April, 1986 (open sessions) and in Munich from 24th to 26th April, 1986 (working groups). The theme of the 14th Binennial Congress is 'Sheet Metal—Requirements and Solutions'.

As an introduction to the open sessions, invited papers on Manufacturing Processes, Corrosion Protection, Light-weight Construction, Noise Damping, and Recycling will be presented.

Papers for the open sessions are invited on technical approaches and solutions referring to the following topics:

- *Production and Properties of Materials, Status, and Development:* Steel Sheet, Non-ferrous Sheet Products, Coated Products, Metal–Plastic–Composites.
- *Forming Operations:* Equipment and Automation, Computer-aided Techniques, Tool Design, Special Technologies, Quality Control, Scrap Recycling.
- *Testing Methods for Sheet Metal:* On-line Testing, Coated Products, Metal–Plastic–Composites, Prediction of Sheet-metal Performance.

Authors are requested to submit abstracts in English by 1st October, 1985. The abstracts should have not more than 250 words typed on an A4-sheet plus two or three relevant figures. They are to be sent together with personal data to the address given below.

The Organizing Committee will inform the authors within six weeks whether the offered paper is accepted or not. More-detailed instructions concerning the form of the preparation and presentation of the papers will be provided at the same time. Complete manuscripts with not more than 10 A-4 pages including tables and figures will be required by 31st January, 1986.

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