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The opencast mining of previously underground-mined coal seams

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SYNOPSIS

The design of an opencast coal mine over areas previously mined by underground mining methods presents several potential methods of mining the coal. The paper describes some basic methods of mining for the No. 2 seam of the Witbank Coalfield, which had previously been mined by the bord-and-pillar method.

SAMEVATTING

Die ontwerp van 'n dagbousteenkoolmyn oor gebiede wat voorheen volgens ondergrondse mynboumetodes ontgin is, bied verskeie moontlike metodes om die steenkool te ontgin. Die referaat beskryf 'n paar basiese metodes vir die ontginning van laag nr. 2 van die Witbank-steenkoolveld wat voorheen volgens die pilaarmetode ontgin is.

Introduction

The presence of bord-and-pillar workings within the No. 2 seam of the Witbank Coalfield of South Africa requires that different methods of mining should be considered, depending largely upon the location of the workings within the coal seam. Observations and measurements within the workings have shown that the vertical locations of the workings within the seam may vary considerably over short distances. Therefore, a coaling method that is independent of the location of the workings should preferably be considered. Two basic methods of mining were considered for the No. 2 seam: one is to collapse the workings during interburden blasting, and the other is to preserve the stability of the workings until coaling takes place. For each of these basic methods, several alternative procedures are possible. Many other methods were considered but were discarded as being unpractical. The following methods were identified as being the most suitable.

Method 1: Collapsing of Bords

Collapsing of the bords during interburden blasting would prevent subsidence from taking place underneath the dragline, but would result in approximately 20 per cent dilution (by volume) of the coal. This method (1) will work only if all the bords collapse during blasting, when, it is thought, the dead load of the blasted interburden should cause the top coal over the bords to fail. In addition, toe damage at the bottom of the blast holes and cratering should assist in the collapse of the top coal into the working. The sequence of mining operations is shown schematically in Fig. 1. A brief description of these operations is given below.

Operation 1. Drilling of the interburden blast holes to the top coal left over the bords, ensuring collapse during blasting.

Operation 2. The dragline excavates broken overburden, leaving approximately 1 m of fragmented siltstone over the coal seam. This is thought necessary because there is little colour difference between the siltstone and the collapsed coal, and the dragline operator could unknowingly cast a large quantity of the coal to spoil.

Operation 3. The bull-dozer moves the remaining siltstone to the dragline. The bull-dozer operation will have improved control on the depth of each pass, and will be able to identify the top of the coal pillars with greater accuracy. The bull-dozer will prepare the top surface of the coal for drilling.

Operation 4. Small crawler-mounted rigs drill the pillars. Trials at Landau Colliery have shown that the locations of the pillars are fairly easy to identify from the depression of the collapsed bords. No prior knowledge of the exact location of the pillars is required. These pillars are then lightly blasted[1].

Operation 5. The blasted coal is loaded.

Operation 6. In some instances, floor coal may have to be ripped since the blasting of the pillars may not fragment this coal.

Method 2: Variation of Method 1

A variation of this method was suggested when an assessment of coal quality and washing showed that the removal of approximately 1 m of the top coal in the pit may be advantageous. This method is referred to as *scalping*, and results in a reduction of the run-of-mine tonnage and an increase in overall yield. This method (2) would not require a bull-dozer to move broken interburden to the dragline, and would reduce the level of dilu-

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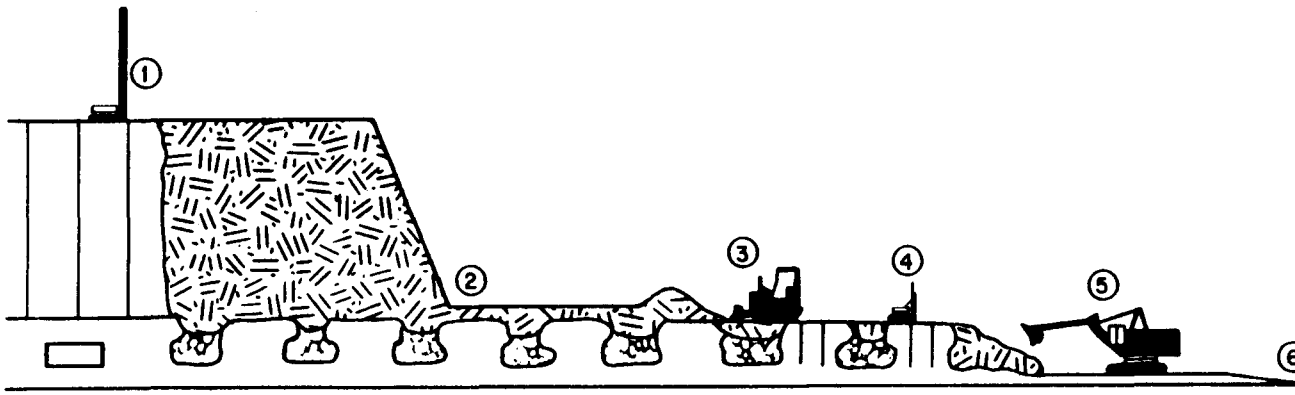


Fig. 1—The sequence of operations in method 1
1 Interburden drilling
2 Dragline moves interburden
3 Bull-dozer cleans to top of coal
4 Drilling pillars
5 Coaling
6 Ripping bottom coal

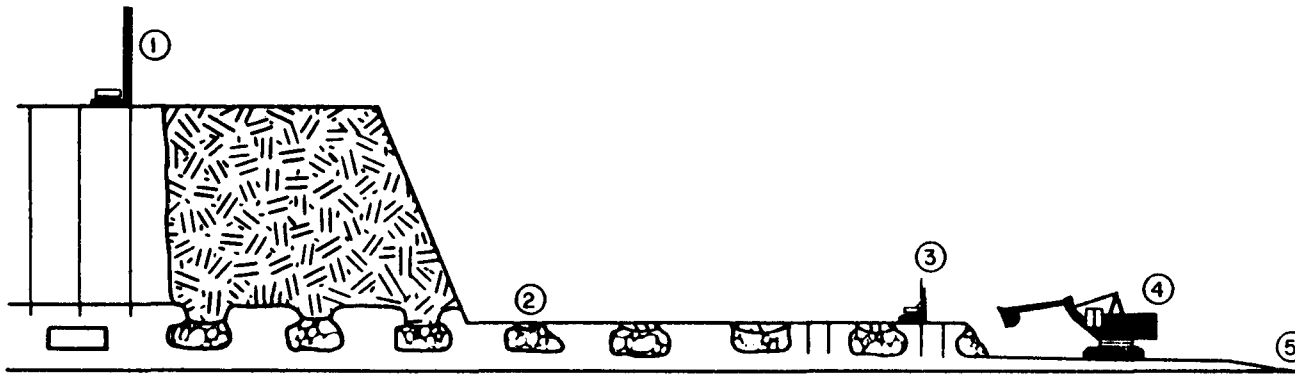


Fig. 2—The sequence of operations in method 2
1 Drilling overburden
2 Dragline excavates overburden and top of coal
3 Drilling coal pillars
4 Coaling
5 Ripping bottom coal

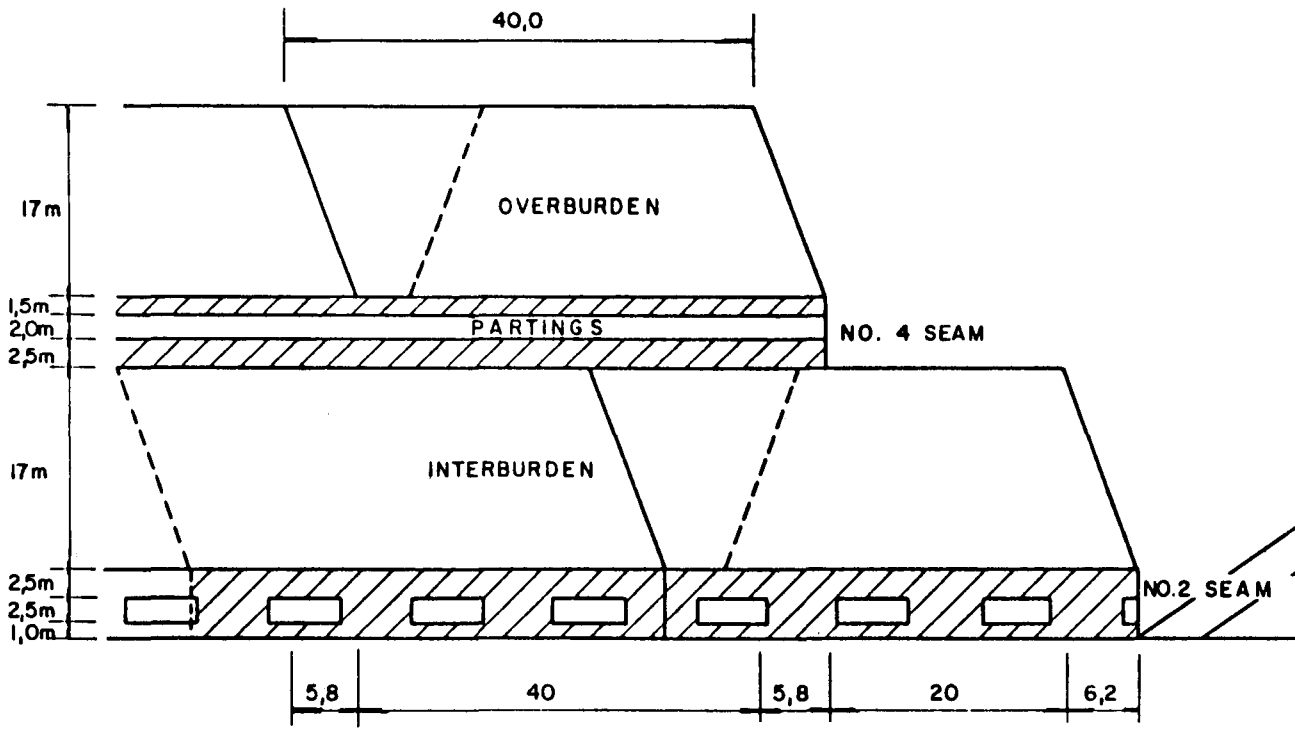


Fig. 3—Average section for method 3

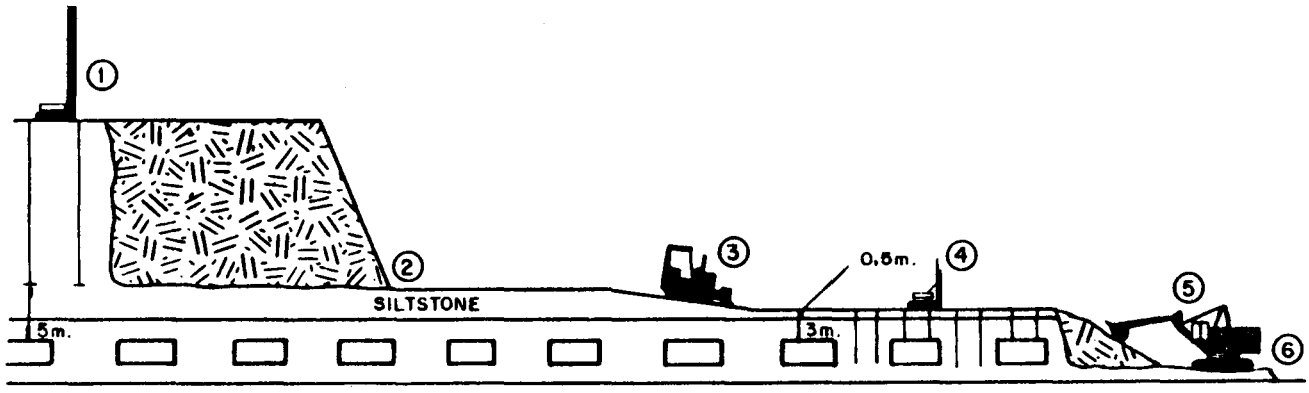
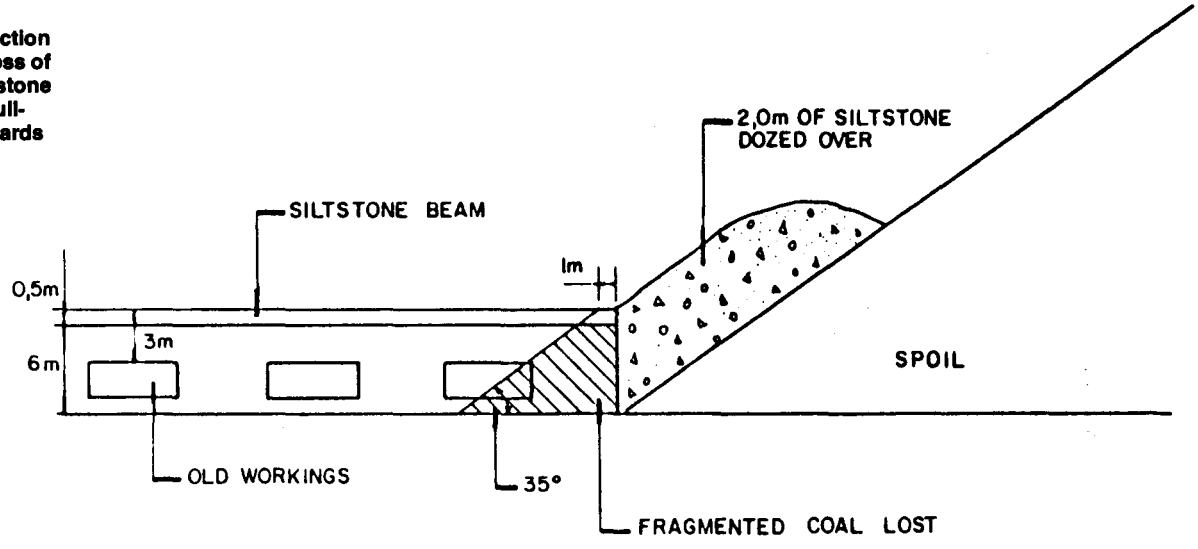


Fig. 4—The sequence of operations in method 3
1 Interburden drilling
2 Dragline moves interburden
3 Siltstone beam is stripped by bull-dozer
4 Drilling coal seam
5 Coaling
6 Ripping bottom coal

Fig. 5—Section showing loss of coal if siltstone beam is bull-dozed towards the spoil



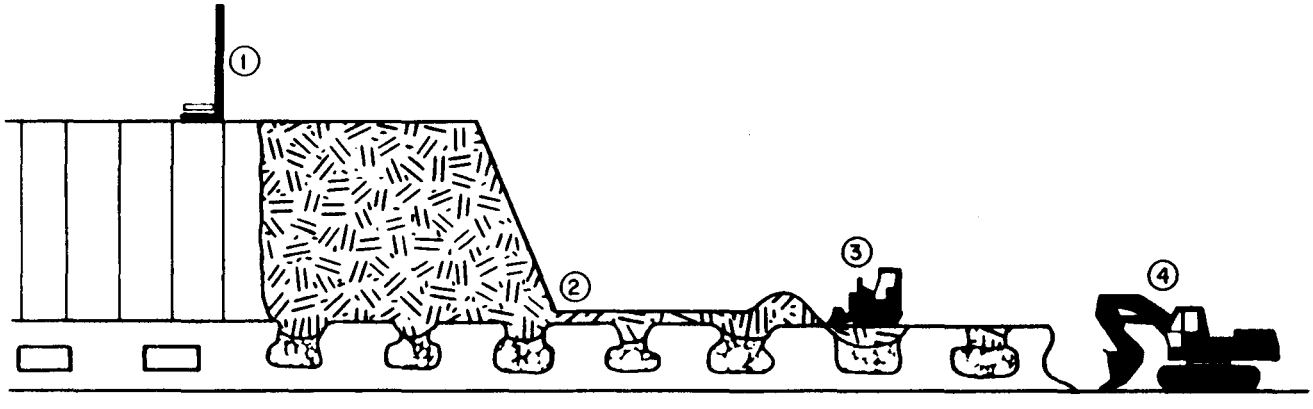


Fig. 6—The sequence of operations in method 4
1 Interburden drilling
2 Dragline moves interburden
3 Bull-dozer cleans to top of coal
4 Hydraulic excavator free-digging unblasted coal

tion of the remaining coal. However, the dragline operation would have to be closely controlled so that over-excavation of the coal would be avoided. The operations for this method are shown schematically in Fig. 2. The mining operations for this variation are similar to those described in method 1 with the exception of the bull-dozer operation.

Method 3: Preservation of the Workings

The main purpose of attempting to preserve the workings would be to minimize waste dilution of coal. Calculations have shown that the top coal of less than 3 m would not be able to support the dead weight of broken interburden[2].

Therefore, the only way that the workings could be kept open would be the leaving of a protective beam of intact siltstone over the workings. This siltstone beam should be mined without blasting to prevent damage to the topcoal beam over the bord. The siltstone could be ripped by bull-dozer until a total thickness of 3 m of coal and siltstone were left. The remaining siltstone would be mined with the coal. In the standard section for the exercise (Fig. 3), the top coal is 2,5 m thick. This siltstone beam after ripping would represent 10,8 per cent dilution of the coal. The operations are depicted in Fig. 4.

In this method (3) the operations are as follows:

Operation 1. The interburden is drilled and blasted. Here the blast holes are drilled to approximately 5 m above the roof of the bords.

Operation 2. A bull-dozer rips the siltstone beam down until the combined thickness of siltstone and top coal is 3 m. The ripped siltstone is bull-dozed over the edge of the coal bench, which may result in some losses of coal, as illustrated in Fig. 5. These losses could be reduced if additional space were provided at the toe of the spoil piles or if the bull-dozer waste were rehandled. The final decision would depend upon the economics of the coal losses versus the cost of rehandling.

Operation 3. The siltstone and coal are drilled and blasted. This would require short holes, possibly with a plug at the end of the holes that intersect the mine workings. For this operation, a prior knowledge of the position of the workings is required so that the depth of the interburden blast holes can be determined. Operations 4, 5, and 6 would be similar those of methods (1) and (2).

Method 4: Collapsing of the Bords and Excavation of the Unblasted Coal

The use of large hydraulic excavators to mine unblasted coal from the No. 2 seam presents a simple solution to coaling through the old underground workings. The sequence of operations for this method (4) is shown in Fig. 6. The number of mining operations is decreased, and the requirements for the ripping of the bottom coal no longer apply. The major uncertainty with this method is whether the hydraulic excavator will meet the production requirements at an acceptable cost.

Method 5: Preservation of the Workings and Excavation of Unblasted Coal

This method (5) uses a hydraulic excavator to mine unblasted coal from seam 2, the sequence of operations being shown in Fig. 7. There should be a further decrease in dilution since the excavator is able to crowd horizontally and remove some of the top siltstone separately.

Method 6: Collapsing of the Pillars

A further variation is to collapse the pillars during interburden blasting, which would result in a subsidence-free bench for the dragline operation. However, the location of the pillars would have to be surveyed accurately so that interburden drilling would intersect the pillars. This method (6) of blasting the pillars would produce a large amount of undesirable fines. There is also some doubt concerning the displacement of the coal if it is blasted with the interburden, since high powder factors may be required with the strong interburden. The sequence of operations is shown in Fig. 8 and is described below.

Operation 1. The drilling and blasting of interburden and coal form a single operation using large-diameter blast holes drilled into the centre of each pillar. The location of blast holes must be accurately surveyed to ensure that each hole intersects the centre of a pillar.

Operation 2. The dragline excavates the fragmented interburden. The colour change between siltstone and coal will be slight, and, since the coal will also be broken, the dragline could easily remove a large proportion of the coal seam unintentionally.

Operation 3. The fragmented coal is loaded by use of a shovel.

Operation 4. The floor coal is ripped and loaded where required.

Discussion

It is thus apparent that the No. 2 seam workings can be either collapsed or preserved prior to coaling. Within each basic method there are several alternative procedures that depend upon the following:

(a) whether, in the collapsed workings, the pillars are blasted or excavated unblasted,
(b) the reduction of dilution in the collapsed bords,
(c) the reduction in the loss from the dragline operations, and
(d) whether the preserved coal-seam workings are blasted or dug unblasted.

Recommendations

Mining method 2 (Fig. 2) is recommended for the following reasons.

(i) *Safety.* This method is relatively safe because the mining equipment will be working on solid or on compacted blasted material, with no risk of expensive machines falling into undetermined areas.
(ii) *Dilution.* Most of the diluted coal will be removed by the dragline, which reduces the costs of plant feed and coal washings.

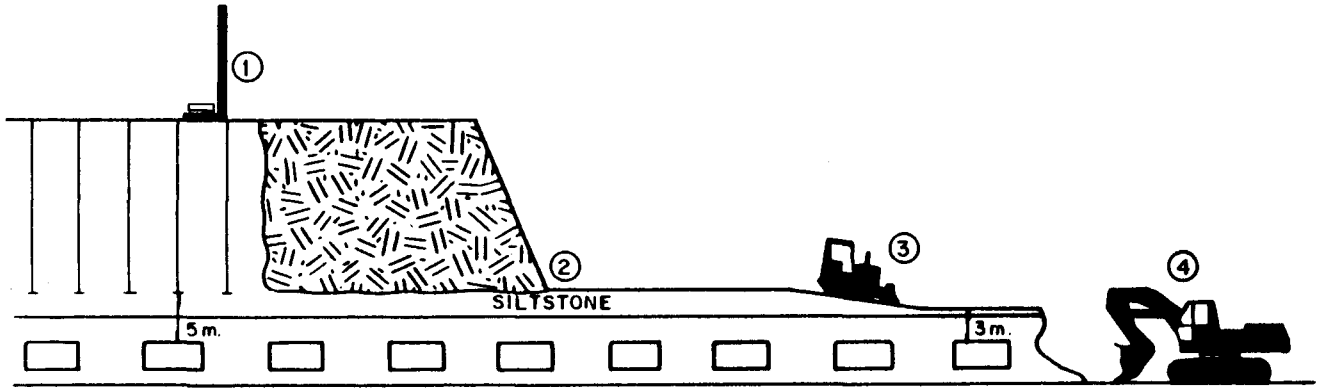


Fig. 7—The sequence of operations in method 5
1 Interburden drilling
2 Dragline moves interburden
3 Siltstone beam is ripped by bull-dozer
4 Hydraulic excavator free-digging coal

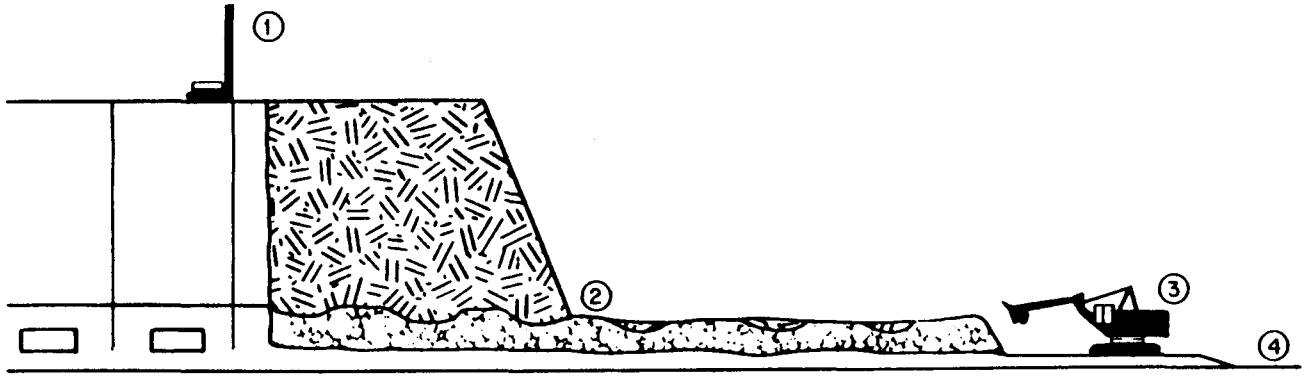


Fig. 8—The sequence of operations in method 6
1 Drilling into centre of pillars to collapse pillars
2 Dragline excavates blasted overburden
3 Coaling
4 Ripping bottom coal

(iii) *Increase in geological yield.* The scalping of the No. 2 seam increases the saleable reserves and the practical yield of the deposit, while all the quality parameters remain constant.

(iv) *Practicality.* This is a practical mining method, using proven equipment and methods in which the coal is drilled and blasted before excavation. Blasting patterns can be varied to yield optimum size distribution and loading rates.

Note

The authors have attempted to define the areas of concern and to itemize their solutions for the problems identified in this paper. The many recommendations discussed were based primarily on the authors' experiences. Further work is required on the identified risk areas in the practical classroom of the opencast mine.

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