

the 28 in. and 42 in. stope widths and at 5 shovels/min in the 72 in. stope width to give a mean oxygen consumption of 1.5 litres/min. The work output of the men in the 28 in. and 42 in. stopes would under these conditions be 2.7 tons per hour and 2.3 tons per hour in the 72 in. stope.

Although it had been suggested to us by the work study engineers that a shovel rate of 10 shovels per minute should be investigated (and even 14 shovels per minute), such a rate of shovelling in stopes in the gold mines is quite unphysiological. A shovelling rate of 10 shovels per minute (with an average shovel load of 13 lb in the 28 in. and 42 in. stopes and 15 lb in the 72 in. stopes and throwing distances of 8, 11 and 14 feet respectively) would require an oxygen consumption of 1.8 litres/min in the 28 in. and 42 in. stopes and 2.2 litres/min in the 72 in. stope (Fig. 1). At these rates of oxygen consumption the "average" Bantu mine worker would be well above 50 per cent of his maximum oxygen intake and would be in anaerobic metabolism. He would require longer rest pauses in order to recuperate. If he did not have long rest pauses he would become unduly fatigued and would be prone to accidents. It is probably for this reason that Moss² found that men shovelling coal at a slow, but steady pace had a higher output than men who work faster but in spurts.

In stopes inclined 15° and 30° below the horizontal, the distances of throw would be increased by 2 and 5 feet respectively in a 42 in. stope and by 4.4 and 3 ft respectively in a 28 in. stope without there being any significant difference in oxygen consumption from that in the horizontal stope.

SUMMARY

This study brings out the following facts:

- (i) The mechanical efficiency of men shovelling rock, at various rates from 3-10 shovels per minute, is the same in a 42 in. and a 72 in. stope width

but it falls off markedly in a stope of 28 in. width.

- (ii) When the dip of the stope is 15° below the horizontal the mechanical efficiency in both the 42 in. and 28 in. stope widths is increased but with a further increase in the dip to 30°, mechanical efficiency is increased only in 42 in. stope width.
- (iii) A one-ft alteration in the distance of throw of a 16-18 lb shovel load results in an 0.03 litre/min change in oxygen consumption in a 72 in. stope, in an 0.05 litre/min change in a 42 in. stope and in an 0.07 litre/min change in a 28 in. stope; a one-lb alteration in shovel load which is thrown 16-18 ft results in an 0.09 litre/min change in oxygen consumption in a 72 in. stope, in an 0.07 litre/min change in a 42 in. stope and in an 0.05 litre/min change in a 28 in. stope.
- (iv) Significant differences in mechanical efficiency were found between individuals and these appeared to be associated with the economy of movement during shovelling.
- (v) On the basis of these studies "optimum" levels of production for the "average" Bantu mine worker can be set for shovelling rock in stopes. They are:
 - (a) 6 shovels/min, with 15 lb load, thrown 8 ft and 11 ft respectively in a 28 in. and 42 in. stope width.
 - (b) 5 shovels/min, with a 15 lb load, thrown 14 ft in a 72 ft stope.

REFERENCES

1. WILLIAMS, C. G., WYNDHAM, C. H. and MORRISON, J. F. 'The influence of weight and stature on the mechanical efficiency of man.' *Int. Z. angew. Physiol.* 23: 107-124, 1966.
2. MOSS, K. M. 'Some effects of high air temperatures and muscular exercise on colliers.' *Proc. Roy. Soc. B.* 95: 181-200 1924.

Book Review

Sedimentary Ores—Ancient and Modern (Revised), edited by C. H. James. Proceedings of the 15th Inter-University Geological Congress. University of Leicester, December, 1967. Special Publication No. 1, Department of Geology, University of Leicester, February, 1969. Obtainable from: Leicester University Bookshop, May's Walk, Leicester LE 17 RD. Price: 42s. Postage and packing, 3s. 6d.

This volume should be of interest to economic geologists and students in this field. A number of illustrated papers on the genesis of ores in sediments are presented; the authors include experts such as Prof G. C. Amstutz,

Dr K. C. Dunham, Prof D. Williams and W. G. Garlick. The papers deal mainly with sulphide deposits, but the late Prof J. H. Taylor's contribution concerns ores of iron and manganese.

Brief references to the Witwatersrand ores represent the only discussion of South African deposits.

With the notable exception of W. G. Garlick's paper on Zambian copper deposits, the Abstracts given are inadequate, necessitating thorough reading of the papers to extract the important matter.

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