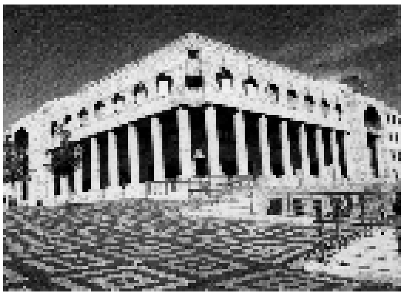
CENTENNIAL SYMPOSIUM
8th August 1996



DEPARTMENT OF MINING ENGINEERING

The Mine Call Factor
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A. Introduction

In South African gold mines, the major measure of the efficiency of the production process is the "Mine Call Factor" (MCF). This factor compares the gold estimated *in situ* by the surveyors (or geologists) with the amount of gold finally produced by the plant - with allowance for losses to tailings. The factor is generally expressed as the ratio between the "gold called for" and the gold accounted for, as a percentage.

In recent years, many mines have been experiencing declining MCFs and numerous investigations have been undertaken to try to establish the causes on a mine by mine basis. There. are many potential 'physical' causes for the loss of gold in a producing mine, ranging from gold blasted into backfill bags up to gold theft syndicates which seem to operate successfully on many mines. However, recent studies (de Jager, 1996) indicate that the popular mythology of gold lost in cracks and washed into gullies cannot begin to explain the recent plunges in the MCF in major mines.

Perhaps a centennial symposium is the appropriate place to review the more traditional sources of apparent gold loss - that is, in the initial valuation of the gold in place in the stopes. In this paper we investigate the difference between what is expected from stope valuation and what is actually from a stope panel. This exposition is based on a set of real sample data from a Witwatersrand type gold mine and on current common valuation practice. Similar results can be obtained from theoretical work based on geostatistical methods.

B. The Case Study

For the purposes of this study, we have taken an area approximately 2000 metres square within a producing mine. This area has been mined continuously in recent years and is still in production. To avoid major complications, we have chosen a reef which is lognormal but not too highly skewed. This is not a very high grade area, but neither is it marginal at current costs. The reef under study is also a moderately thick reef, since extra complications arise in the sampling and valuation of very narrow reefs. In short, we have chosen an area which should be well behaved as regards variations in value.

This area has been sampled on the usual basis of face samples every five to six metres, taken at regular intervals as the stope advances. As in most traditional mines, the sample information follows a very rough 'grid' of about five to six metres in the two-dimensional plane of the reef Sampling was carried out by hand chipping channels across the reef. The individual sections of the reef are combined to provide a single average value across the reef at the sampled location. This is usually expressed as an accumulation grade over the reef times width of reef - so that the effective stoped grade can be directly calculated.

It is usual to estimate the value in the stope by averaging the accumulation values in the stope face. In some cases, more than one face is used to estimate the remainder of a stope. For this study, we have simplified the situation as follows:

- a face is taken to be a 30 metre stretch of samples, usually 5 or 6 altogether;
- a stope is taken to be a 30 by 30 metre rectangular stope panel.

Obviously, the study as described here can be carried out for other geometries and stope sizes. The estimated gold values as produced by the survey office consist of the average accumulation for all samples on the face, divided by the stoping width planned for that stope. We have emulated the 'true' stope panel values by simply averaging all of the sample values within 30 by 30 metre panels across the study area. This is the closest we can expect to come to the actual resource figures. In this particular study area, we have just under 2000 panels with sufficient sampling to serve our purposes.

C. Grade/tonnage curves

To compare the estimates produced from the face sampling with the 'actual' values in the stopes we have constructed 'grade/tonnage!' curves more commonly known on the gold mines as 'payability' graphs. In brief, we apply a cutoff value or pay limit to the values and calculate the percentage of the area which is ted to be above this cutoff and the average of the values over this 'payable' percentage. This exercise was carried out on:

(a) the individual channel samples;
(b) the 30 metre face averages;
(c) the 30x30 metre stope panels.

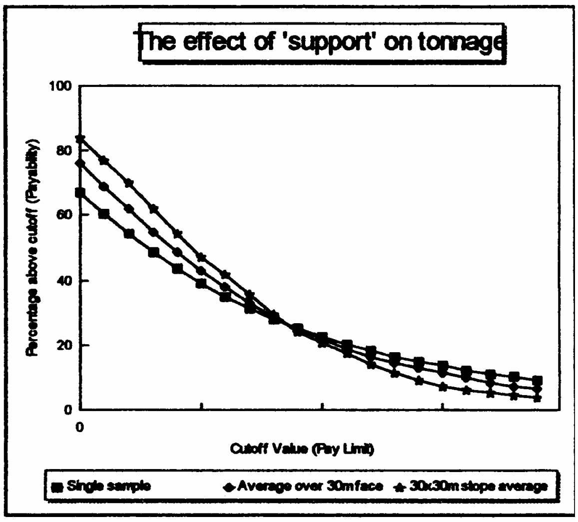

Figure 1 – Comparison of payability percentages for different sizes of area

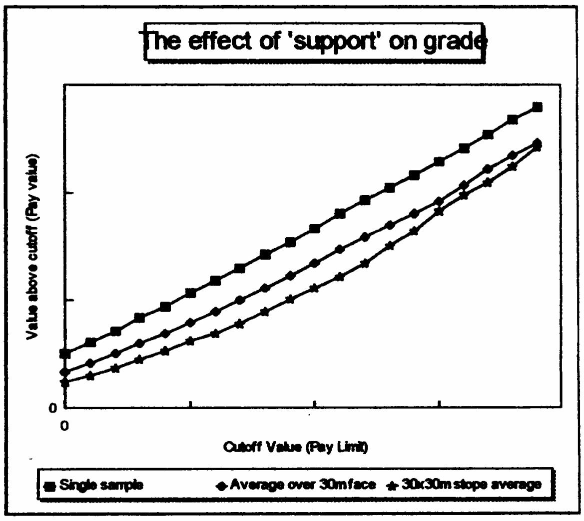

Figure 2 – Comparison of pay values over different sizes of area

Figure 1 shows the comparison between the percentage payabilities for the three different 'support' sizes: point, face average and area average. It can clearly be seen that there is a significant difference between the percentage payability in the three cases.

Of more concern, perhaps, are the results shown in Figure 2. This graph shows the average value of the payable proportion of the area. It is quite obvious from this graph that, the bigger the area selected, the lower the achieved grade for a specific cutoff or pay limit. The two graphs taken together show that, for a larger volume of ground, the average grade will always be lower than for a smaller area. This is a direct consequence of averaging over a volume or area. A payable area on average may well contain unpay material which will be mined. On the other hand, unpay stopes may well contain payable material which will be left behind.

From Figure 1, it can also be seen that - for high cutoffs - the tonnage in payable stopes is considerably less than that indicated by the face sampling.

D. Mine Call Factor

The Mine Call Factor (MCF) is generally expressed as the "gold called for" versus the "gold accounted for". However, this is expressed in different ways by different mines. In many cases, the ratio calculated is between the average grade in grams of gold per tonne of ore estimated versus grams per tonne of ore milled. That is, the MCF would be the grade found in the stope divided by the grade measured on the face expressed as a percentage. If we perform this calculation on the lower two lines in Figure 2, we obtain Figure 3 as an illustration for how the MCF would change with rising pay limit in our case study area.

There seems to be little cause for concern in this graph, since the MCF varies between 89 and 99 per cent depending on the pay limit. That is, in general, the stope value will be approximately 91% of that value predicted by the face sampling. Most mines work with this level of MCF without concern. However, it is necessary to look also at Figure 1 to determine what tonnage is being considered here. There is a crossover point at which the tonnages in face and stope become equal. At cutoffs below this point, there is more tonnage available in stope panels than indicated by the faces. For cutoffs above this point, the reverse is true with considerably less payable tonnage available in stopes than might be expected. If we calculate the ratio between the tonnage indicated by the face sampling and that indicated by the average value within the stopes, we produce Figure 4. From this graph it is clear that the ratio of grade called for to grade achieved is only really valid at the point where the comparison between tonnages is 100%. This graph is analogous to the factor often known as "surveyor's shortfall".

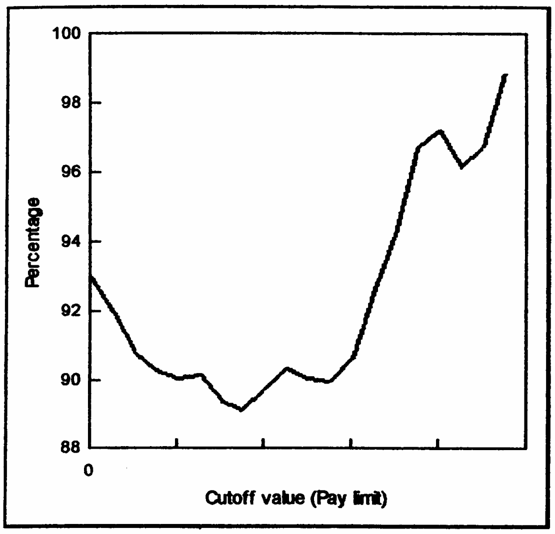

Figure 3 – Average value over stope panel ÷ average value of face sampling (×100)

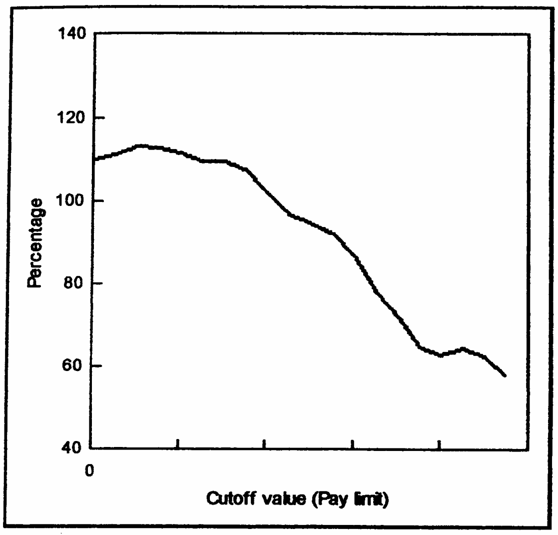

Figure 4 – Percentage of the indicated tonnage which is actually above cutoff

E. Production Controls

From the above analyses it can be seen that many stopes which appear to be payable according to the face sampling will go 'unpay' at some point. There are two possible scenarios which can be considered here:

1. stop the stope when the face sampling becomes unpayable;
2. once the decision to mine a stope has been made, the whole stope is mined even if the face goes unpay.

For a particular production situation these two scenarios could be studied in detail. For the purposes of this study, we interpreted the two alternatives as follows:

1. compare grade obtained from payable stopes with that obtained from faces which were payable at the same pay limit;
2. assume that the proportion of payable ground as indicated by the face samples is actually mined and find the effective average grade for stopes totalling that tonnage. This effectively means that the pay limit being applied to the stopes is lower.

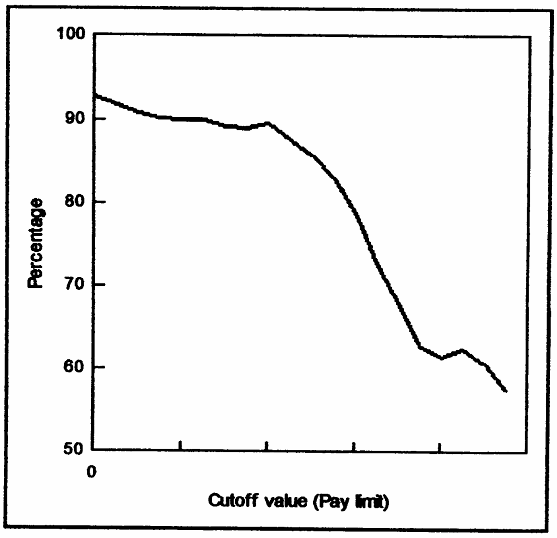

Figure 5 – MCF versus pay limit for situation when stopes are stopped on unpay faces

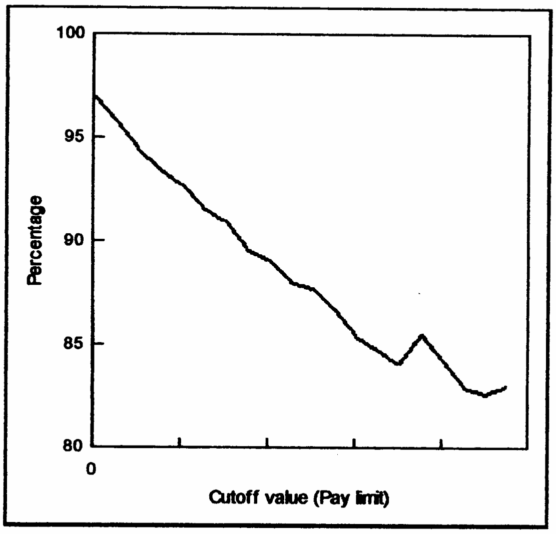

Figure 6 – MCF versus pay limit for situation when selected panels are mined regardless of subsequent face values

These two scenarios were applied to the area under study and some rather surprising results were obtained. Figure 5 shows the MCF for the scenario - stopping the stope when the face becomes unpay - for increasing pay limits. It can be seen that the MCF stays very consistent at a small but steady decline until the 'crossover' point on the grade/tonnage curve. Once this point has been passed, the MCF declines drastically, eventually falling below 60% for the range of cutoffs considered.

In contrast, Figure 6 shows the effect on the MCF of rising pay limits if planned stopes are mined regardless of the unpayability of subsequent faces. This graph shows a steady and consistent decline in MCF with rising cutoff value. However, the scale of this graph is somewhat different from that in Figure 5. The decline in MCF for the same range of pay limits is only to 84% not 55% as in scenario 1.

F. Conclusions

It has been said that there are many possible physical causes for the apparent loss of gold indicated by a falling Mine Call Factor. In this paper we have not considered these factors although they can contribute significantly to a low MCF. Neither have we considered such problems as the accuracy of the sampling process underground and the assaying process in the laboratories. What we have attempted to show in this paper is that significant declines in the Mine Call Factor may well be due to the valuation process itself and to the management decisions which are based on those valuations.

In previous years, when the pay limit or cutoff values stayed at a consistent level - below the 'crossover point' - Mine Call Factors remained reasonably consistent over long periods, albeit with considerable fluctuations on a month to month basis. With rising costs in the mines and rising pay limits, the actual decision process to mine or not to mine a stope becomes of increasing importance in the maintenance of a reasonable Mine Call Factor and, thus, of an efficient producing gold mine.

G. Reference

de Jager, E.J. (1996) "the analysis of the Mine Call Factor in gold mining, with specific reference to Western Holdings Mine", PhD thesis, University of the Witwatersrand.