Diamond value management—knowledge management and the measurement of value addition

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Synopsis

Diamond Value Management's objective is to achieve $/ton revenue improvement across De Beers group mines. The respective % improvement contributions are measured against targets set by each of the operations. Degree of target achievement is measured via a maturity model at each operation. DVM comprises seven elements. It spans several value chain facets and various collaborative projects are conducted under its umbrella. New technologies in De Beers are also evaluated from a DVM perspective.

Introduction

Within the current operations and exploration goal, Diamond Value Management (DVM) features in two of the strategic leverage areas.

These are

- ➤ Operational margin improvement
- ➤ Growth and delivery to plan.

The objective of Diamond Value Management within this action plan is to provide a 10–20% improvement in the dollar per ton revenue across the group mines (using 1998 actual figures as the baseline) by 2004.

The scope of the Diamond Value Management project

Elements of Diamond Value Management

Diamond Value Management comprised initially six components.

- ➤ Diamond control
- ➤ Diamond damage
- ➤ Process efficiency—free diamond recovery
- ➤ Liberation—locked diamond recovery
- ➤ Optimum top cut-off size
- ➤ Optimum bottom cut-off size.

An additional element called Waste Management was later added to give the current seven elements of Diamond Value Management.

Measurement of improvement

Potential contribution

The estimated average potential contribution of each component of DVM towards the overall 10–20% improvement in the dollar per ton for the group is indicated below

Diamond control	2%
Diamond damage	6%
Process efficiency	1%
Liberation	8%
Top cut-off	2%
Bottom cut-off	1%

It is important to note that this was an average estimate for the group. Some mines would be above and some mines would be below, depending on the level of technology currently used at a particular mine and the level of optimization already achieved. Each mine was therefore requested to provide estimate figures more relevant to its local operations. These initial estimates are shown in Table I.

Proposed measurement – Size Frequency Distribution (SFD)

The proposal to measure the improvement in dollar per ton revenue was to use the diamond size frequency distribution curve. For each mine, current year to date diamond SFDs are compared against a baseline diamond SFD calculated for 1998.

This was selected as the method of measurement because when evaluating bottom line revenues at the operations this excluded variables that could have an influence on it. For the purposes of the comparison of the current baseline against the measured 1998 diamond SFD baseline, a fixed rand per carat per sieve class figure was chosen, so that current figures could be compared to the baseline figures.

This method was evaluated by the De Beers Mineral Resource Management Department (MRM), where initially the raw 1998 annual baseline was determined, and then compared to baselines with various degrees of confidence and accuracy, taking grade, source and facies into account.

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Table I

Initial estimates of percentage increase in $ per ton revenue against a 1998 baseline to be achieved by the end of 2003—DVM element objectives

	Koffie	CTP	Finsch	Venetia	Namdeb	Namaqua-land
Diamond control	1.0%	2.0%		1.0%	4.0%	2.0%
Diamond damage	4.5%	2.0%		3.0%	6.0%	10.0%
Diamond liberation	4.5%	20.0%	4.5%	6.0%	2.0%	4.0%
Process efficiency	9.5%	1.0%	3.5%	2.0%	2.0%	2.0%
Top cut-off size	0.5%	1.0%	2.0%			1.0%
Bottom cut-off size	2.0%					
Waste managment	1.0%	1.0%		2.0%		
Mining tool						
Total	**23.0%**	**36.0%**	**10.0%**	**14.0%**	**14.0%**	**19.0%**

	Orapa	Jwaneng	Oaks	Premier	Debmarine
Diamond control	1.0%	0.5%	1.0%	1.0%	
Diamond damage	2.0%	1.0%	6.0%	4.0%	3.0%
Diamond liberation	11.0%	4.0%	5.0%	4.0%	4.0%
Process efficiency	3.0%	2.0%	6.0%	1.0%	1.5%
Top cut-off size		0.5%		2.0%	
Bottom cut-off size	0.5%	2.0%			
Waste managment			2.0%		
Mining tool					9.0%
Total	**17.5%**	**10.0%**	**20.0%**	**12.0%**	**17.5%**

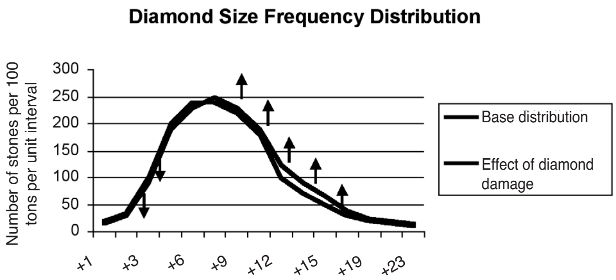

Figure 1—An example of the principle of change expected in the diamond SFD due to a decrease in the DVM element for diamond damage

The principle of a change in diamond SFD is shown in Figure 1 and and example of an actual change in the diamond SFD against baseline is shown in Figure 2.

The elements of DVM

Diamond Control

Diamond control is concerned with the protection of the product at source, and involves monitoring of the procedures and plans put into place at the mines to ensure the correct practices are maintained.

A risk evaluation can be done with a LIMN flowsheet, where the potential for exposure to free diamonds in various parts of the flowsheet can be evaluated. This can then be linked to the overall security information system, which forms the basis of a risk management system, and if the potential risk is deemed too high, corrective measures can be taken.

This forms a whole separate topic and will not be taken further here.

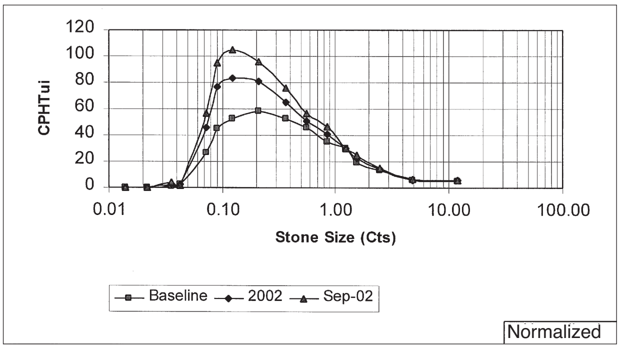

Figure 2—An example of an actual change in the diamond SFD against baseline for a De Beers operation

Diamond damage

Diamond damage is defined as any effect during the winning of individual diamonds which could result in a reduction of their value. This includes

- Diamond breakage (a piece or pieces missing)
- Abrasion
- Impact scarring
- Etching.

The first objective was to establish the current levels of process induced diamond damage around the group mines and implement changes where necessary.

The second objective, which has become the main issue, was to determine the revenue implications of diamond damage and justify capital for process changes where necessary.

As a result of diamond and simulant work done around the group mines, a number of practices have been stopped, modified, or will be phased out.

Examples of these include

- Pneumatic conveying of free diamonds
- Use of impact crushers
- Pumping of diamond concentrates in a water medium is being replaced by jet pumping or modified to reduce tip speeds
- Drop heights for free diamonds are being minimized and construction materials are being changed to minimize the effect of impact
- Scrubber and milling parameters are being optimized.

Conversely, certain practices have been recommended or cleared as being 'diamond friendly'. Examples of these include

- High pressure rolls crushing—inter-particle crushing
- Pumping of DMS concentrates in a ferrosilicon medium
- X-ray machines using rubber socks below the ejectors
- The capsule system for transporting pure diamonds.

Quantitative diamond damage assessments are carried out in our final sort houses and feedback given to the operations to try to identify the root cause of the changes, which can be positive or negative.

Diamond breakage testwork is also done by members of this team at the mines to assess diamond damage in the various plant processes. This involves profiling a pre-selected set of diamonds for diamond damage, including the value, then putting the diamonds through a unit process, collecting the diamonds, and re-evaluating the diamonds for diamond damage and revenue.

Diamond damage levels on the alluvial deposits on the West Coast tend to be lower than the kimberlite mines, as the diamonds have already been through a natural screening process by the river that took the diamonds to the sea.

Diamond liberation

Diamond liberation refers to the extent to which the diamonds are liberated or extracted from the host ore source e.g. kimberlite, alluvial, fluvial or conglomerates.

The objective is to obtain maximum liberation of diamonds for minimum diamond damage and maximum revenue potential.

Measuring techniques for liberation are via the diamond SFD curves, stage crushing testwork and more recently, flooring exercises.

The optimum recrush size can be established by estimating the additional revenue at a given recrush size and at the same time establishing the associated working costs for each recrush size.

Diamond release curves produced by testwork on the mines and statistical analysis by MRM give an indication of the optimum economic recrush size for a given orebody and process.

Diamond process efficiency

Diamond process efficiency refers to the extent to which all the liberated or free diamonds are recovered during the recovery process. The objective is to recover >99% of all free diamonds.

Key performance indicators and size frequency distribution curves are being used on the mines to ensure optimum recovery of all free diamonds. This is verified with tracer testing and technical audits.

Expert systems are being introduced on dense medium circuits and X-ray management systems are supplied with all X-ray machines. This is supported by regular audits and trouble shooting.

Current ways of doing things are being questioned. An example of this is the preferential mill that has been developed for one of our operations to remove the shell that has been causing high ferrosilicon losses and loss of diamonds within the shells. By establishing the difference in energy required to break the diamonds and to breakup the shells, a mill has been designed to operate in that energy gap. The process efficiency initially appears improved while minimizing the diamond breakage.

Mining tool efficiency for offshore operations has been receiving extensive attention. This refers to the effectiveness of the drill head and the seabed crawlers to collect and lift at required rates of cubic metres per hour. The objective has been to improve recovery volumes through the drill head from the ocean floor by at least 33%, without detriment to diamond breakage or process efficiency.

Top cut-off size

Top cut-off refers to the largest diamond that the plant has been designed to recover. The objective is to optimize large diamond recovery.

The top cut-off size required for any given process plant varies, depending on the diamond size frequency distribution of the orebody and the occurrence of large diamonds.

Extrapolation techniques are being applied by MRM to establish a top cut-off size, which will ensure the economic recovery of all large diamonds.

The effect of an incorrect top cut-off size can manifest itself in a number of ways

- ➤ If the top size is too low, this can lead to increased or higher diamond damage than necessary
- ➤ If the top size is too high, this can result in an increased loss due to locked diamonds by insufficient liberation
- ➤ The effect of the middle cut-point also has to be considered as this also has a bearing on the effectiveness of the top-size chosen.

Bottom cut-off size

Bottom cut-off refers to the smallest diamond that the plant has been designed to recover. The objective is to maximize economic viability with market requirements. The bottom cut-off is determined by MRM and is based on diamond supply and demand.

Larger bottom cut-off relates to lower capital cost and lower working costs for a new plant. The revenue per ton must therefore be optimized without losing sight of the cost per ton required to produce the diamonds.

Bottom cut-off sizes are regularly re-evaluated by MRM

Waste management

Waste management refers primarily to the amount of 'external waste rock', namely non-diamondiferous material that is treated unnecessarily through the treatment and recovery processes.

This also centres on removing problematic internal waste material as early as possible in the treatment process. The aim of upstream waste removal is to enhance process efficiency and reduce feed to the recovery section and overall processing costs, while maximizing potential revenue generation.

The amount of external or waste can have a significant effect on the diamond recovery process. Increased waste has the effect of

- ➤ Unnecessary crushing of hard waste rock material and poor liberation of the diamonds from kimberlite
- ➤ Decreasing the efficiency of the DMS process. The amount of waste that can be tolerated as a percentage of head feed changes from one operation to the next. Establishing those limits per operation is critical, as the revenue loss from poor diamond recovery or displacement of diamond bearing ore becomes significant.

There is a considerable effort going into various waste sorting initiatives around the group. The concept initially looked particularly promising for the West Coast mines, but recent improvements in the technology have made this an attractive option for many of the kimberlite mines as well. This is currently a centrally co-ordinated project from TSS Metallurgy in Johannesburg.

The extent of Diamond Value Management

Diamond Value Management is not restricted to only the optimization of mining and metallurgy within the operations.

Within the basic diamond pipeline, Diamond Value Management principles can be applied to the geological prospecting and deposit evaluation aspects, and even to certain aspects in the DTC with regard to sorting and evaluation.

Diamond damage

Involvement of Geology and the DTC in the reduction of diamond damage and quantifying derived benefits.

Bottom cut-off size

The optimum cut-off size will be supply-demand related, in addition to there being a business case influencing the optimum size. There is still room for some optimization.

Top cut-off size

This is related to the breakage of large stones. Extensive data is now available from various group mines and attempts to correlate to process variables are being made.

Other areas of potential benefit

By doing extensive flooring exercises, it would be possible to determine a number of issues relating to the diamond size frequency of a particular mine. These include

- Confirmation of optimum diamond footprint
- Indication of potential increased liberation
- Potential for changing the top cut-off size
- Total diamond content curve.

An extensive flooring exercise has recently been completed at an operation. This has shown that a significant increase in dollar revenue is still possible, if the normal recovery process is optimized.

The cost of doing such exercises obviously needs to be justified, but such exercises can be of great benefit to the group in determining total diamond content, and ultimately the sort of diamonds that might be recoverable with changes to the processing flowsheet. The DTC would need to advise on the value of these extra diamonds in terms of justifying the ROI.

Collaborative projects

There are currently two main collaborative projects in progress under the DVM umbrella.

Blasting and fragmentation

The aim is that through a combination of theoretical evaluation, model development and practical testwork, a method of optimizing the blasting method to prepare the material for subsequent treatment will be developed, which will also minimize diamond breakage.

This is being done in collaboration with an institute in Australia, and co-ordinated by De Beers TSS in Johannesburg.

Advanced comminution and liberation research

This project is an extension of the blasting and fragmentation project into the comminution area. The outputs of one will be part of the input into the other

This project only started in 2000 and is in the fourth year of a five-year project.

In conjunction with this is the use of a simulation package (LIMN) and the new development of a diamond wizard. This will enable the development of new models to be utilized around the group immediately and will be used on all group mines.

New and future technologies

New and future technologies are also evaluated from a Diamond Value Management perspective, to ensure that the principles are considered in terms of the various elements of DVM.

Examples of the new technologies are

- Latest final recovery designs
- Latest diamond recovery processing equipment
- Advances in comminution technology
- Advances in coastal mining techniques
- The outcomes of future research into overall diamond winning processes.

Management of Diamond Value Management

Diamond Value Management has now been developed to optimize the various group operations, and will be

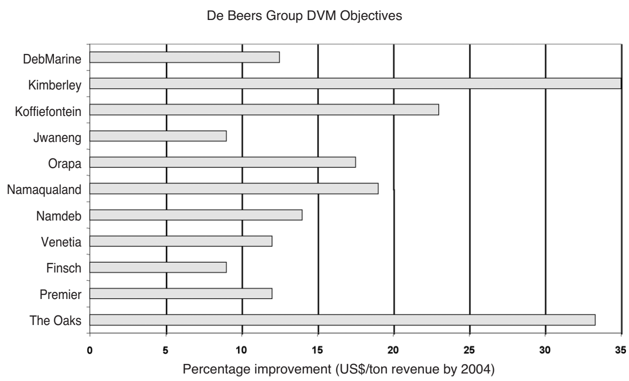

Figure 3—De Beers Group mines self-determined DVM objectives in terms of improving the US$ per ton revenue by 2004

Table II

The central DVM team that conduct annual visits to the mines

Chris Rowan	Group DVM Chairman
Joe McAlinden	General Manager—Metallurgy
Phil Rider	Group DVM co-ordinator
Peter Brammar	MRM Revenue Manager
Peter Sergeant	Principle Technology Leader
Hans Langenhoven	MRM Metallurgist—baselines/cut points
Arrie Fouche	Diamond Control/Risk
Hendrik Grobler	Divisional Geotechnical Engineer—blasting
Paddy Lawless	Divisional Geologist—diamond damage

implemented and co-ordinated in the group, with the knowledge management aspects integrated.

- Each De Beers group mine has a self determined DVM objective in terms of improving the US$ per ton revenue by 2004 (Refer Figure 3)
- Each mine has a DVM programme which is reviewed regularly on mine and during technical visits
- A central DVM team (refer Table 2) visit each operation once a year and have bi-annual group DVM meetings to discuss progress and cross-pollinate new ideas
- The mines carry out a DVM self assessment each year, which is then reviewed by the central DVM team during the annual visit. This self assessment is referred to as the Co-Assurance Assessment System (CAAS). This takes the seven elements of DVM, expands the diamond control into a number of different areas, adds a management and HR element to arrive at 12 domains for evaluation.

In each domain, the issues that have to be addressed are listed with current status and action plans. The aspects in the CAAS document are cross-linked where possible to the Balanced Score Card, which is another recent initiative within the De Beers Group.

The basis of this CAAS document is that the individual mines determine for themselves what the desired rating for individual issues will be and then measure where the current situation is against the desired level. The visiting DVM team confirm or suggest adjustments to these ratings.

- As revenue improvements attained through DVM become sustainable, these become part of the Strategic Business Plan (SBP) for the mines the following year
- All new mines incorporate the benefits of DVM into plant designs
- Best practice and knowledge exchange form an integral part of the DVM drive
- The diamond damage monitoring teams will continue at the DTC in Kimberley and Gaborone
- Collaborative projects with external research institutes in the areas of blasting, fragmentation and comminution will continue, with the goal of a 'mine to mill' type planning tool becoming available by the end of 2004.

There have been many positive spin-offs of DVM in De Beers, and one-on-one contact can be arranged.

DVM measurement and value add

Up until the end of 2002, the measured improvement in US$ per ton revenue across the group mines was between 6–15%.

Having measured the percentage improvement in US dollar per ton revenue against baseline for a particular period, the improvement is related to the revenue received for that particular operation. This is then summed across the group to give a group value add figure.

The future for DVM

DVM will continue as a way of doing business on the operations, and will be advanced and developed into a world best practice. This De Beers will strive for not only as input into any new projects, but also for the current operations. This will also be shared with any new joint venture partners. ◆

South Africa to host the world's largest petroleum congress in 2005*

South Africa will host the 18th World Petroleum Congress in September 2005. The WPC is the most important event in the international oil and gas industry. PetroSA, the national oil company, will host the congress and a senior executive at PetroSA, Ms Imogen Mkhize has been seconded as the CEO of the 18th WPC.

The congress is further evidence of South Africa as the preferred destination for large-scale global conferences and exhibitions. The congress will be held in Johannesburg from September 25-29, 2005. The theme is 'Shaping the Energy Future: Partners in Sustainable Solutions'.

Described by the Department of Minerals and Energy as 'the world's biggest, most prestigious meeting in the oil industry', the congress follows South Africa's hosting of the World Summit in August/September 2002, the African Union Summit in July 2002, and the 2001 United Nations World Conference Against Racism.

PetroSA is the short name for The Petroleum Oil and Gas Corporation of South Africa (Pty) Ltd. It manages all the commercial assets of the South African Government, with the mandate to put South Africa in a stronger position through the acquisition of oil and gas to build the national reserves. PetroSA is a leader in GTL technology through the GTL refinery in Mossel Bay, which is one of only two in the world and the biggest of its kind. ◆

* *Issued by: Nhlanhla Ngwenya, PetroSA Corporate Image and Communication, Tel: 021-417 3000 / 082 878 0734.*