The introduction of concrete sausage packs at Rustenburg Platinum Mines Limited

by S. STONE* (Visitor)

SYNOPSIS

Because of problems encountered with conventional timber supports, a system of concrete sausage-shaped support pillars was tested. The pillars are 3 m long, 0,6 m wide, and between 70 and 80 cm high (the height of the stoping width). They consist of bags filled with a grout of cement/slagment and sand in the ratio of 1:2, and are installed in a staggered pattern 6 m apart on dip and 2 m apart on strike.

These support packs have proved successful, and, although they cost more than the timber supports formerly used (R4,63 per centare supported as against R2,26 for the conventional timber pack), their use is felt to be justified when account is taken of the costs of lost production and low productivity due to the bad hangingwall conditions that occurred with the conventional system.

SAMEVATTING

Vanweë die probleme wat met konvensionele houtstutte ondervind word, is daar 'n stelsel van worsvormige betonsteunpilare getoets. Die pilare is 3 m lank, 0,6 m breed en tussen 70 en 80 cm hoog (die hoogte van die afboudikte). Hulle bestaan uit sakke wat met 'n bry van sement/slaksement en sand in die verhouding 1:2 gevul is en word volgens 'n verspringende patroon 6 m uitmekaar op die helling en 2 m uitmekaar in die strekking aangebring.

Hierdie steunpakke het geblyk suksevol te wees en hoewel hulle meer kos as die houtstutte wat vroeër gebruik is (R4,63 per sentaar gesteun teenoor R2,26 vir die konvensionele houtpak) word daar gevoel dat die gebruik daarvan geregverdig is as die koste van verlore produksie en lae produktiwiteit as gevolg van die swak daktoestande wat met die konvensionele stelsel voorgekom het, in gedagte gehou word.

Introduction

The Merensky platinum horizon in the Rustenburg District lies in the upper portion of the differentiated zone of the norite lopolith of the Bushveld Complex. In this District, the Merensky horizon has been proved over a strike of approximately 220 km, and Rustenburg Platinum Mine is mining in an area approximately 26 km in length and 5 km in width on the dip of the reef. The geological successions in this area are shown in Fig. 1.

The reef dips north at between 8 and 10°. Dislocations such as faults and dykes are rare and of little consequence, but unconformities known as potholes and koppies occur frequently.

Potholes are circular depressions up to 15 m deep and 90 m in diameter. Within these, the distinctive chrome band is not always present. Koppies are circular upheavals of similar dimensions in which pyroxenite disappears, leaving only the chrome band and rendering it unpayable. The economic metals produced after the reduction of the ore consist of all members of the platinum group (platinum, palladium, osmium, iridium, rhodium, and ruthenium), gold, nickel, and copper.

Method of Support

Until three and a half years ago, the mining method used at Rustenburg was the herringbone system of hand lashing and bilby cars, panels of approximately 12 m being drilled and blasted. At present, the mine is busy with a mechanization programme in which panels of approximately 36 m are being scraper cleaned according to normal goldmining practice, and problems have arisen with the supports used, which were 0,6 by 0,6 m timber packs, with 0,6 by 1,2 m timber packs on the gulleys. These problems arose after mining had proceeded for some 60 m on strike, when what is commonly known at Rustenburg as a 'back break' occurred. This happened when a parting plane of 10 to 13 m in the hanging-

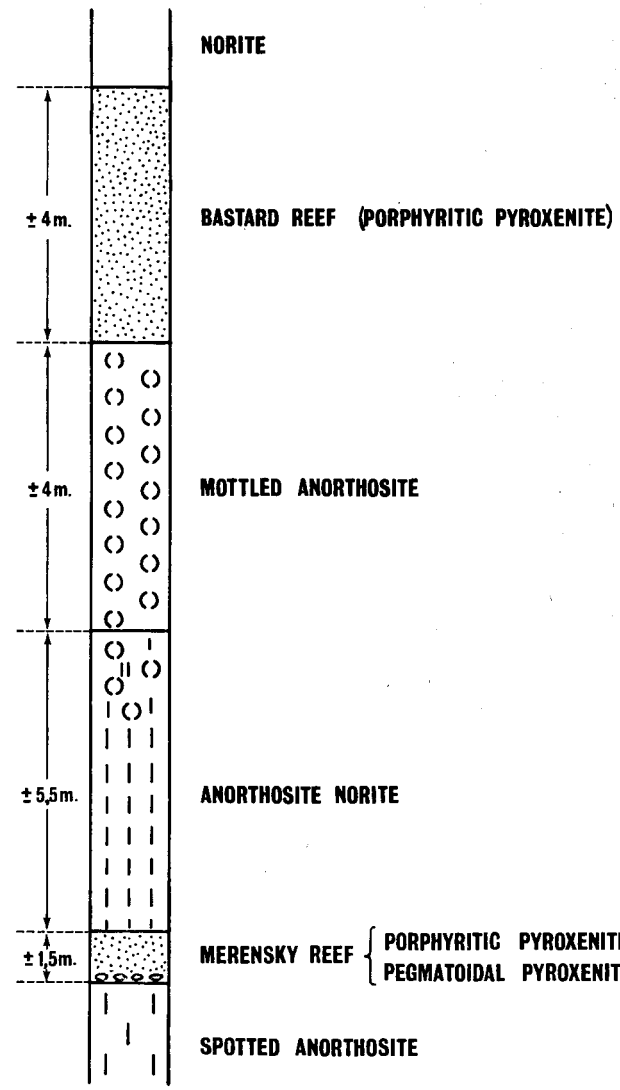

Fig. 1—Section showing the geological successions at Rustenburg Platinum Mine

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wall, which has very little cohesive property, caused a large 'slab' of rock to break away, the only resistance to this being the 0,6 by 0,6 m timber packs used as support. The problem therefore was not one of pressure as is commonly experienced on many gold mines, but was more one of 'dead' mass, which occurs when a supporting beam breaks away.

It was therefore felt that a means had to be found of holding the supporting beam in position and so preventing this 'back break', which caused major delays in production and was also dangerous. As the gold mines of Johannesburg Consolidated Investment Co. Ltd have had much success with grout-filled packs, i.e. normal skeleton packs filled with cement grout, it was decided to use something similar at Rustenburg. Because the stoping width is approximately 75 cm, it was thought that the 'sausage' idea would be more suitable.

Initial Trials

The initial trials were a problem in that sand, cement, etc. had to be transported underground and then somehow dumped or placed in a container so as to form a concrete pillar. As bags were already being used successfully to hold the cement mixture, special bags were made up measuring 3 m in length, and 1 m each in width and height.

Initially, a dry-mix pump was hired, and an attempt was made to pump the sand and cement, which was mixed in the cross-cut below, into the bag in the stope. This was unsuccessful, and a compressed-air placer was then used to blow the mixture into the bag. During the first attempt, the bag was blown to pieces, but by trial and error 5 bags were filled completely.

These concrete pillars, or sausages as they are called, were left for some weeks, and observations were made to determine the results. It was decided that a full-scale experiment was worthwhile, and a cementation company was engaged on a contract basis to pump concrete from the surface. As a longwall stoping system was being established at Frank Shaft, the experiment was started in this area.

The contracting company moved onto the mine and erected pumps, mixers, etc., while the mine installed 25 mm high-pressure piping from the surface down the shaft and on two levels in the longwall stoping area. It was at this point that problems were encountered with the sand that was to be used for the mix.

The contractors, who are operating the crushing plant on the mine, were asked to supply finely crushed rock for the purpose, and, after much deliberation, they managed to produce a quantity of what was required, but it was soon found to be unsuitable owing to its high specific gravity. The mine was therefore obliged to buy sand at R3,30 per cubic metre.

The next problem concerned the use of shuttering to keep the bag in place. At first, sticks were installed to form a 'cage' for the bag, and this worked well in the first experiment because the concrete mix was fairly thick. However, with the mix from the cementation plant, the bag pushed through between the sticks, and instead of increasing in length upwards until flush with the hanging, the concrete became broader and broader so that it formed a pillar approximately 30 cm high, pushed out between the sticks as far as the material could stretch. It was obvious that some kind of shuttering was required. The use of gum planks nailed onto the inside of the sticks was considered but did not prove very successful, and for this reason lightweight steel shuttering frames that could easily be clipped together and used over and over again were made up.

Support System

The complete support system operates as follows.

(1) The Shiftboss of the section concerned estimates how many packs will be required for the following day. He informs the cementation company of the quantity by a requisition and they make up the quantity required. The grout is a mixture of cement/slagment and sand in a ratio of 1:2.

(2) The miner concerned installs the shuttering as required with the bag inside, and the cementation personnel underground inform their colleagues on

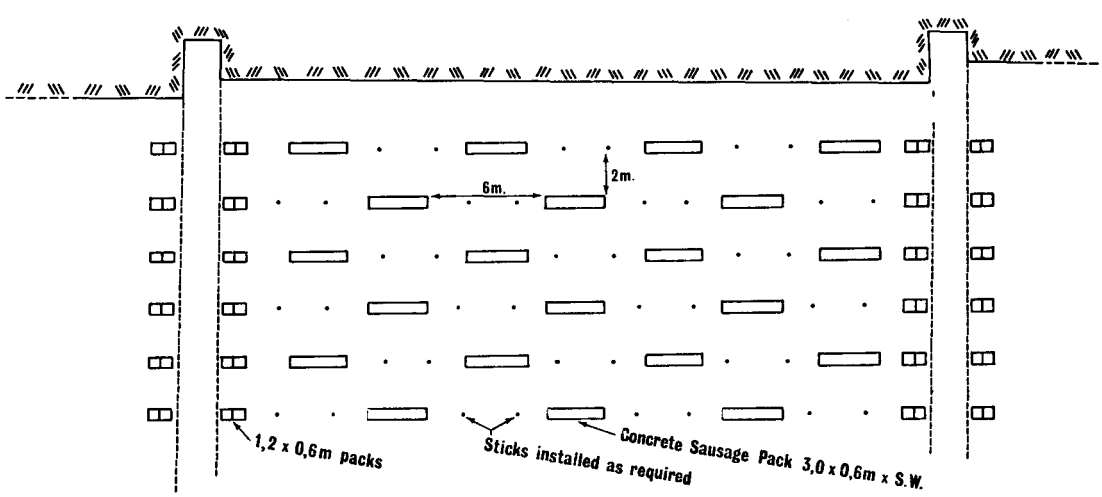

Fig. 2—A panel showing the spacing of the concrete-sausage packs in relation to the additional support provided by 0,6 by 1,2 m packs and sticks

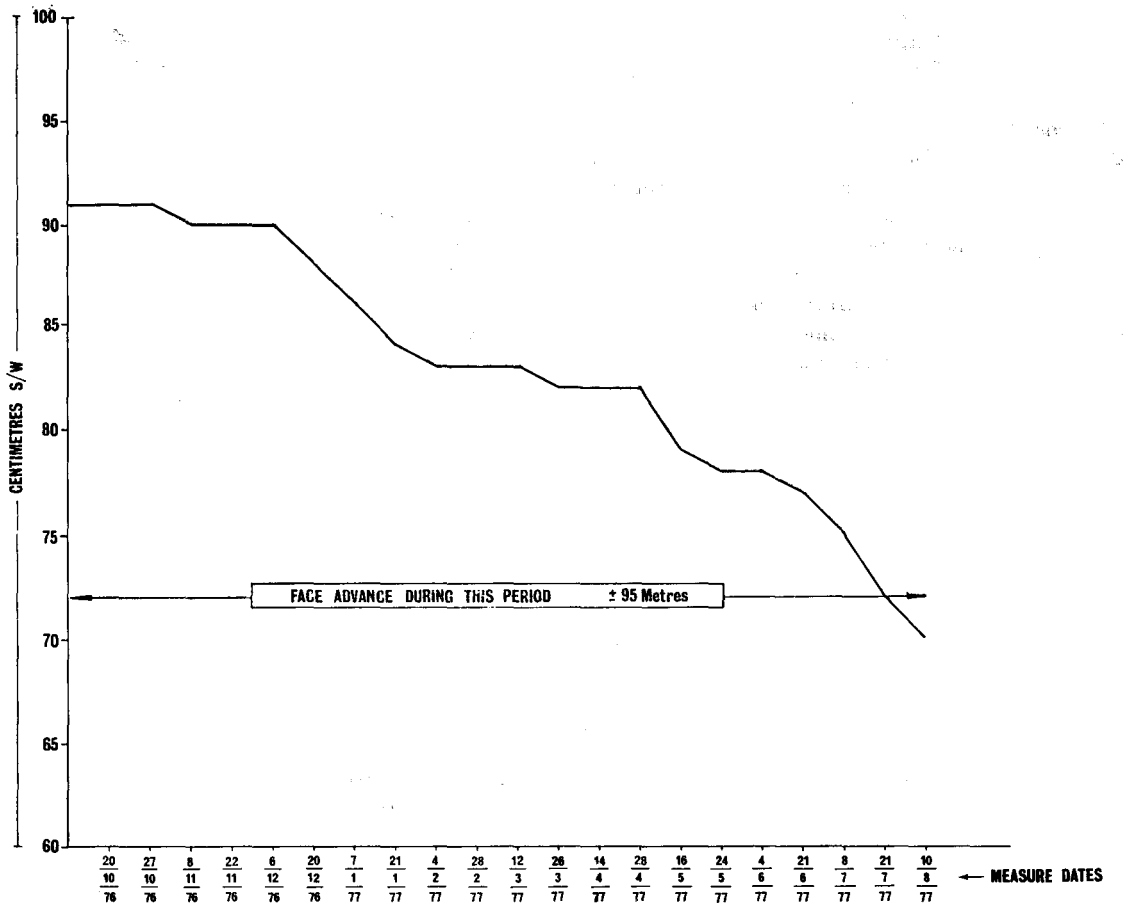

Fig. 3—Graph showing longwall closure

surface by telephone when to commence pumping.

(3) Once the signal has been received, clear water is pumped through the system, and the cement mixture follows immediately. In this way, the required number of sausages are made up. On completion of pumping, the system is again flushed with clear water. Molasses is stored underground for use in emergencies, and, if a bag breaks or a pipe bursts, it is quickly poured onto the cement mix to prevent it from setting. Problems have been encountered when the cement mix has run into an ore pass, but this is a very rare occurrence.

(4) When a pillar has been completed during the earlier part of the shift, the shuttering can be removed and blasting can take place on the pillar without any damage to it. In fact, one miner managed to blast all his panels every day for 3 consecutive months, giving a face advance of 26 m per month. At present, pumping is done in double shifts to keep up the rate of production in relation to the pumping capacity.

(5) The pillars are 3 m long, 0,6 m wide, and the height of the stoping width (between 70 and 80 cm). They are installed in a staggered pattern 6 m apart on dip and 2 m apart on strike. Where necessary, extra supports in the form of sticks are installed, especially where friable hanging occurs. Normal timber packs are installed on gulleys (see Fig. 2).

Results

The longwall is approximately 1000 m on dip, and the widest distance on strike is approximately 235 m. The supports have proved to be very successful as no back breaks have occurred to date and there has been an improvement in the general hangingwall conditions in the stope.

Pegs were installed at the outset so that the amount and time period of sag in the area could be determined. It can be seen from Fig. 3, which depicts these measurements over a period of time, that the sag was gradual and not excessive.

The shape of the concrete pillar was a point for consideration at the outset. It was thought that the present shape would be tried first, although the pillar would be stronger if built square. The idea was that the pillars could be used as blast barricades, for ventilation control, and as a means of sealing off areas as required in a longwall situation, and, if the present-shaped pillars proved unsuccessful, a different shape would be tried. Consideration would also be given to the reinforcement of the pillars. However, as the present pillars have so far proved successful, the present shape with no reinforcing has been adopted. If conditions warrant a change, modifications will be made.

Costs

The costs of various materials, pumping, salaries, etc.

of the concrete sausages are as follows.

Slagment	Slagment : 73,77 cents for 50 kg	
	Transport : 0,38 cents for 50 kg	
	Total cost : 74,15 cents for 50 kg	
∴Total cost per cubic metre at 50 kg × 28 = R20,76		
Cement	Cement : 103,25 cents per 50 kg	
	Transport : 0,33 cents per 50 kg	
	Total cost : 103,58 cents per 50 kg	

Total cost per cubic metre = R31,39.

The difference in transport costs for slagment and cement is due to the different sources of these materials: slagment from Pretoria and cement from Lichtenburg.

Sand	R3,30 per cubic metre delivered on site	
Pumping	R2,45 per cubic metre	
M21 grout bag	R11,26 per bag	
Labour	Skilled R9204 per month	
	Unskilled R9000 per month	
Pump rentals	10 pumps at R50 per month	R500,00
	16 mixers at R14 per month	224,00
		R724,00

The actual costs and consumption for the period April to October, 1977, were as follows:

Average amount pumped per month (1015m³ × 2,45)	R2 487,00
Average amount of cement per month (9977 m³ × 103,58)	10 334,00
Average amount of slagment per month (212 m³ × 74,15)	157,00
Average no. of bags (490 × R11,26)	5 517,00
Average quantity of sand delivered (644 m³ × 3,30)	2 125,00
Skilled labour	9 204,00
Unskilled labour	9 000,00
Pumps and mixer rental	724,00
	R39 548,00

Average centares supported per month	8 540
∴ Cost per centare supported	R4,63

The original estimate was approximately R2,00 per centare supported, and, as can be seen from the above, the actual costs were more than double those anticipated. The reasons for this are as follows.

(a) The cost of cement has increased by more than 10 per cent.

(b) It was thought that a 50:50 slagment: cement mixture could be used, but the ratio is now 25:75 because the use of slagment in larger quantities produces a mixture that takes too long to set.

(c) It was not expected that sand would have to be bought, there being large quantities of sand available, however, owing to its high specific gravity, the available sand cannot be used.

(d) The cost of the grout bag used has increased from R10,50 to R11,26.

(e) According to the contractor's original plan, 3 men would have supervised the project. However, because of double-shift pumping and other factors, this number has increased considerably (at the time of writing, the matter was being investigated to establish a more realistic skilled-labour force).

(f) The unskilled-labour position is similar, and is also under investigation.

(g) The mining personnel tend to over-support, i.e., instead of installing sticks in areas of blocky or friable ground, they install concrete sausages closer together.

For comparison, the approximate cost of conventional support, i.e., 0,6 by 0,6 m timber packs, is as follows per pack:

Material	R7,00
Surface labour	R0,10
Hoisting	R0,35
Underground transport (and pack building)	R6,00
Equipment costs	R0,10
Total cost per pack	R13,55
At approximately 6,0 centares per pack, the cost per centare	R2,26

The above figures do not include packs that have to be re-installed after having been blasted out.

Advantages

Although the cost per centare supported is higher for the concrete sausages than for conventional support, the new system has the following advantages.

(1) The new system provides very rigid support with quick load-bearing characteristics and has prevented back breaks. The load-bearing characteristics are shown in Fig. 4. It should be noted that the graphs in this diagram show the characteristics of concrete blocks 0,6 by 0,6 m square with timber

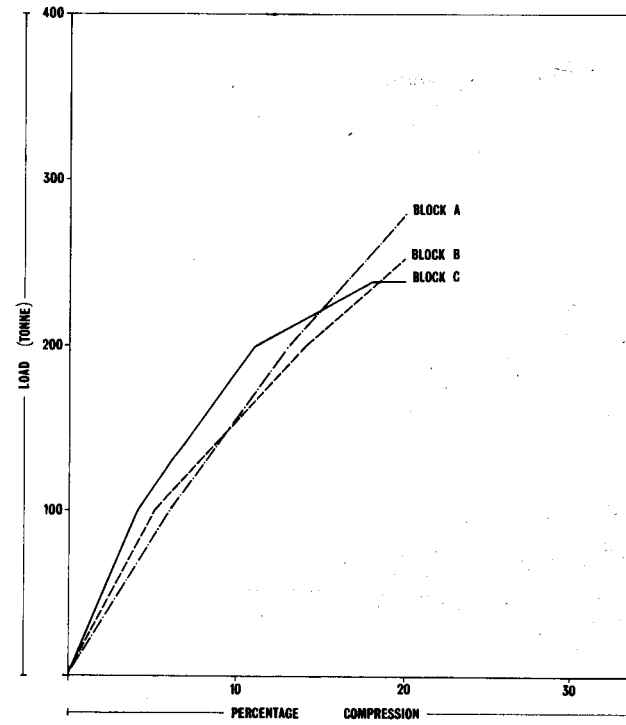

Fig. 4—Load-bearing characteristics of a concrete cube with sides of 0,6 m

blocking above and below, which had to be installed to prevent damage to the press that was used to crush them. These small blocks were tested because of the difficulty in transporting and handling a block of the size used underground. However, from the information obtained, it was calculated that a concrete sausage of the dimensions used underground could carry a load of 1000 t. As can be seen from the graphs, these small concrete pillars failed at a load of between 240 and 280 t.

(2) The sausage pillars can be used as ventilation controls on strike.

(3) In a longwall, once a new centre gulley has been established, a continuous concrete wall can be installed on dip thus *permanently* sealing off back areas.

(4) The amount of timber used is very small, reducing fire hazards.

(5) The shape of the pillar can be changed to suit the conditions.

(6) More shaft time becomes available as a result of the small amount of timber that needs to be transported.

(7) Total extraction is possible because it is not necessary to leave stabilizing pillars.

(8) The concrete pillars are not blasted out.

(9) The areas adjacent to those supported by concrete pillars, which had been mined by the use of conventional pack support, had to be abandoned because of caving and blocky ground.

Disadvantages

(i) The costs are higher than for the conventional support system, but could be reduced somewhat if the pattern used at present were changed. A new layout (indicated in Fig. 5) in which every second row of concrete sausages is replaced by a full row of sticks will be used on a trial basis. The cost saving resulting from this change will be R1,23 per centare, i.e. R3,40 per centare supported. It should be borne in mind that, although the costs are higher than for conventional support, the conventional system has proved inadequate for the conditions at Rustenburg. If the cost of lost production, low productivity due to bad hangingwall conditions, etc. that occur

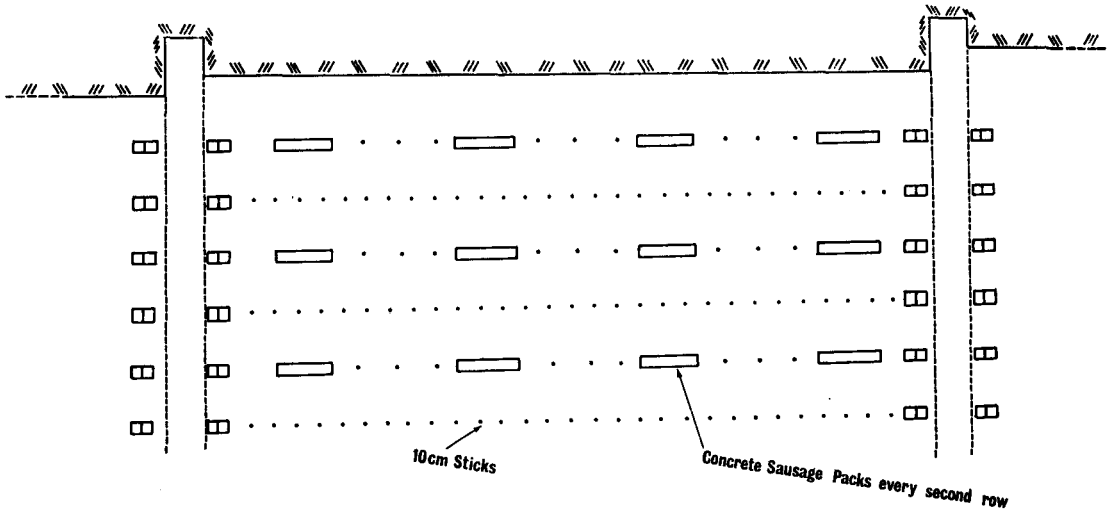

Fig. 5—A panel showing the revised layout of concrete packs in relation to sticks and 1,2 by 0,6 m matt packs

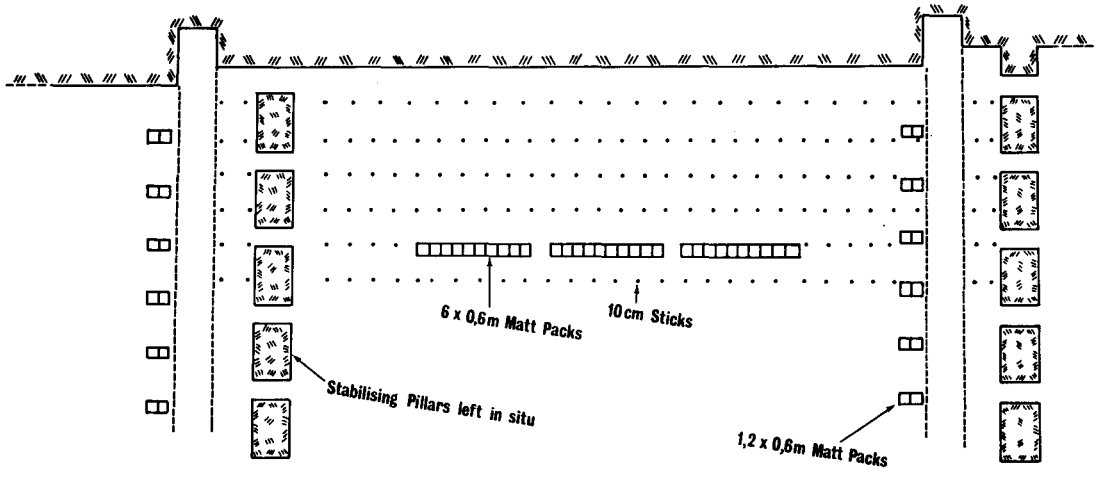

Fig. 6—A panel showing the spacing of the stabilizing pillars in relation to the additional support provided by sticks and six 0,6 m matt packs

with conventional support were to be calculated, the additional approximate R1,20 per centare for the concrete-sausage pack would be found to be money well spent.

(ii) With the new system, more water has to be handled in the stopes, and this is a problem at Rustenburg, where the broken ore is difficult to handle when mixed with abnormal amounts of water because it sticks in the ore-passes and hoppers.

(iii) The ore-passes could get blocked by grout flowing into them, but this is a rare occurrence.

Conclusion

Although the use of concrete-sausage packs has proved to be most beneficial to Rustenburg Platinum Mines Ltd, further experiments are being conducted with different types of support to establish an optimum support system for the conditions in the mine. One of these experiments is based on the leaving of stabilizing pillars on the gulleys, with sticks and solid rows of matt packs as indicated in Fig. 6.

The problem with this proposed system is the lock-up of ore in the pillars, present calculations showing that the cost per centare varies with the grade. If one includes the value of metals lost as a cost, the cost of this system could be between R2,84 and R4,49 per centare, depending on the grade of the ore. This system will be the subject of a paper at a later date, when more facts are available.

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AECI Limited.
Afrox/Dowson and Dobson Limited.
Amalgamated Collieries of S.A. Limited.
Apex Mines Limited.
Associated Manganese Mines of S.A. Limited.
Billiton Exploration S.A. (Pty) Limited.
Blackwood Hodge (S.A.) Limited.
Blyvooruitzicht G.M. Co. Ltd.
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Bracken Mines Limited.
Buffelsfontein G.M. Co. Limited.
Cape Asbestos South Africa (Pty) Ltd.
Compair S.A. (Pty) Limited.
Consolidated Murchison (Tvl) Goldfields & Development Co. Limited.
Deelkraal Gold Mining Co. Ltd.
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Durban Roodepoort Deep Limited.
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East Rand Prop. Mines Limited.
Engineering Management Services (Pty) Ltd.
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Free State Saaiplaas G.M. Co. Limited.
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Gardner-Denver Co. Africa (Pty) Ltd.
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Hartebeesfontein G.M. Co. Limited.
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Hubert Davies Heavy Equipment (Pty) Ltd.
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