MICRODIAMOND ANALYSIS

Small is beautiful

The recovery and analysis of microdiamonds helps to predict the presence of commercial-sized diamonds in kimberlites. It is a cost-effective method for prioritising targets for bulk sampling.

BY ERIKA BARTON

ABOVE Synthetic diamonds recovered after caustic fusion process illustrating the absence of corrosion on diamond surfaces

A microdiamond is defined as a diamond that is smaller than 500 µ (0.5 mm). The number of microdiamonds in a given rock sample increases exponentially with decreasing size and it is this aspect, that makes size distribution analyses possible. A sufficient number of microdiamonds have to be recovered to be able to, reliably, extrapolate the microdiamond size distribution to the potential size of commercial-sized diamonds. This governs the size of sample required for a microdiamond analysis. In a kimberlite sample of 200 kg with a grade of 100 ct per 100 t, one can expect to recover one diamond per kilogram.

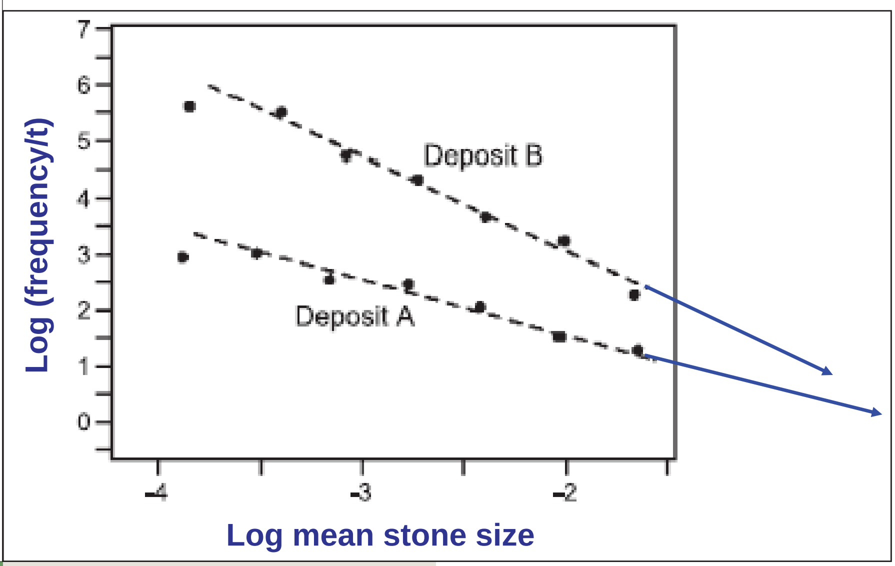
The cost of evaluating diamond-bearing kimberlites, lamproites and other diamond-bearing rocks tends to increase by an order of magnitude at each successive evaluation stage. Following the discovery of a kimberlite, the abundance of subcalcic chrome-rich garnets and detailed chemical analysis of kimberlite indicator minerals gives an idea of the diamond potential of a kimberlite. However, the ultimate economic evaluation necessitates the recovery of diamonds and an assessment of their value.

In addition to target generation for the more expensive mini bulk-to-bulk sampling stages microdiamond analysis can also play an important role in resource extension projects on existing mines. It is important to note that not all kimberlites contain microdiamonds but may have economic grades of commercial-sized diamonds. Conversely, some kimberlites may contain high concentrations of microdiamonds but lack economic grades of commercial sized stones. In these instances, only mini bulk or bulk sampling can provide the necessary information to evaluate these deposits.

Size distribution analyses and diamond grade

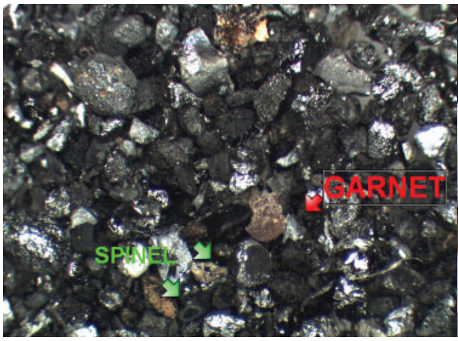
The mathematical relationship between microdiamonds and macrodiamonds has been established in the literature. As with any predictive tool, it is important to bear in mind that certain assumptions are made and geological processes cannot be absolutely quantified. A size distribution analysis, taking into account the uncertainties, can provide a cost-effective tool for prioritising kimberlite occurrences for bulk sampling. These assumptions include:

- the presence of a micro/macrodiamond relationship



LEFT Hypothetical example showing that deposit "A" is likely to have a higher grade than deposit "B" despite lower stone count

BELOW LEFT Fusion pot containing dissolved kimberlite and caustic soda being transported by an overhead crane to the pouring room which is fitted with an extraction unit
BELOW MIDDLE Kimberlite solution being poured through a screen. Insoluble residue containing diamond will then be acid-washed to remove excess caustic soda
BELOW RIGHT The MSA sorting laboratory. Sorting staff are trained by Owen Garvie



ABOVE Sorting residue after caustic fusion for diamonds using a 60X binocular microscope

- a sufficient number of microdiamonds are recovered
- efficient recovery of diamonds in the smallest sizes for both the micro and macrodiamond populations
- single diamond population
- no disruption of size distribution due to geological processes (e.g. dilution due to country rock xenoliths, diamond resorption etc.).

Size distribution diagrams are used to plot diamond frequency (diamond numbers) versus the mean stone size for each size fraction. The relationship between diamond numbers and micro to macro diamond cannot be evaluated in isolation. This hypothetical example illustrates that deposit A, despite having a lower stone count than deposit B, has the potential to contain a higher grade because of the inherent micro to macrodiamond ratio.

Africa's first commercial microdiamond laboratory

In December 2005, a memorandum of understanding was reached between SGS South Africa (SGS) and the MSA Group (MSA) to build the first commercial microdiamond laboratory in Africa. SGS provided the infrastructure and expertise in large-scale mineral processing and MSA provided the expertise in quality control and diamond sorting. Building commenced in June 2006, commissioning in the early part of 2007 and the first commercial sample was processed in April 2007. Located on the SGS site in Booysens, Johannesburg is Africa's first commercial microdiamond laboratory. The bottom level contains 16 kilns designed to process up to 8 kg each of kimberlite. The upper level houses the diamond sorting laboratory. Security cameras are strategically located to monitor all aspects of the operation.

Between 5 to 8 kg of kimberlite can be processed at one time in each kiln. No breakage of kimberlite core is necessary and pieces as large as 15 cm can be handled. The amount of kimberlite that can be processed within each kiln is intimately related to the kimberlite composition. Where different phases or facies of kimberlite can be identified, it is advisable to treat them separately. The diamond distribution on both the macrodiamond and microdiamond scale can be facies related and are inherently variable. Processing distinct facies separately provides additional information and is the rationale behind the use of microdiamond analysis in modelling resource extensions.

Sodium hydroxide (NaOH) is added to the kimberlite and the mixture is heated overnight at a temperature of 550° C. NaOH destroys the silicate bonds in minerals and these are dissolved. What remains are the insoluble minerals and the larger mineral grains. The following morning the fusion pot is lifted out of the kiln and transported by an overhead crane to the pouring room. All residual grains larger than 75 μ, and which are not soluble in NaOH, can be recovered using this process. This residue is acid cleaned and a second-stage dissolution process using a mixed chemical flux is used to remove the bulk of the remaining garnet and ilmenite. The resulting small residue ensures the complete recovery of all diamonds. The residue is examined twice, using a binocular microscope with a 60x magnification, to ensure the total recovery of all diamonds. Natural and synthetic diamonds are recovered in the sorting laboratory.

Quality control to evaluate both the efficiency of diamond recovery and diamond damage, is monitored by the

BELOW Uncut microdiamonds

addition of synthetic diamonds, referred to as spiking, in varying sizes, at the start of the process. Typically, spike recoveries are greater than 90%, and are generally 96 to 100%. Diamonds are highly resistant to caustic soda and therefore diamond etching and damage is eliminated. The synthetic diamonds recovered are routinely examined for signs of damage. Recovery rate of the spikes is reported and the recovered spikes are stored on sample cards. In addition, synthetic diamonds from an unknown source, assumed to be introduced during the sample collection, if present, are recorded.

The recovered natural diamonds are separated into 13 sieve classes by careful screening using a shaker to ensure that the diamonds report to the correct sieve class. Each diamond is examined individually and colour, clarity, morphology and the dimensions are determined and reported. All macrodiamonds and the microdiamonds are weighed using a seven-place microbalance. Diamonds greater than 300 μ are weighed individually and the smaller diamonds are weighed in groups. The diamond data reported can now be used to undertake size distribution analysis.

Microdiamond analysis forms an important part of the diamond exploration pipeline. However, the exploration and evaluation of a kimberlite or a kimberlite region for diamond potential involves many steps including the analysis of the more abundant diamond indicator minerals and ending with the final bulk sampling stage. The appropriate use of all these techniques is necessary in the planning of a cost-effective diamond exploration programme. 3S

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