Poster Session Only

The Mine Call Factor --- conditional bias at its worst

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Abstract

This poster presentation will illustrate the problems of declining Mine Call Factors (MCFs) particularly in the Wits gold mines. The significant increase in "gold losses" in many mines over the last few years can often be explained by updating the "regression corrections" first introduced by krige in the 1950s.

The regression effect (or conditional bias) is a well known problem and is encountered, to some extent, in all producing mines. theoretical methods of correction are available. This poster session will demonstrate the relative merits of:

(a) classical regression corrections
(b) simple volume/variance calculations
(c) stope-by-stope conditional bias correction

One of the effects which is generally not appreciated is that skewed distributions have a different kind of conditional bias from that in Normal distributions. The volume/variance effect in Normal distributions is clear cut and generally well understood: cutoffs below the mean value over-estimate grade and under-estimate tonnage; cutoffs above the mean over-estimate grade and over-estimate tonnage. With the lognormal distribution, the crossover on tonnage is a lot less clear cut since the distribution of the logarithms changes in *median* as well as in *variance*. Compare the grade/tonnage curves for logarithms (based on Normal theory) with those on grade (based on lognormal theory).

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 (cf. 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.

The purpose of this presentation is 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 poster we illustrate 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 practices and compared to theoretical work based on geostatistical methods.

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.

It is usual to estimate the value in the stope by averaging the 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 100 metre stretch of samples, usually 5 or 6 altogether;
- a planning block is taken to be a 100 by 100 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 value 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 100 by 100 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.

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 expected 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 100 metre face averages;
(c) the 100 by 100 metre stope panels.

The theoretical grade/tonnage graph 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 the lognormal grade/tonnage curves. 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.

It can also be seen that --- for high cutoffs --- the tonnage in payable stopes is considerably less than that indicated by the face sampling.

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 the grade/tonnage graph, we can obtain 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 case study, 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 the graph 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. 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".

Alternate scenarios

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:

- what happens when we select whether or not to mine the panel on the basis of the face value;
- selecting whether or not to mine on the 'true' average value over the panel.

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:

- compare grade obtained from payable stopes with that obtained from faces which were payable at the same pay limit;
- compare the gold recovered against the gold expected according to the predictions.

These two scenarios are shown as two graphs. Comparing the face value against the actual panel value mined, the grade call for this moderately skewed case is pretty stable until half way through the range. However the gold recovered is significantly below that predicted --- and the comparison becomes extremely unstable for high cutoffs. If we take the panels which were actually payable, we see that the grade call is pretty stable at around 90% of expected value. The gold recovered is higher than expected for the first half of the graph and then drops drastically as the cutoff rises into the tail of the distribution.

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.

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.

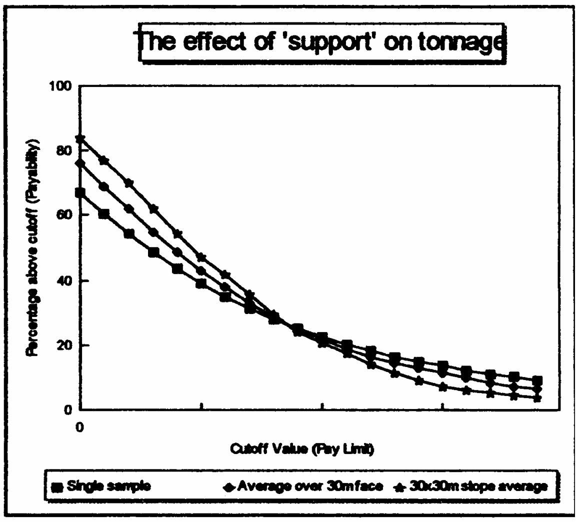

Figure 1 – Comparison of payability percentages for different sizes of area

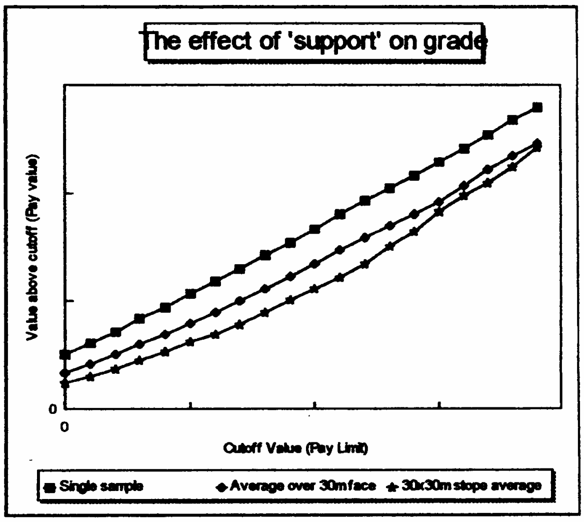

Figure 2 – Comparison of pay values over different sizes of area

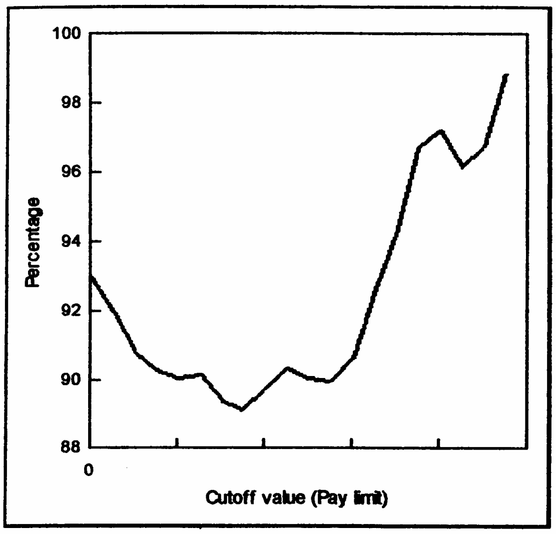

Figure 3 – Average value over stope panel ÷ average value of face sampling (×100)

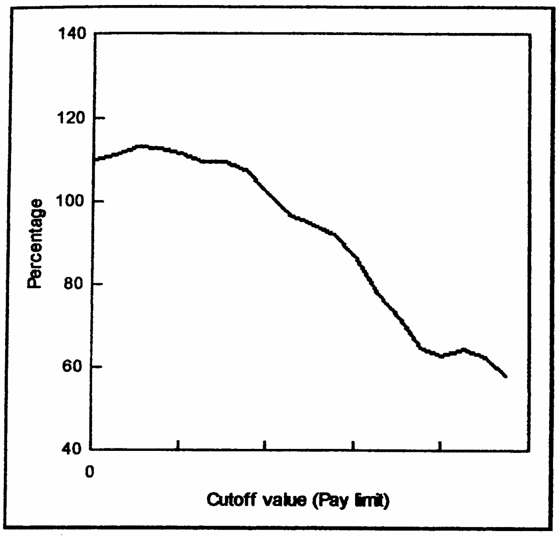

Figure 4 – Percentage of the indicated tonnage which is actually above cutoff

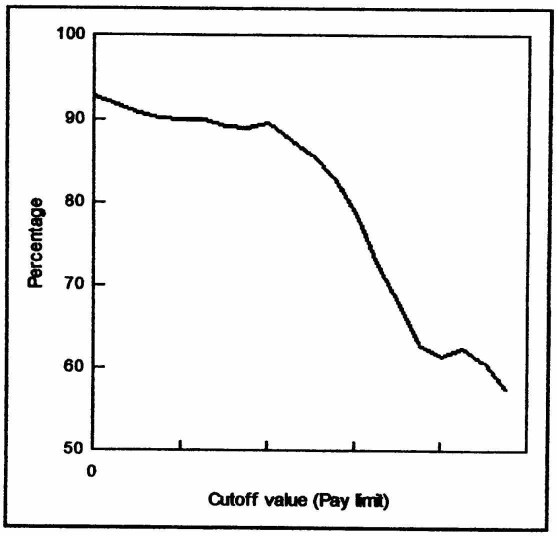

Figure 5 – MCF versus pay limit for situation when stopes are stopped on unpay faces

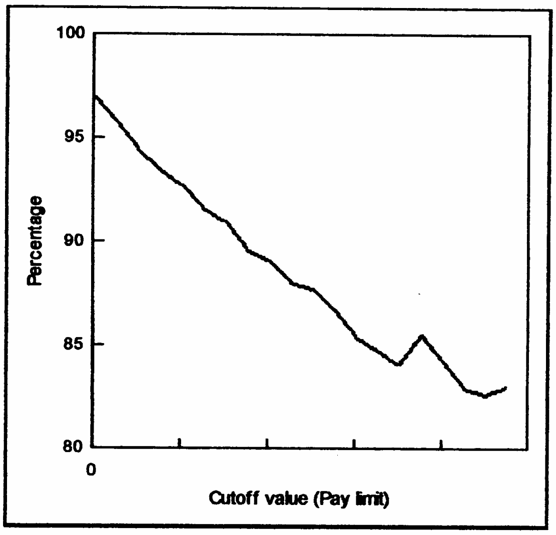

Figure 6 – MCF versus pay limit for situation when selected panels are mined regardless of subsequent face values