

Discussion Regarding Gold Grades and Reporting

What is the Most Relevant Information?

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Introduction - There are Grades and Then There are Grades

The convention practice is for gold companies to report **head grades** to the mill and a **recovered grade** from the processing plant. The difference between the two, by calculation, is regarded as the “tail” i.e. that what goes to the tailings dam. That is logically simple and auditable, and is comparable from one period to the next as a performance measure of a gold mine and treatment plant.

Note that there are many more grade measures used before the ore gets to the mill head grade sampling point. There is a **resource grade** which is more geologically oriented. There is the **reserve grade** which takes into account a mining plan and expected recovery of a resource into a mill-deliverable state. Add to this list a **diluted grade** on mining, though this could also be the head grade.

Open Pit Grades

Open pit calculations may be more homogeneous than underground grades but this is a generalisation. Open pitable orebodies can have many different populations with differing characteristics that need to be accommodated in any resource and reserve calculation. The challenge is for geological statisticians to incorporate them into a plan to provide a target head grade that will only be truth tested in a mining operation that delivers ore to the mill.

It is necessary for open pit mines to do one last run at trying to get the grade right by doing grade control drilling on a flitch by flitch basis, continuously for each flitch. Often, in highly oxidised deposits where visual recognition of ore zones can be difficult, it is this final sampling stage that is most critical to estimating the grade that will be mined and delivered to the mill.

That grade will always be subservient to the size of equipment to be used in the mining and the precision in mining to prescribed cut-off boundaries. That is easier where the boundaries between gold bearing material and waste is sharp but it becomes less precise when it is an economic rather than a geological cut-off. A typical question is to ask how far the gold bleeds into the country rock and how economic it is to chase it. Should the lower grades be stockpiled for another day or just taken in one exercise and perhaps be disappointing to investors because the average grade falls? It is usually a matter of degree with achieving exact precision being a distraction.

There are numerous examples where the head grade to a mill is substantially different to reserve grades, requiring a recalibration of reserves with the benefit of actual mining and processing information. The variability of the distribution of gold within a defined deposit is as variable as the many different host rocks that are bulked together for definition of an economic resource that is to be mined, at the most efficient scale with most productive mining equipment.

Underground Grades

Underground deposits, especially narrow vein deposits, present a different level of complexity that comes with deeper, less visible deposits and more complex mineralisation that leads to greater metallurgical considerations. Being primary deposits they often have more strict boundary definition when compared to the more disseminated oxidised deposits that tend to “bulk out” any issues, such as distribution across rock types.

Anyone who looks at an underground project through the exploration phase will be disappointed if he assumes that spectacular underground geological grades from sampling and drilling will carry through to actual mined grades. In some cases the novice investors may be shocked at how the grade figures come down along the pathway to production.

It is common for underground mines to experience 25% dilution in mining but depending upon over-break and ground conditions, it should be best to consider a range of 15-25%. The bigger the equipment, for economies of scale in extraction, the greater the dilution. Air-legging rather than mechanised mining should result in lower dilution as there is more precise control. The longer the drilling round e.g. 2.4m rather than 1.8m, the lesser the control when experiencing variations in strike and when the veins pinch and swell. Thus there can be greater the dilution.

Grade within a vein will be variable, especially when there is a proportion of nuggety or coarse gold, but less variable when the gold is fine or invisible e.g. 50 microns. Drilling to establish grade may be unreliable due to non-representative sample sizes and variability within the orebody. Central Norseman is typically quoted as an example of a company that drilled to establish structure and success was defined as having gold in even only one or two intercepts out of 10, due to the coarse nature of the gold. A geostatistician will have all sorts of methods to calculate a reliable grade, including the imposition of top-cuts and bottom cut-off grades in order to get a manageable population, but the best method is historical experience in mining the orebody in question. Invariability this will throw the ball back into the geostatisticians court and will require further adjustments to the estimation methodology.

The Effect of Beneficiation

Beneficiation of orebodies to increase the grade to the plant, before and after milling, is a technique that is attempted from time to time. Mechanised ore sorting aims to reject barren material up front. If successful, it can raise the grade from e.g. 3 gpt to > 5 gpt, but it is a case by case consideration. The question can be asked as to what the real head grade is; the pre-benefication grade or the post-benefication grade.

The grade reduction through mining dilution can be reversed to some extent with the beneficiation or pre-concentration before moving to the gold recovery circuit

and related processing. The main point is that the contained gold remains the same, but lower processing costs are incurred after the removal of barren material.

So, grade control can be exercised in the actual mining process or in the treatment process, but the contained gold remains the same.

Another method of beneficiation can be with the use of a flotation cell. If all the gold is associated with sulphides, a flotation circuit can produce a concentrate that may, in some cases, result in the doubling of the grade - or some other useful improvement.

Often such a flotation circuit can be used where the ore has a proportion of refractory gold. By concentrating the sulphides to achieve a mass pull of 10-20% prior to ultra-fine grinding, there can be significant energy cost savings. However, this is a separate topic.

Quoting Grades in Internal Reporting and Stock Exchange Releases.

As stated above, the investment community has been conditioned to accept head grades and recovered grades as key indicators in assessing operational performance. It is the default data that can greatly affect shareholder perceptions of success or failure, of over or under performance. They set the baseline for meeting, or failing to meet, shareholder expectations. Variations can have an impact on share price performance. However, these should not be regarded as the only, or the best information available, regarding grades.

Consider this scenario in an one pit or an underground mine;

- The drilling returns a raw grade of, say, 5 gpt in intercepts and sampling.
- The imposition of cut-offs changes that grade,
 - but consider whether it shows a real understanding of the orebody or it is just the imposition of conservatism.
- A resource geologist calculates a resource using the adjusted grade.
- A mining engineer creates a reserve and a mining plan, probably with an even more conservative grade.
- The mining crews have a target to achieve and their success is judged on whether or not they achieve that grade.

That all seems logical. The head grade sampling is taken as the ore enters the mill, but what about an uplift in the grade through beneficiation through ore sorting or flotation into a concentrate? If the ore is sorted prior to entering the mills it would be legitimate to say the head grade has increased; not a problem. But, what about when the beneficiation occurs after the milling process e.g. with a flotation circuit that can double the grade. Should the company report both grades - i.e. before milling and after flotation?

If a company reports a lower head grade than shareholders expect, in comparison to the reserve grade, it is likely to result in disappointment and therefore a lower share

price. But what if the company claws back the grade through beneficiation with a flotation circuit? Does it get no kudos for doing this?

In one example there was an underground mine that decided to relax the tight grade control in mining, because it was having the effect of slowing down the rate of underground development. It was taking longer to open up new headings and stopes and therefore it compromised the optimum operation of the mine.

The decision was made to accept more dilution at the mining face in order to speed up the development along the drives. There was more waste produced and that compromised the reportable head grade, but there is no change to the contained gold. There is just more non-payable rock with the payable rock. So, the company decided to compensate for this by reducing the non-payable rock to the mills through preliminary hand sorting, and then with the use of a flotation cell. It effectively shared the grade control between the mining face and the flotation cell. The better time efficiency at the mining face, through getting increased tonnes, balanced out the cost of milling the additional waste ore to a lesser or greater extent. What it definitely did was provide greater mining flexibility and a faster track to opening up additional headings and greater flexibility in the mining plan.

So what is the most important grade measure to use? Maybe the answer is to provide multiple grades;

1. an in-situ grade,
2. a diluted head grade after milling,
3. a beneficiated grade after flotation and before entering the gold recovery phase and
4. a recovered grade.

To some extent we are playing around with reporting various numbers, but the real number is how many ounces of gold are produced and at what cost. That should not vary irrespective of what grade you want to talk about. The Company's mission is to produce those ounces at the minimum cost. Everything else is ancillary but it still has to keep shareholders happy.