THE JWANENG RESOURCE EXTENSION PROJECT – DEFINING THE RESOURCE, SHAPING THE FUTURE

M A Roberts
Jwaneng Mine Debswana

1 Introduction

Debswana's Jwaneng Mine (south-central Botswana) is the richest diamond mine in the world and has been contributing substantial revenue to Botswana since the mine started operating in 1982. The resource consists of 3 separate volcanic pipes/vents namely North, South and Centre pipes (2 additional small kimberlite bodies have also been intersected within the mining pit) which erupted through Transvaal strata and the overlying Karoo sediments ~245 million years ago. Although earlier drilling and geophysical surveys suggest that the 3 pipes extend to depths greater than 1km below the surface, the resource is only at an indicated level of confidence to a depth of 400m, and mining activities will start exploiting the inferred resource material below 400m in 2014.

Figure 1. Location map of Jwaneng mine. Inset shows position of pit.

2 Project Scope

The extension of the indicated resource to below 400m is a key strategic priority at Jwaneng Mine and the scope of the Jwaneng Resource Extension Project (JREP) involves

the delivery of an indicated resource estimate down to ~850m below surface, which will then support mining operations for the next ~20 years including all key expansion activities such as the Cut 8 Project and beyond.

Phase 1 of the JREP project involved the delineation of the 3 kimberlite pipes to high inferred level and was completed in 2007, and was principally aimed at the delineation of the kimberlite pipes between 400m and 1000 meters below ground level (mbgl). Phase 2 (JREP2) will focus on:

- defining/refining the internal geology and volumes of the pipes through the recovery of drill core and the application of the understanding of modern volcanology processes to the interpretations
- development of physical property and metallurgical models for the pipes
- delivering a grade/revenue model to:

850mbgl	-	Centre Pipe;
800mbgl	-	North Pipe;
700mbgl	-	South Pipe.

This will take the Cuts 6, 7, 8, and the potential Cut 9 resources to an indicated level of confidence. All of these resources extend, in part, below the current indicated resource. The payback of Cut 8 lies within the current indicated resource, although 76% of the total Cut 8 resource lies below the 400m indicated resource level, where confidence in the geological model is low due to the paucity of high quality core-derived geological data.

In total, 45km of core will be drilled during Phase 2, and represents one of the largest kimberlite resource evaluation/extension projects ever undertaken (Figure 3). Key aspects of this project include:

- the use of micro diamonds only, to deliver a full grade model;
- full integration of ancillary data sets such as downhole geophysics, petrography, geochemistry and Portable Infrared Mineral Analysis (PIMA);
- the use of state of the art core drilling technologies through our local drilling partners – De Wet Drilling.

Drilling commenced in August 2009 and will continue until end 2011, with the planned sign off on the extended Jwaneng Resource expected by the end of 2012.

3 Jwaneng Resource Extension Project Delivery Process

The data acquisition, interpretation, model generation, estimation and sign off processes on the extended resource are highlighted and explained below in Figure 2. Two key areas in JREP include the linkage between the interpretation and modeling activities and the overarching innovation/assurance/knowledge management processes which are there to add value throughout the updated resource delivery process.

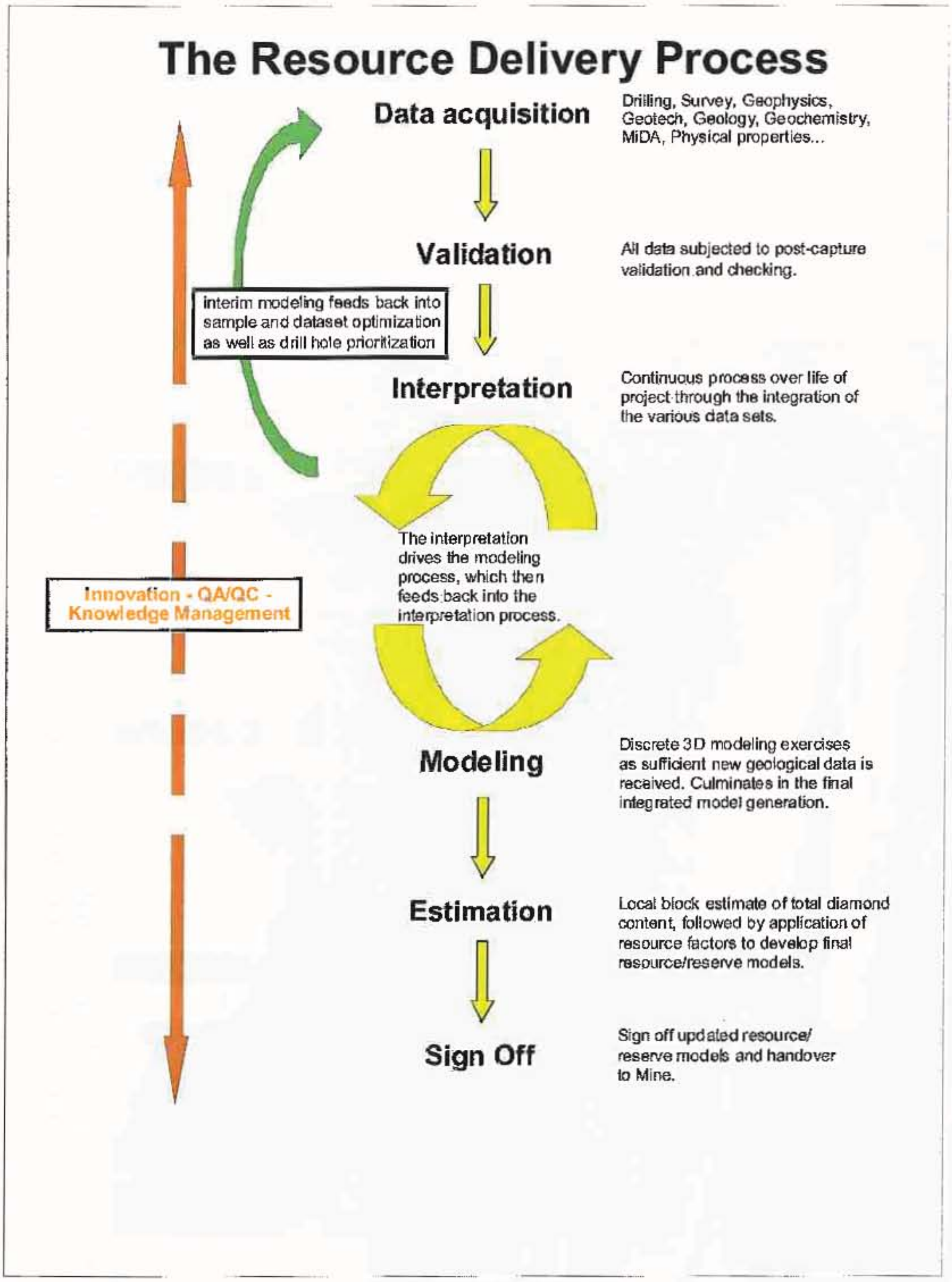

Figure 2. Process map for JREP.

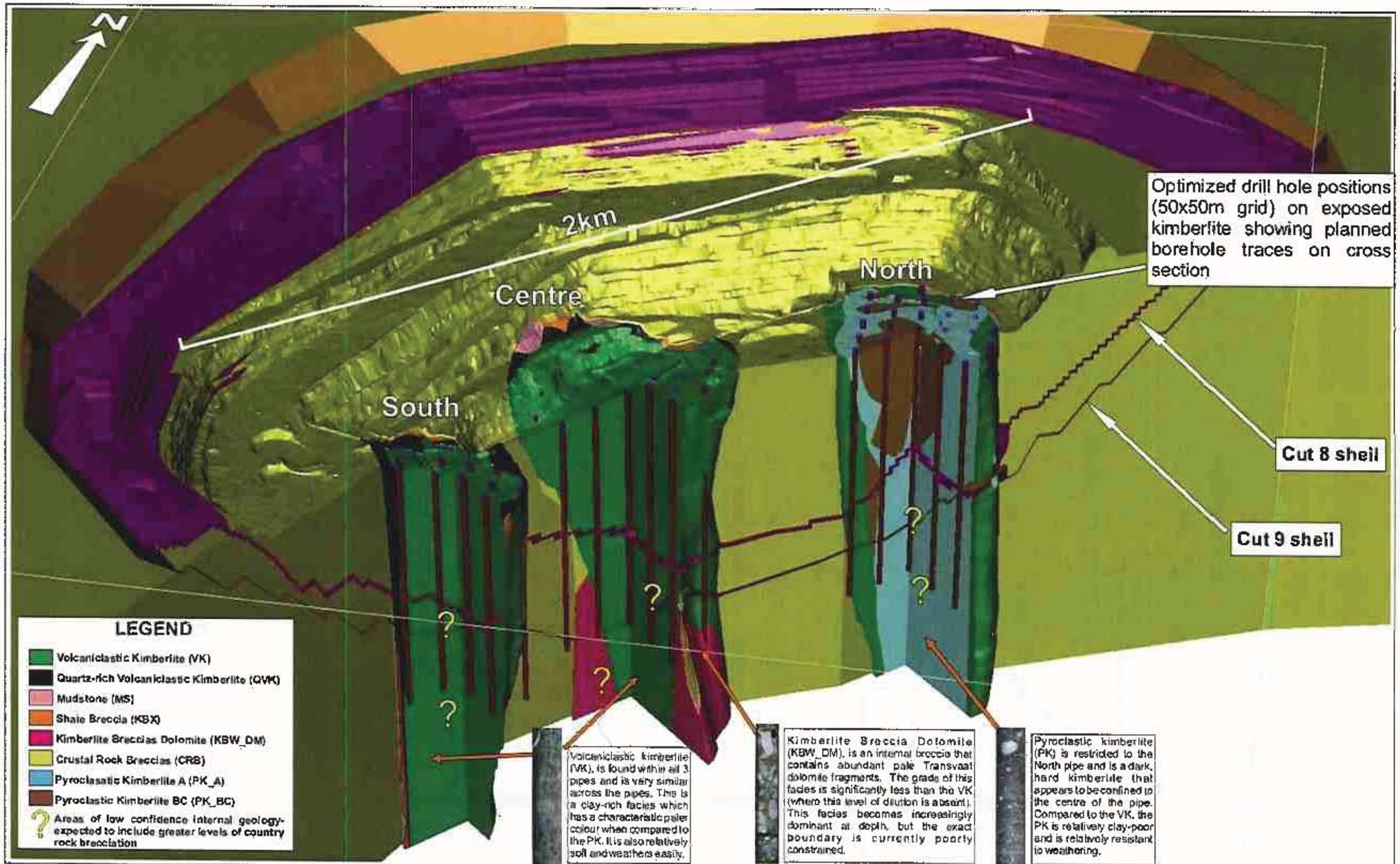

Figure 3. Cross section through the three Jwaneng kimberlites showing planned boreholes and question marks indicating areas of higher geological uncertainty. Both Cut 8 and Cut 9 conceptual pit positions are indicated.

4 Drilling

Experience from the delineation phase of JREP (Phase 1), has shown that heavy duty core rigs are required to consistently drill stable holes to the required depth in the Jwaneng kimberlites (which represents some of the most challenging drilling conditions in the industry). Two SCHRAMM T-130 XD drill rigs have been procured and customized by the JREP drilling partners (De Wet Drilling, a Botswana company with extensive kimberlite drilling experience throughout Southern Africa) for this purpose. These rigs have a pull back of 70 tonnes, and are the largest core rigs ever used by Debswana.

Due to the high content of smectite clays in the Jwaneng kimberlites and their associated propensity to spectacularly degrade (disintegrate/collapse) during drilling, heavy duty core drilling technology together with a purpose built fully integrated mud treatment system is being used to chemically stabilize the drill holes and drill core in order to successfully drill core holes in the kimberlite to depths greater than 600m and recover suitable core for geological analysis. Use of, and adaptation of modern drilling mud technologies is critical to the success of the drilling. As a result, the JREP drilling program is supported by experienced mud technicians and engineers. Safety around the drilling project is a primary concern and automatic rod-handling equipment will be used to attach the heavy drilling rods to the drill string, minimizing manual intervention and thereby reducing the risk of serious injury on the project.

Figure 4. De Wet Drilling Schramm setup in the pit.

5 The use of Micro-Diamond Analysis (MiDA) for grade estimation

The relationship between micro-diamonds (<0.5mm) and diamonds recovered during mining activities has been observed for decades, and recent advances in modeling the relationship between micro-diamonds (MiDA) and macro-diamonds (MaDA) now allows for a full extrapolation of the total diamond content curve (TDC curve) from the MiDA population only (Figure 5) where the relationship between the MiDA and MaDA has been demonstrated. The ability to rely on the MiDA for determining the grade estimate substantially reduces the time and cost of any evaluation exercise where the MiDA/MaDA relationship can be demonstrated, and the stability of the resource/revenue performance is established (by a factor of over 2), as core drilling alone can provide both geology and samples for diamond recovery without having to rely on large diameter drilling with the high drilling costs and the costs of recovering macro-diamonds through a plant. Existing revenue models for the different kimberlite facies will be used for the resource calculation. If new facies are encountered, revenue sampling may be required for assurance purposes.

The recovery of MiDA from the core is achieved through chemical dissolution of the rock which allows for the recovery of the chemically inert diamonds down to a size of 0.075mm intact (i.e. no/minimal breakage) thereby allowing diamonds as small as 10^{-5}cts to be weighed and then modeled.

6 Techniques

In order to determine the internal geology (lithofacies) of the Jwaneng kimberlites, together with the distribution patterns of other physical and geometallurgical properties (which are required to optimize future diamond recovery), numerous geological data sets will be acquired. These include:

- visual geological and geotechnical logging
- dilution measurement
- downhole wireline geophysics
- geochemistry
- petrography
- mineral chemistry
- spectral geology
- density
- rock hardness
- ore dressing studies
- micro-diamond sampling

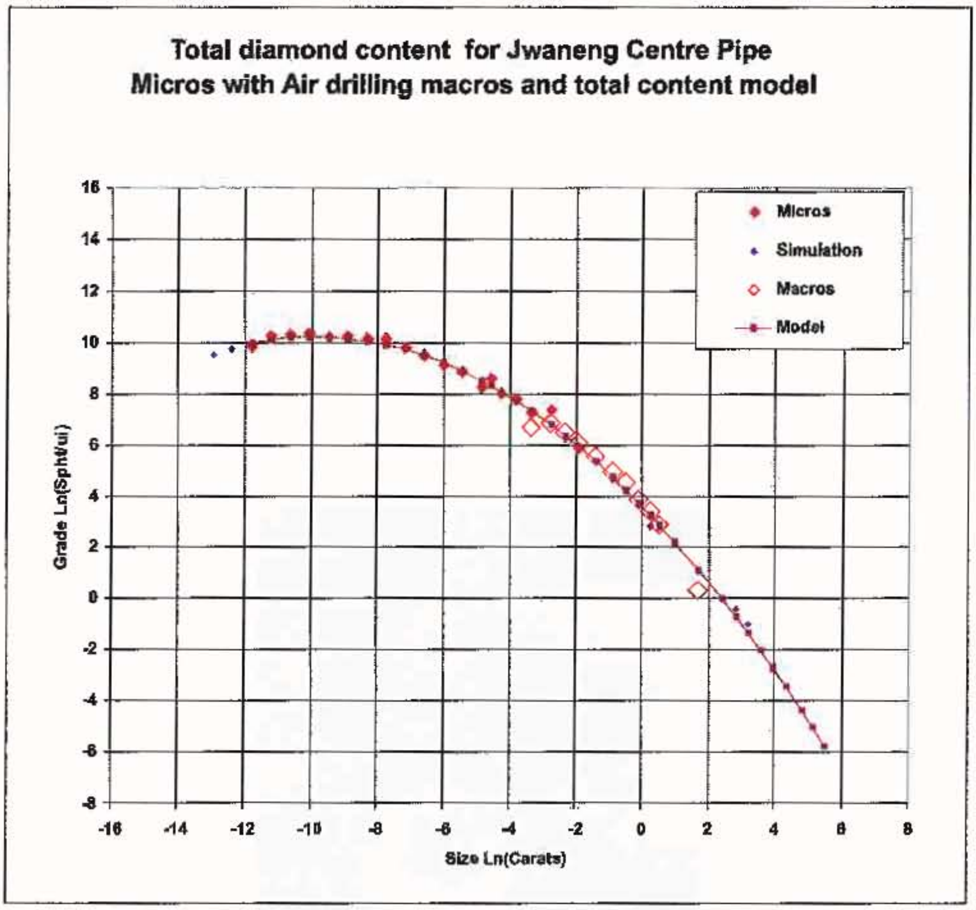

Figure 5. Log plot of stones per hundred tonnes versus diamond size (in carats) showing the link between the microdiamonds, the modeled macro diamond distribution and actual macro diamond distribution from the Centre Pipe, Jwaneng. The modeling of the macro diamonds from the micro diamond population is consistent with the actual macro population and therefore allows for the targeted recovery of micro diamonds.

Integration of these unique data sets will allow for confirmation and improved definition of existing geological unit boundaries and could potentially result in the identification of additional sub-units. The identification and delineation of the internal geological boundaries as part of a coherent geological model is critical for the micro-diamond estimation process, and will have the greatest impact on the accuracy of the estimated local block grades.

By applying the understanding of how modern day equivalent volcanic processes occur, the eruptive history of the Jwaneng kimberlites can be established and allows for development of realistic geological models and helps the understanding of what controls diamond distribution within the kimberlites (Figures 6 and 7).

7 Conclusions

Through the use of state of the art drilling technology and the use of Micro Diamond Analysis to estimate resource grade, JREP will deliver an indicated resource that is extended from the current 400m limit to 850m by end 2012. This will be the largest resource program yet undertaken on Jwaneng, the world's richest diamond mine, and endeavours to lead the way in kimberlite resource extension projects. The integrated dataset that will be produced on this project will be one of the most comprehensive kimberlite datasets and will allow for a rich understanding of the formation of the kimberlites through the application of the understanding of modern volcanology. The accurate definition of the Jwaneng resource will help shape Jwaneng's and Botswana's future for the next 20 years and beyond.

Figure 6. An example of modern day maar eruption similar to that which would have produced the Jwaneng DK2 kimberlites ~245Ma. Note the highly gas-rich and explosive nature of the eruption producing large ash clouds; with no formation of lava flows or lava fire fountains. The eruption would have consisted of a series of sustained blasts that would have lasted days to months.

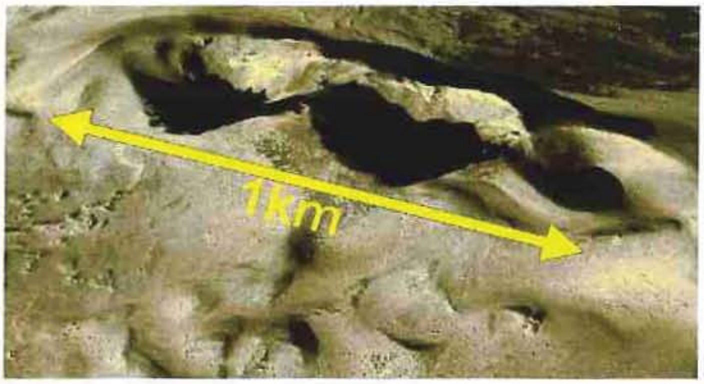

Figure 7. Post eruption, this is how the 3 volcanic craters of South, Centre and North Pipe may have appeared. Note the limited vertical height of the edifice and significant in-filling of the craters during, and post eruption. After several periods of erosion, these low volcanic tuff rings would have been eroded away

The Author

Martin Roberts, *Section Project Geologist*, Debswana

I started working for De Beers at the beginning of 1998 as a field geologist near Venetia before going to read towards my PhD in Cambridge. I returned to work as a field geologist in Zimbabwe with De Beers Group Exploration managing early stage exploration projects, and eventually serving as the Exploration Manager for the operation before closing it down in 2006. In 2007 I moved to Gaborone to manage De Beers Prospecting Botswana's northern projects including the Orapa area projects. In Aug 2008 I transferred to Jwaneng Mine (Debswana) as the Technical Lead on the Jwaneng Resource Extension Project.