THE MARSFONTEIN DIAMOND MINE—
A CASE HISTORY

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Abstract

A stream sediment anomaly found in February 1993, south east of Mokopane, was systematically followed up using kimberlite indicator exploration sampling techniques. This led to the discovery, in February 1997, of the M1 Pipe during follow-up drilling. The 0.4 hectare pipe was evaluated, in terms of diamond grade and average carat value, by treatment of percussion drill cuttings. Mining commenced in August 1998 with values of 1 433 cpht being found in the overlying eluvial gravels. The grade of the unweathered kimberlite ranged from 355 cpht near surface to 81 cpht at the bottom of the pit at 150m. When mining ceased at the end of 2000, 970 347 tons had been treated to yield 1 826 031 carats. Total revenue after processing of stockpiled material was US$246 300 000 and average value per carat US$128. Over 800 large stones (above 10.8 carats) were produced, the largest being a broken stone estimated to have been over 400 carats in size. The discovery of Marsfontein showed that small, very rich, kimberlites can still be found in South Africa by following up subtle indicator anomalies using traditional systematic sampling methods.

Introduction

Marsfontein was a classic diamond exploration discovery. It was found by field exploration with sampling the primary exploration search method. This is the approach that has led to the discovery of most, if not all, the kimberlite diamond mines found to date. Like all exploration discoveries Marsfontein was found not by one or two people but by a number of people working together as a team.

Geology

The simplified regional geology of the discovery area is shown on Figure 1. The town of Mokopane is in the north west corner and the distance east west is about 60 kms. Draped around the basement granite in the north east are quartzites and conglomerates of the Wolkberg and Black Reef Formations. These are overlain by the Malmani Dolomites and above those lie the shales and quartzites of the Pretoria Group. The Bushveld Complex rocks appear right in the west. Dips south of the granite are to the south at around 50° and in the west are to the west at around 10 to 20°. The Zebediela fault, part of the Thabazimbi-Murchison lineament, throws these older formations against flat lying volcanics of Jurassic age, Karoo lavas.
The exploration model used was very simple. During the early and mid nineties kimberlite dykes (fissures) were targeted, particularly those known to contain diamonds, using reconnaissance road sampling techniques. The objective was to find pipes associated with these known occurrences. These studies were conducted in several areas; around the Sanddrift fissure near Prieska, in the Boshof area and around Dullstroom, Nelspruit and Marnitz. South east of Mokopane a fissure had been found cutting dolomites (Figure 1) and this is why this area was targeted along the assumed kimberlite trend direction of east north east.

Because diamonds are so rare, sampling for kimberlites involves the search for durable heavy minerals (indicator minerals) present in kimberlite. Figure 2 shows peridotitic and eclogitic garnets, chrome diopside and the opaque minerals, ilmenite and chromite. The chemical composition of these minerals confirms their mantle origin and says something about the potential diamond content of the kimberlite.

Figure 1. Simplified regional geology
Sampling

Figure 3 shows the stream sediment anomaly which led to the discovery. Samples were collected from stream crossings along a gravel road here in February 1993. Two samples reported values of 9 and 3 garnets and check sampling confirmed these results. In May 1993 the chemistry of these indicators was determined by microprobe analysis and Figure 4 shows the chemistry of some of garnets found. This confirmed some garnets as kimberlitic and showed that undiscovered kimberlites were present in the area. The chromite chemistry is shown in Figure 5. Many of these grains are likely to be of Bushveld Complex origin but a few are kimberlitic and two actually fall in the diamond inclusion field.
Figure 3. Stream sediment anomaly

Figure 4. Garnet chemistry from microprobe analysis
By the middle of 1993 therefore, an early stage target had been defined. Mineral rights acquisition was then undertaken and following this, from April 1995, a systematic sampling programme commenced in order to locate the source of this stream sediment anomaly.

The stream sediment anomaly shown on Figure 3 was however only one of a number of similar anomalies found in this general area. Consequently, as a first stage of systematic follow-up work, 1 km reconnaissance line sampling was laid out across the whole region. Figure 6 shows the results on the farm Marsfontein which was sampled at the end of 1995. The garnet counts are shown with highs of 10 and 12 appearing in the north central part of the farm. The area outlined was then selected for closer interval sampling. In June and July 1996 samples were collected from this area on a 200m grid. These results are shown on Figure 7 where the garnet counts are contoured at 5 and 10. It is apparent that a kimberlite dyke or fissure runs south west to north east across the area. In the central part of the grid area however the results suggested the presence of more than just a linear feature such as a fissure and the area outlined was selected for more detailed sampling.

**Figure 5.** Chromite chemistry from microprobe analysis
Figure 6. One kilometer reconnaissance sampling results on Marsfontein farm

Figure 7. 200 metre grid sample results on Marsfontein
Figure 8 shows the sampling results of the 50 x 50m grid which was laid out and sampled over the anomalous area in November 1996. Contours are shown at 10, 15, 20 and 25 garnet counts. Three bulls-eye anomalies emerged and ultimately all of them turned out to be kimberlite bodies. The one towards the southeast overlies the M1 Pipe on Marsfontein. Four small diamonds were found in these loam samples confirming yet again that diamonds are the best indicators one can find. The drill section referred to below was laid out centrally within the circular anomaly in the southeast.

![Figure 8. 50 metre grid sample results on Marsfontein](image)

**Drilling**

The discovery drill section is shown as Figure 9. Reverse circulation drilling in a 'fence' pattern was conducted with a geologist, on the rig, using a binocular microscope to log the washed and screened drill chips. This methodology gives real time control of the drilling. Holes 1 and 2 were drilled to their planned depth but found nothing, then hole number 3 hit kimberlite near the planned end depth and the geologist decided to drill on. Hole number 4 then found nothing and hole number 5 was drilled vertically and stopped in kimberlite at 89 m. This is not a blind body as it appears from this section, the kimberlite outcrops out of this section line.

This drilling was undertaken in February 1997, almost exactly four years after collection of the original stream sediment samples.
Evaluation

Following the intersection of the M1 kimberlite in the third hole, drilling was gradually stepped up, with more drills being added to drill the small target measuring about 90m by 45m at surface, which narrowed at a depth of about 140m to a 10m wide, dyke-like body.

Micro-diamond counts indicated a high grade, which was confirmed by excellent peridotitic and eclogitic garnet and chromite compositions from this Group 2 kimberlite. The garnets indicated contributions from both peridotitic and eclogitic sources. Diamond recoveries from large diameter percussion drilling confirmed a high grade and a decision was made to go ahead and mine the pipe based on grades and stone valuations obtained from drilling, missing out the usual step of bulk sampling.

In June 1998, an agreement was concluded to mine the pipe in conjunction with De Beers and their empowerment partners, New Diamond Corporation (later to become Naka Mining). A photograph of the mine is shown as Figure 10.
Detailed magnetic surveys were unable to outline the M1 Pipe, because it lay within a strongly magnetic dyke. The presence of the pipe could, however, be inferred from a low magnetic intensity zone within the linear magnetic high. See Figure 11.

Detailed gravity surveys however, showed a clear gravity bulls-eye low, which outlined exactly the shape of the pipe. See Figure 12.
Figure 11. Geophysics - Magnetics

Figure 12. Geophysics - Gravity
Mining

Mining of the 0.4 hectare pipe commenced on 31st August 1998. In the first two days of mining the 15 metre thick eluvial gravels overlying the pipe, 40 000 carats were produced at a grade of 1 433 carats per hundred tons (cpht). In the first month, 24 781 tons were treated to produce 165 251 carats (grade 667 cpht). This material was worth US$934 per ton. The value of the first months production was US$ 23.14 million, payback of capital being achieved in 3.4 working days.

The weathered kimberlite grade was 509 cpht. The unweathered kimberlite grade started at 355 and ended at 81 cpht. This latter grade was probably the result of higher dilution as the pipe got smaller with depth and dilution increased.

Kimberlite from the mine was treated from September 1998, to the end of 2000, when the economic limit of mining was reached in the 150m deep pit. In total 970 347 tons were mined and treated to produce 1 826 031 carats for an overall grade of 188.18 cpht. Further low grade stock piles from gravels around the pipe and from a stockwork of kimberlite veinlets in diabase were processed in 2001 and produced an additional 94 534 carats.

Total revenue from M1 was US$246 300 000 from the 1 920 565 carats produced, an average of US$128 per carat.

Stones

The mine produced 813 special stones (+10.8 carats) with the largest being one of 145 carats. This stone was part of a much bigger stone that was found broken into 5 pieces. When put together, it was estimated that a further piece of about 70 carat was missing. This would have made it a plus 400 carat stone. Four stones over 100 carats were produced. These were: 145.7; 114.2; 100.8 and 100.0 carats in size. The next 16 stones ranged in size from 99.6 to 40.25 carats.

Conclusion

Marsfontein proved conclusively that small pipes with subtle, small amounts of kimberlitic minerals at surface can still be found in South Africa and can be very lucrative.