

A Geologist's Guide to Destroying Shareholder Value and a Business Improvement Model to Insure Against it

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ABSTRACT

Many aspects of best practice resource evaluation do not create value, but poor practice can certainly destroy value. Generally companies prefer to present how their good practice adds value and for this reason few publications exist on examples of how poor practice can destroy value. However in big and small companies there are many previous and current examples of poor practice destroying value.

The incremental expenditure required to move from poor practice towards best practice can be looked upon as insurance against destroying shareholder value. Examples of how poor practice in geology has destroyed value are presented as well as the improvement model used by BHPBilliton to add value and insure against destroying value.

INTRODUCTION

The scope of this paper (Figure 1) is the continuous improvement of the cycle of data collection and analysis through to the generation of resources, grade control and reconciliation. This cycle is referred to as the resource evaluation cycle.

Continuous improvement relies on our ability to funnel and communicate the best improvement projects through to management approval and executing those projects in the most efficient way. Simply having good ideas and intuitively knowing they can add value is often not enough, as we have to compete against good improvement projects from other departments and against other demands where expenditure is limited.

Improvement projects aimed at moving towards best practice in the resource evaluation cycle can and should be justified in numerous ways. In this paper, examples of poor practice destroying value are discussed with the view to communicating how best practice may not always add value but can reduce the risk of costly errors. Also discussed is the BHPBilliton process of continuous improvement and the methodology for selecting and implementing projects that can add value and/or reduce risk.

CASE STUDIES

Examples of how poor practice can destroy value in the various stages of the resource evaluation cycle are discussed. The examples have been modified so as not to identify the operations or companies involved. The examples do not focus on areas such as the quality of blast-hole sampling and in pit grade control, as best and poor practice in these areas is deservedly well covered in the literature (e.g. Edwards, 2001).

The examples are far from exhaustive, rather they are intended to illustrate how there are a large number of areas where poor practice often unexpectedly can destroy value. This leads the author to stress that while improvement projects need to be prioritised, ultimately as an insurance policy best practice needs to include all aspects of the resource evaluation cycle.

QA/QC in an open cut calcium carbonate deposit

Calcium carbonate, as with many other industrial minerals, is sold at different prices depending on the product quality. The

analysis equipment broke down and new equipment with new standards gave consistently different analyses. The previously used standard was not certified and resulted in customers receiving better material than they had paid for. A bias was also introduced into the resource and ore reserve estimates. The standards should be verified by round robin analysis and be prepared from matrix matched ore (run of mine ore).

The cost of this error may not appear great and the customer is happy. However it brought forward a costly pit cutback and increased the amount of non-saleable material that normally could have been blended to produce lower grade material. In addition the customer who has set up his process to accept the higher grade ore is no longer willing to accept lower grade ore.

Collar surveys for drilling in a feasibility study

Surveyors surveyed approximately 6000 drillhole collar locations when they had been drilled (approximately 10 years previously). The drilling geologist identified each hole with an alphanumeric prefix identifying the area (down to the nearest 25m) in which the hole had been drilled. An audit of the alphanumeric prefix against the survey location indicated some errors either in the collar survey or the hole prefix. Survey record books had been lost, thus the collar locations could not be verified. This resulted in a perceived lack of confidence in hole locations which required costly and time consuming verification drilling. Survey practices and hole naming procedures should have been documented and audited at the time of drilling.

The several million dollars and approximately six months required to redrill parts of the deposit is not the only negative result of the incorrect collar locations. This error had a snowball effect in which management began to question other non-geological aspects of the information supplied.

Database for a pre-feasibility study

An error in database management procedures added one zero to the platinum grades and reports highlighting the previously undiscovered potential for economic platinum were provided to high level management in head office. This resulted in a loss of trust in the site geologists, which could have been avoided by adherence to good database management procedures.

While the upfront cost of this error was not great the direct involvement of head office management in the day-to-day project operation increased dramatically. Arguably this resulted in a loss of morale, a drop in productivity and increased costs.

Percussion drilling in an open pit calcite mine

This deposit was percussion drilled in stages ahead of pit cutbacks. The brightness (brighter calcite is more valuable) of the calcite in this drilling was consistently lower than what was mined.

It was found that trace amounts of silt or sludge contamination from percussion drilling were downgrading the brightness. When the percussion samples were sieved to remove the fines the bias was removed. This is the exact opposite to normal good practice

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in which everything possible is done not to lose any part of the sample. This bias could have been recognised sooner if percussion drilling had been twinned by diamond drilling.

Due to this sample bias the cutback design and scheduling was sub-optimal. The cost incurred was significant as the biggest cost at the mine was waste stripping.

Reconciliation in an open pit limestone mine

A belt sampler had been built and installed according to good practice. At some stage maintenance personnel had modified the belt sampler because it was occasionally jamming. The modification meant that only part of the belt width was going into the sample. This was not readily apparent because safety guarding obscured the sample station.

Investigation showed that because of the non-representative sample the precision was significantly poorer than expected. Although there was no bias in the sampling, customers were complaining of out of specification product, which led to some products being shipped at better than specified grade to insure that the product met the desired specifications. Equipment such as belt samplers should not be modified without approval of a sampling specialist.

The lack of precision in the product grade ultimately resulted in increased waste stripping costs due to high grading. In addition one new customer who tested trial shipments was almost lost. This was because the product required tighter than normal grade specifications and two out of the first three shipments did not meet this specified grade.

QA/QC in an open pit copper deposit

Arsenic was a contaminant in the ore and the arsenic grade data (diamond drilling and face samples) was of very poor precision. This resulted in poor reconciliations and an inability to predict arsenic grade into the mill.

Historically, sample collection, preparation and analysis had been optimised for low variability copper not the high nugget effect of arsenic.

Because spikes in arsenic grade could not be predicted the mill sometimes had had sub-optimal copper recovery due to arsenic recovery being suppressed in the flotation circuit. While this cost may not appear significant a change in copper recovery of a few percent meant the difference between mediocre and above expected profits.

Transfer of geological knowledge from an open pit to an underground precious metal deposit

Open pit operations were of approximately 12 months duration for which a contract graduate geologist was hired for grade control. Neither the pit walls nor benches were mapped. During grade control the location of economic mineralisation was identified by blast-holes and visually via subtle differences in the alteration mineralogy.

The mine started underground and a new geological team hired. The ore between drillholes was difficult to follow in the underground development and due to this the operation was suspended for several months until the geological understanding improved. If good geology had been practised in the open pit and this knowledge transferred to the new team it is likely that operations would not have been suspended. While the cost of a short-term mine closure is significant, arguably in this case the

negative impact on the investors was a greater cost to the operation.

Structural modelling in an underground high grade narrow-vein nickel mine

An inclined crosscut was designed to intersect a tabular gently dipping ore shoot the location of which was defined on 40 x 40m drilling. The crosscut failed to intersect the ore shoot at the expected level due to an offsetting fault, which resulted in costly underground redevelopment. Due to time constraints only the ore zone was interpreted and modelled. Subsequent investigation indicated that the fault and the relative offset had been mapped in the decline. This issue emphasises the importance of good geological knowledge outside the immediate ore zone.

Domaining in an underground and open pit epithermal gold project

Multiple complex shaped domains were modelled on a 5g/t cut-off. This produced a high grade but relatively low tonnage resource for which consultants completed a costly pre-feasibility study. The pre-feasibility study indicated a profitable but predominately underground operation.

Infill drilling ahead of a feasibility study indicated that the ore was not where it had been interpreted to be and there were concerns that the ore may not be minable at a 5g/t cut-off. The ore was remodelled on a more continuous 1g/t cut-off, which included some internal waste. Gold grades were interpolated using inverse distance and the resource calculation indicated a lower grade and much higher tonnages. The pre-feasibility was partially redone using the new model and the focus of management changed to a profitable open pit operation.

A detailed audit of the resource model before a bankable feasibility study indicated that the first model was over-domained and the tonnage was under-estimated and grade over-estimated. The second model over-smearred grades and the tonnage was over-estimated and grades were under-estimated. It was determined that the 1g/t envelope was appropriate and a non-linear interpolator was used. This gave a more realistic result between the two extremes mentioned above. If the more appropriate resource estimation tools had been used from the start significant expenditure would have been saved by reducing misdirected work.

Reconnaissance mapping in a nickel laterite due diligence study

Nickel laterite geology from drilling was assumed to be simple and continuous both horizontally and vertically. Thus the ability to high grade the project was assumed and the returns calculated during the due diligence were high. Subsequent mapping of erosion gullies indicating post lateralization erosion and deposition structures complicated the geology significantly. This reduced the potential for high grading. Basic reconnaissance mapping should have been completed as a reality check on the assumptions used for the due diligence.

Risk based estimation and stope design in an underground nickel deposit

Most 2.5m deep drillhole rings of an approximately 5 x 20 x 100m stope design were marginally above cut-off. After mining, stockpile sampling and visual inspections demonstrated that most

of the stope was well below economic cut-off. In this case conditional simulation could have been used to create stope designs that minimised the potential loss while maximising the potential upside.

Drillhole compositing in an underground gold deposit

One of the ore shoots in this deposit consisted of an approximately 5m - 10m thick shear hosted ore zone with a sharp geological footwall and hanging wall. The drill hole intersections within the shear zone were composited from the hanging wall to the footwall and if the final sample was less than 0.5m in length it was discarded. In this case the highest grades were preferentially on the footwall and hanging wall contact and the discarded samples reduced the metal content by approximately 10%. For all deposit types the length and metal lost during compositing should always be calculated and the compositing method adjusted accordingly.

This deposit is not yet in operation and therefore this error has not incurred any cost. However it is possible that a potentially profitable operation could have been sold due to the under-estimation in gold content.

Grade interpolation in an underground gold deposit

In this deposit there was poor reconciliation in the extremely high grade areas. In these areas <5cm thick shears with visible gold cut across the trend of the main ore zone by 5-20°. The inverse distance squared interpolation only accounted for continuity in the direction of primary mineralisation. In this case a technique that can model continuity at different cut-offs, such as multiple indicator kriging or sequential indicator simulation, would have been desirable. In this case better local estimation of gold would have lead to improved stope design and increased profits.

DISCUSSION

Most of the examples of poor practice would appear obvious and easily avoidable to a geologist. Despite this such examples are surprisingly common and there are many reasons for their occurrence, e.g. low staffing, high turnover, inexperience etc.

A continuous business improvement model called operational excellence (OE) is described below. It is anticipated that the implementation of OE across BHPBilliton sites will significantly reduce the examples of poor practice and add value throughout the resource evaluation cycle.

OVERVIEW OF OPERATIONAL EXCELLENCE

For a business to improve consistently it is imperative to have an improvement model. The improvement model BHPBilliton has adopted is OE, which is a collection of practices that enable a business to accelerate improvement and sustain the capture of long-term benefits. By using a common improvement language and methodology across BHPBilliton the company incorporates it's consistency, rigor, discipline, and data into it's decision-making processes. The alternative is to allow individual managers to improve the business in their own way at their own time. (Destra Consulting, 2002)

OE has three main components, benchmarking, networks and knowledge sharing and Six Sigma. Six Sigma is an externally

acknowledged and recognizable brand for business improvement, which is modelled directly on General Electric, one of the worlds most respected companies (Destra Consulting, 2002).

OE was designed as an improvement model for all aspects of BHPBilliton's business and as such not all the tools and approaches are directly applicable to the improvement of the resource evaluation cycle. Summarised below are those aspects of OE directly applicable to the resource evaluation cycle

BENCH MARKING

Benchmarking identifies global improvement opportunities through comparing performance against other best practice operations and companies (Lawrence and Yeates, 2002). Benchmarking of the resource evaluation cycle as applied at BHPBilliton (summarised in Figure 2) consists of defining in detail accepted best practice and scoring (a rating out of 100%) ourselves and being scored against the definition of best practice. This is done with an impartial external facilitator and external experts.

All operations are scored for each major area of the resource evaluation cycle and the scores are summarised via a graphical representation. Only the best operation for each area is identified and each operation knows their scores. In this way each operation determines where their strengths and weaknesses in the resource reserve cycle are as well as who within the company can be called upon to share best practice (Lawrence and Hadwen, 2002).

NETWORKS AND KNOWLEDGE SHARING

Networking and knowledge sharing allows good ideas to be shared quickly and directly with all levels of the organisation reducing implementation times of proven practices and solutions. In addition, a standard language, measures and goals can be encouraged breaking down 'silos' and improving communication (Destra, 2002).

At BHPBilliton networking and knowledge sharing is encouraged via annual meetings of technical specialists, communities of practice, newsgroups, a leading practice library and learning centres which encourage communication on specific areas of the resource evaluation process, e.g. resource modelling.

In addition, there is a website which provides useful information in the way of policies, codes, conferences, news, research projects, BHPBilliton resources and reserves, toolkits and internet links.

SIX SIGMA

Introduction

Six Sigma equips people with the skills and capabilities to continually identify and solve priority improvement projects (Destra, 2000). One of the key distinguishing features of Six Sigma from a typical geoscientist's viewpoint is that the effectiveness of improvement is equally dependant on non-technical aspects such as communication and acceptance of change. As part of the Six Sigma approach, ideas and improvement come from the bottom up and not just the top down. This does not mean that management relinquish control of the process, rather that the best ideas are put forward and they

are more likely to succeed because they have the support of all involved.

The Six Sigma process is divided into sections on how improvement projects are selected, prioritised and implemented with the emphasis below being on project selection and prioritisation.

Project Selection

Areas for improvement are sought from all the people involved in the resource evaluation process. The key at this stage is that no idea is a bad idea, with the aim being number of ideas not quality. Figure 3 is a process map detailing how this list of ideas can be reduced into a manageable number of improvement projects that will add the most value to the operation. The ideas not selected for immediate improvement are not discarded but are parked ready for further consideration in future improvement cycles.

The first step for reducing the number of improvement ideas is to remove ideas that are essentially the same but are worded differently, and (where possible) grouping of ideas that are related but still have key differences. The remaining ideas are then screened against mandatory, realistic and measurable constraints. Examples of constraints could be a limited budget or limited time. Each idea must pass each constraint to be considered further.

Following absolute criteria screening, ideas are compared by way of tools such as risk versus opportunity matrices, payoff matrices and risk assessment. Risk versus opportunity matrices consist of combining likelihood and consequence on axes of a graph. Examples of payoff matrices would be cost versus benefit, impact on customer versus impact on company, payoff versus ease of change, resources required versus time to implement. Risk versus opportunity matrices consist of assessing ideas relative to:

- Long-term consequence of doing nothing.
- Short-term consequence of doing nothing.
- Long-term opportunity if we fix the problem.
- Short-term opportunity if we fix the problem (Destra, Consulting, 2002).

The best projects may be evident from the process or a formal scoring and ranking of improvement projects against key criteria could be used to distinguish between similar ideas and to make the ranking process more auditable and transparent.

Project Implementation

Six Sigma was originally developed for an existing repetitive and controllable process for which the data to quantify the impact on business performance are available or can be obtained quickly. Many parts of the resource evaluation process do not fit well with the definition of an OE project, thus the relevant Six Sigma

tools must be selected for each improvement project. Many books have been written about implementing Six Sigma and the tools are not discussed further here. For a more detailed description of implementing Six Sigma the reader is referred to Pande et al. (2001).

CONCLUSION

There are many published examples of how best practice has added value in the resource evaluation cycle and fewer published examples of poor practice destroying value. Traditionally, an operation or department's position on the scale between best practice and poor practice depends largely on the management skills of the staff. As the quality of management varies thus the position on the scale between best practice and poor practice will vary greatly. If an organisation is to move towards best practice and maintain improvements a standard way of doing business and improving (an improvement model) that gives equal weighting to technical and non-technical aspects is required. In addition, this model must provide insurance against performance varying greatly depending on the skills of individuals. The model BHPBilliton has chosen is Operational Excellence (OE), which is a way of doing business that is aimed at moving all aspects (not just geology) of an organisation towards best practice and ultimately a share price that consistently outperforms its competitors.

ACKNOWLEDGEMENTS

The assistance of C Handley, J Macdonald and G Yeates in reviewing this document is greatly appreciated. The author is also grateful for BHPBilliton's approval to publish this document.

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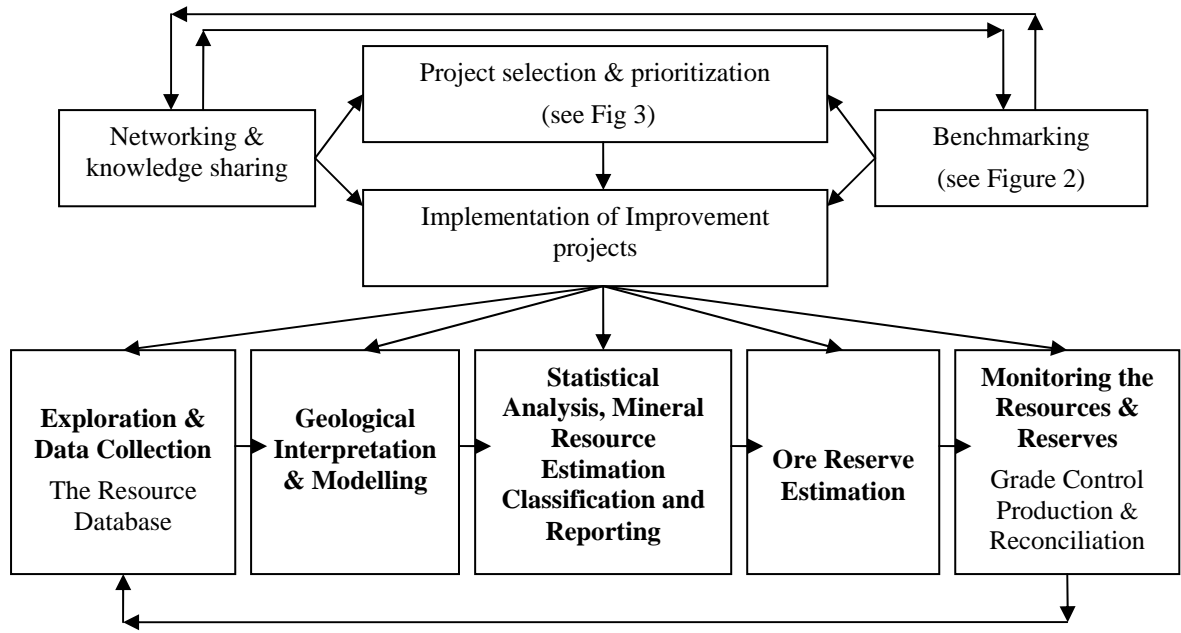


Figure 1 Overview of Operational Excellence as applied to the resource evaluation cycle. The lower part of this diagram is modified from Edwards (2001). Note that ore reserve estimation is not discussed in this paper.

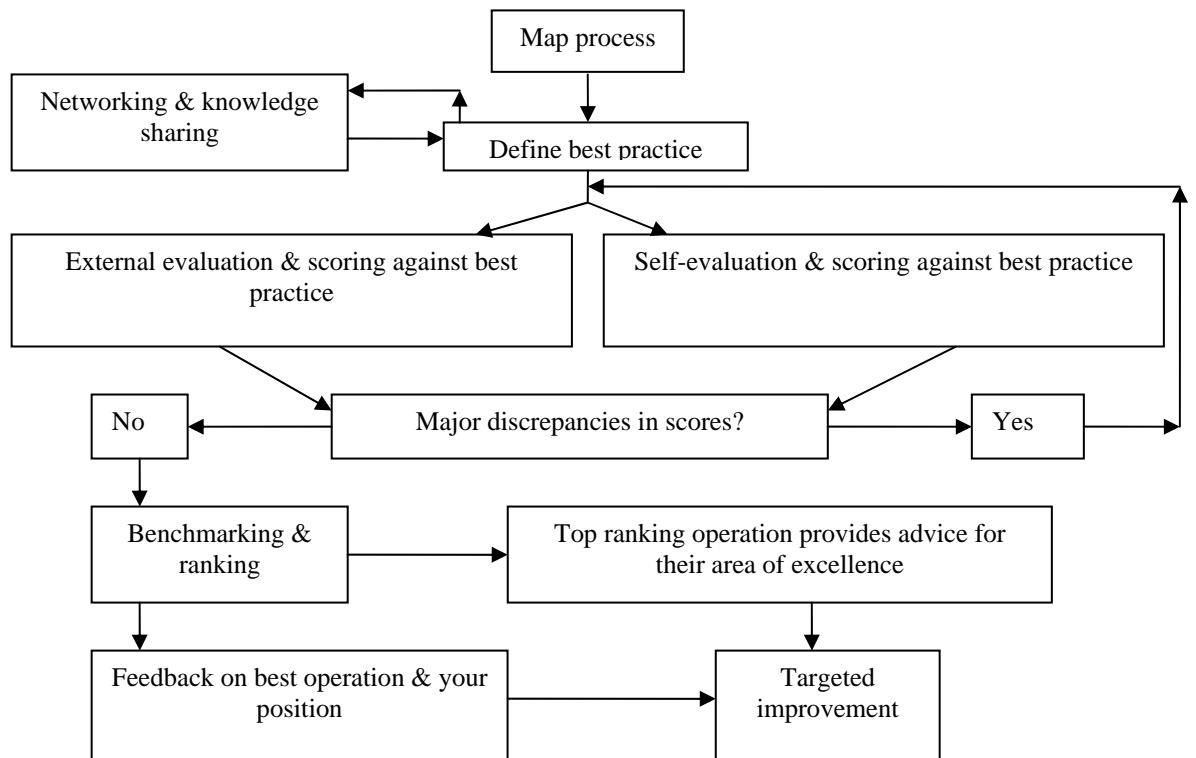


Figure 2 Benchmarking process map.

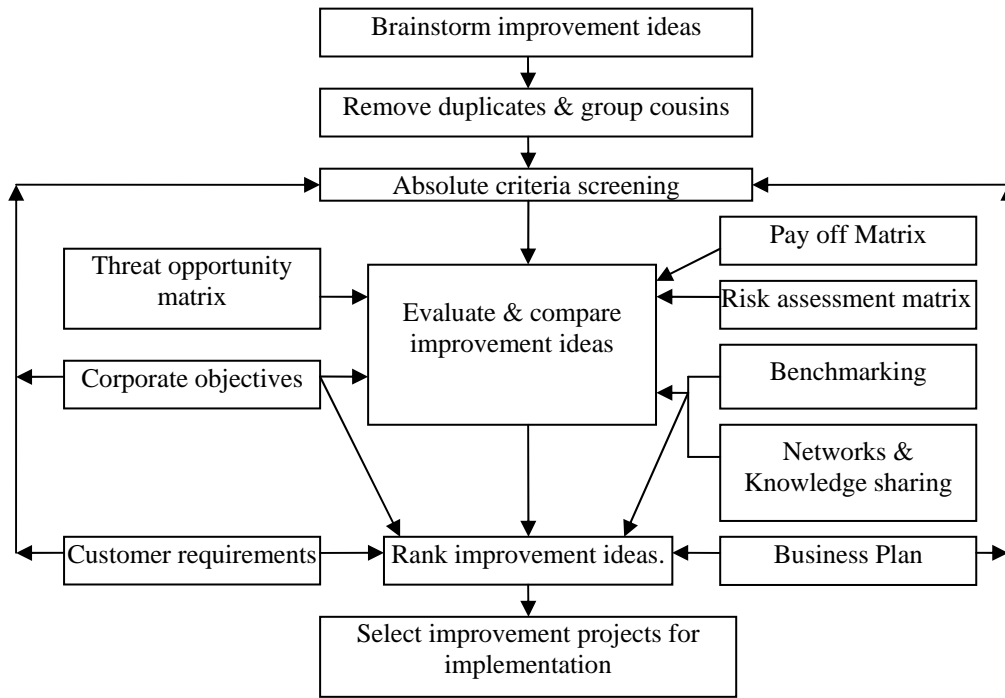


Figure 3 Project selection and prioritisation process map.