EXPLORE
NUMBER 143 JUNE 2009

The GOPE 25 Kimberlite Discovery, Botswana, Predicated on Four Mg-Ilmenite Grains from Reconnaissance Soil Samples: A Case History

Falconbridge Limited discovered 62 kimberlites in four fields in Botswana between 1978 and 1982 (Fig. 1). Its discovery of the Tsabong and Kokong kimberlite fields in 1978 resulted from follow-up of several regional surface kimberlite indicator mineral ("KIM") anomalies, identified by DeBeers and referenced in a 1976 publication (Baldock et al. 1976). KIM anomalies revealed by Falconbridge's large 1980 Central Kalahari reconnaissance soil sampling program led to Falconbridge's Kikau-Khutse discoveries and to the economically significant Gope 25 kimberlite discovery in 1981. During the Botswana program, the authors were part of Falconbridge's senior Southern African exploration management team. The team was headed by Chris Jennings (Fig. 2), *(see page 2)* who after leaving Falconbridge played a role in the discovery of numerous other kimberlites world-wide, including the Diavik Mine kimberlites in Canada. Chris Jennings was optimistic about Botswana's diamond potential as the Orapa and Jwaneng mines (now owned by Debswana Diamond Company) are two of the largest and most profitable diamond mines in the world, accounting for a quarter of global gem diamond production. Following Falconbridge's initial kimberlite discoveries, John Gurney was retained as a consultant (Gurney et al. 1993) and, inter alia, supervised a landmark collaborative KIM geochemistry research program, involving work on samples

continued on page 2

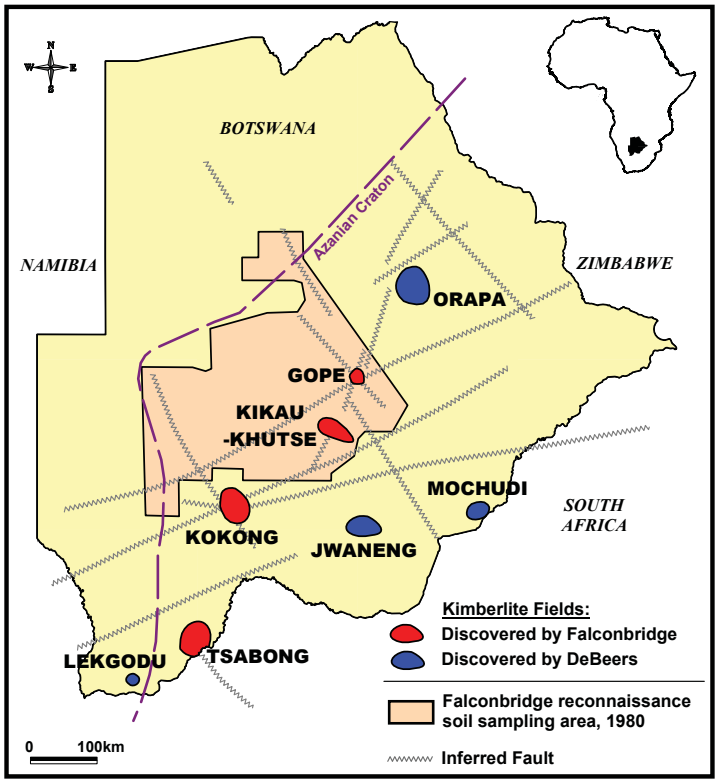

Figure 1. Botswana, 1982. Falconbridge made the first Tsabong and Kokong kimberlite discoveries in 1978. The 1980 Central Kalahari reconnaissance soil sampling program resulted in Falconbridge's Gope and Kikau-Khutse kimberlite discoveries in 1981.

https://doi.org/10.70499/HXRJ9303

The GOPE 25 Kimberlite Discovery, Botswana... continued from page 1

Figure 2. Botswana Diamond Exploration Meeting, 1978 (Tsabong). Front: Dave Fielding, Mike Waldman, Richard Fynn, Debbie Caskey*, Andy Moore, John Blaine, Ash Clarke (hat), John Gurney# (hat)Back: John Harris, Hugo Dummett*, John Lee, Roger Billington, Chris Jennings (hat), Nick de Bever (All Falconbridge staff, except: *Superior Oil, #Consultant).*

from a large number of barren to highly diamondiferous kimberlites.

The four kimberlite fields discovered by Falconbridge, and the Orapa and Lekgodu kimberlites, are some of the alkaline volcanic pipe concentrations that define a major NE-SW trending lineament extending from South Africa to Zambia (Moore et al. 2008). Kimberlites in central and southern Botswana are covered by Tertiary age Kalahari Group sand, which is sometimes more than 100 m thick. KIM are believed to have been transported to the present flat-lying, semi-arid land surface through the largely unconsolidated sand cover by means of bioturbation, mainly by termites (Lock 1985). Falconbridge conducted the first aeromagnetic surveys over the Tsabong and Kokong kimberlite fields and these surveys detected many of the 55 kimberlites it discovered there. These included the Tsabong M-1 kimberlite pipe (Daniels et al. 1991) that, with an area of 180 hectares, is one of the world's largest known kimberlites. Soil sampling techniques were developed in these areas and soil samples were processed in a dedicated

continued on page 4

Note: *This EXPLORE article has been extracted from the original EXPLORE Newsletter. Therefore, page numbers may not be continuous and any advertisement has been masked.*

The GOPE 25 Kimberlite Discovery, Botswana... continued from page 2

Falconbridge heavy mineral laboratory in Gaborone, Botswana. The significance of distinct Mg-ilmenite chemical signatures was soon recognized (Lee 1993) and the relevant exploration techniques, later critical in the discovery of the Gope 25 kimberlite, were developed in-house. The introduction of rotary reverse circulation drilling, conducted by SDS Drilling of Calgary (with Canadian drillers), resulted in much quicker and more effective drill evaluation of kimberlite targets than provided by the traditional cable tool drilling method. KIM grains recovered from soil and drillhole samples in the Gaborone laboratory were forwarded to Mineral Services laboratory in Cape Town, South Africa for electron microprobe analysis. Non-magnetic heavy fractions of kimberlite drillhole samples were sent to the Falconbridge Metallurgical Laboratory in Thornhill, Ontario for what were probably the first large-scale microdiamond analyses conducted in Canada. In essence, the microdiamond recovery technique used by SGS Lakefield today stems from this work. Falconbridge recovered relatively small numbers of microdiamonds from several Tsabong and Kokong kimberlites. These kimberlite fields are currently being investigated by other companies.

Central Kalahari reconnaissance program rationale and sampling method

Having learned much in the preceding two years, Falconbridge decided at the end of 1979 to apply its expertise in the remote, unexplored Central Kalahari region, which included part of the area between the Orapa and Jwaneng mines. The surrounding area had previously been soil sampled, mainly by De Beers. Falconbridge considered the Central Kalahari to have good potential for kimberlite discoveries, partly based on the regional fault/structural pattern (Fig. 1) which was inferred from the 1975-1977 CIDA-sponsored aeromagnetic survey of Botswana (Pretorius 1978). Much of the Central Kalahari is underlain by Late Paleozoic to Jurassic age Karoo sediments, with a generally subdued magnetic background. However, the east-central part, which includes the Gope area, is underlain by Jurassic age Karoo basalt with a very noisy magnetic background, which invariably makes kimberlite detection by magnetic methods difficult. Falconbridge's 1980 helicopter-supported reconnaissance soil sampling program covered an area of 78,500 km^2. Samples were collected at 474 sites on a fairly regular grid, the average sample density being 1 sample per 165 km^2 (Fig. 3). Each sample comprised 20 kg from the surface deflation layer scooped along a 1 km traverse which minimized the effect of landforms such as pans and relict sand dunes. Sampling was completed in 3 stages over a 6 month period. The +0.42 mm sample fraction was processed in the Gaborone laboratory, followed by the 0.25 - 0.42 mm fraction from selected parts of the survey area.

continued on page 5

The GOPE 25 Kimberlite Discovery, Botswana...

continued from page 4

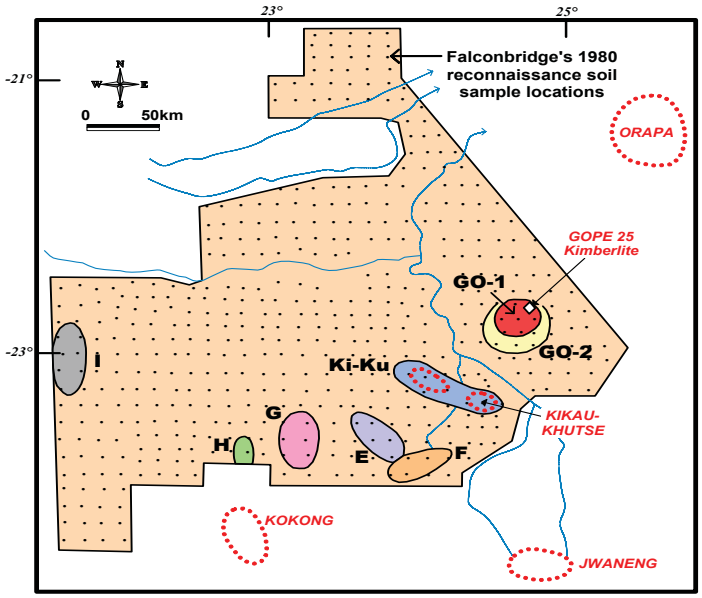

Figure 3. Mg-ilmenite anomalies GO-1, GO-2, Ki-Ku, E, F, G, H and I, identified by Falconbridge during its 1980 Central Kalahari reconnaissance soil sampling program. The Orapa, Jwaneng, Kokong and Kikau-Khutse kimberlite fields and the Gope 25 kimberlite are also shown. Kimberlites in the area are covered by Kalahari Group sands, which are 80 m thick at the Gope 25 kimberlite. (Boundary of area sampled, sampling grid and drainage are from Moore & Dingle 1998).

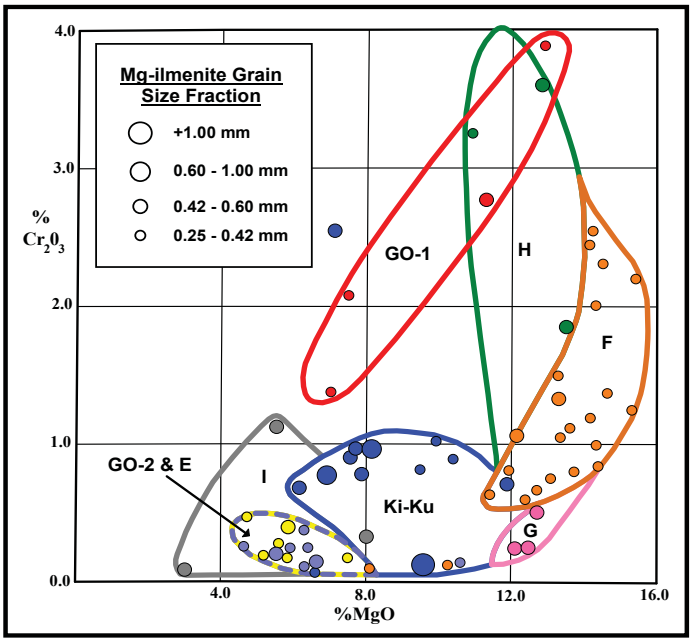

Figure 4. Cr_2O_3/MgO plot for the 65 Mg-ilmenite grains recovered from Falconbridge's 1980 Central Kalahari reconnaissance soil samples. The distinct chemical signatures of the eight Mg-ilmenite anolalies are evident. Anomaly GO-1, which was defined for only four Mg-ilmenite grains, contains the economically significant Gope 25 kimberlite.

Reconnaissance program results

Eight Mg-ilmenite anomalies, namely Anomalies GO-1, GO-2, Ki-Ku, E, F, G, H and I (Fig. 3) were identified in the southern half of the reconnaissance survey area. In Botswana, surficial Mg-ilmenite (specific gravity=4.7) concentrations are often detected proximal to kimberlites. Very few pyrope garnets (specific gravity=3.6) were recovered in the southern part of the area sampled, but (probably fluvially transported) pyropes are plentiful in the northernmost part, where drainages empty into the paleo-Makgadigadi Pan Complex (Moore & Dingle 1998). The Cr_2O_3/MgO plot for the 65 Mg-ilmenite grains recovered from soil samples in the survey area (Fig. 4) shows that each of the anomalies has a distinct chemical signature (given that the signatures of Anomalies GO-2 and E overlap). These chemical signatures suggest a range of diamond preservation potentials in the kimberlite sources, a high Cr_2O_3 / high MgO content of ilmenite suggesting high preservation potential. Anomaly GO-1 was assigned a high priority, despite being represented by only four relatively small Mg-ilmenite grains, because the distinct aggregate chemical signature of these grains (differing from the signatures of the other anomalies) suggested that they were derived from local kimberlites with a reasonably high diamond preservation potential. Anomaly H Mg-ilmenites are probably related to the Kokong kimberlite field and Anomaly F Mg-ilmenites were probably transported from the area with shallow sand cover near Jwaneng. The recovery of relatively coarse-grained Anomaly Ki-Ku Mg-ilmenites, 50 km north of Anomaly F, suggested that these grains were derived from local kimberlites.

Follow-up of reconnaissance program Mg-ilmenite anomalies

Falconbridge quickly acquired prospecting licences over the area covered by Mg-ilmenite anomalies identified in the reconnaissance program and conducted aeromagnetic surveys, followed by ground geophysical surveys, more soil sampling and drilling. Within Anomaly Ki-Ku, the six barren to slightly diamondiferous Kikau-Khutse kimberlites were discovered beneath 40 m of sand. Within Anomaly GO-1 the highly diamondiferous Gope 25 kimberlite (Fig. 3) was discovered beneath 80 m of sand in 1981. A subsequent study (Moore & Dingle 1998) showed that the 20 kg Falconbridge samples SW of Anomaly Ki-Ku contained 2 % to >10 % of +0.42 mm sand-sized material, as did those in the northern part of the area sampled. By contrast, in the intervening area, which approximates to the area underlain by basalt, and includes the Gope area, the samples contained only 2 % to <0.5 % of +0.42 mm sand-sized material. It is not surprising that only four Anomaly GO-1 Mg-ilmenite grains were recovered (three of which were in the finest fraction processed, namely 0.25 - 0.42 mm), given the relatively fine-grained nature and the relative thickness of the sand cover. Had it not been for the recognition of the distinct chemical signature of these four Mg-ilmenite grains, suggesting a local source with a reasonably high diamond preservation potential, Anomaly GO-1 might not have been followed up, in which case the Gope 25 kimberlite would not have been discovered by Falconbridge.

continued on page 6

The GOPE 25 Kimberlite Discovery, Botswana... continued from page 5

The Gope kimberlites

The garnet geochemistry (high proportion of G10 garnets) and microdiamond results for Gope 25 kimberlite were much more encouraging than those for the Tsabong, Kokong and Kikau-Khutse kimberlites. In 1982 Falconbridge and its JV partner Superior Oil concluded an agreement with De Beers enabling it to earn a 50% interest in the Botswana properties through expenditure on them. Delineation drilling, underground development and bulk sampling were subsequently conducted at the Gope 25 kimberlite and four additional, smaller diamondiferous kimberlites were discovered. The aggregate Cr_2O_3/MgO chemical signature of Mg-ilmenites from the five Gope kimberlites is consistent with that of the Anomaly GO-1 surficial Mg-ilmenites.

By 1998 De Beers had earned its 50% interest in the property. In 2007 Gem Diamonds Limited acquired 100% of Gope Exploration Company (Pty) Ltd, the owner of the Gope property, from De Beers and Falconbridge (by then a subsidiary of Xstrata PLC) for US$34 million. Gem Diamonds owns diamond mines at Letseng in Lesotho (Southern Africa) and in the Kimberley region of Western Australia. The Gope 25 kimberlite pipe measures 10.3 hectares at 80 m depth (immediately below the sand cover) and 9.1 hectares at 300 m depth. In late 2008, the Gem Diamonds website www.gemdiamonds.com reported a "resource of 105 million tonnes, 78 million tonnes indicated and 26 million tonnes inferred" for the Gope 25 kimberlite, with an average in-situ grade of 19.4 carats per hundred tonnes and an average diamond price of US$131 per carat. It also stated that a Mining Licence Application was submitted in July 2007 and that the company hopes to develop a world-class producing mine at Gope by 2013. Many other companies have conducted further diamond exploration in the Central Kalahari region since the Gope discoveries, but no new potentially economic kimberlite discoveries have been made.

Summary

The Gope 25 kimberlite is the most economically significant of the 62 kimberlites discovered by Falconbridge in four fields in Botswana between 1978 and 1982, in areas where the Tertiary age sand cover thickness sometimes exceeds 100 m.

In 1980 Falconbridge conducted a 78,500 km^2 helicopter-supported reconnaissance soil sampling program at a sample density of one sample per 165 km^2 in the semi-arid Central Kalahari area, part of which is located between Debswana's Jwaneng and Orapa diamond mines. Eight Mg-ilmenite anomalies were detected in soil, each invariably having a distinct chemical signature with respect to Mg-ilmenite grain Cr_2O_3 and MgO content. Anomaly GO-1 was assigned a high priority, despite being represented by only four relatively small Mg-ilmenite grains, because the distinct

continued on page 7

The GOPE 25 Kimberlite Discovery, Botswana... continued from page 6

aggregate chemical signature of these grains (differing from the signatures of the other anomalies) suggested that they were derived from local kimberlites with a reasonably high diamond preservation potential. The relatively small number of Mg-ilmenites recovered at Anomaly GO-1, and their generally small grain-size, are partly attributable to the fine grained nature of the soil in the Gope area relative to most of the area sampled.

In 1981, following aeromagnetic and ground geophysical surveys, Falconbridge's drilling within Anomaly GO-1 intersected the 10.3 hectare diamondiferous Gope 25 kimberlite pipe beneath 80 m of sand. The new owner of the property, Gem Diamonds Limited, applied for a Mining Licence in 2007 and hopes to mine the Gope 25 kimberlite by 2013.

It is concluded that recognition of the probable significance of the distinct Mg-ilmenite chemical signature of Central Kalahari reconnaissance soil Anomaly GO-1, which was defined by only four generally small Mg-ilmenite grains in an area with relatively fine grained soil, was crucial in Falconbridge's discovery of the Gope 25 kimberlite.

Acknowledgements

The dedication and skill of Falconbridge's Southern African exploration team (Fig. 2) made the successful five-year Botswana diamond program possible. The Central Kalahari reconnaissance soil sampling program was conceptualized by senior Southern African management (the authors), logistical planning was conducted by Roger Billington and the helicopter-supported sampling and Gope 25 discovery drillhole supervision were conducted by Andy Moore. The efficiently operated company laboratory in Gaborone, managed by Carol Spark, was vital to success. Falconbridge was fortunate to be able to retain John Gurney as a consultant, with particular reference to his KIM chemical criteria for identifying diamondiferous kimberlites. The authors thank Gem Diamonds Ltd. for supporting publication of this paper, Andy Moore for valuable discussions and Stu Averill for suggesting this contribution to EXPLORE.

References

BALDOCK, J.W., HEPWORTH, J.V. & MARENGWA, B.S. 1976. Gold, base metals and diamonds in Botswana. *Economic Geology*, **71.** 139-156.

DANIELS, L.R.M., JENNINGS, C.M.H., LEE, J.E ., BLAINE, J.L., BILLINGTON, F.R. & CUMMING, B. 1991. The geology of crater volcanics and sediments associated with the M1 Kimberlite, southwestern Botswana. *In: Proceedings of the Fifth International Kimberlite Conference,* **1**, 129-139

GURNEY, J.J., HELMSTAEDT, H. & MOORE, R.O. 1993. A review of the use and application of mantle mineral geochemistry in diamond exploration. *Pure and Applied Chemistry*, **65**, 2423-2442.

LEE, J.E. 1993. Indicator mineral techniques in a diamond exploration program at Kokong, Botswana. *In: Diamonds - Exploration Sampling and Evaluation.* Prospectors and Developers Association of Canada, Toronto, 213-235.

LOCK, N.P. 1985. Kimberlite Exploration in the Kalahari region of Botswana with emphasis on the Jwaneng kimberlite province. *In: Proceedings of Conference on Prospecting in Areas of Desert Terrain*. Institute of Mining and Metallurgy, *London*, 183-190.

MOORE, A.E., & DINGLE, R. 1998. Evidence for fluvial sediment transport of Kalahari sands in central Botswana. *South African Journal of Geology,* **101**, 143-153.

MOORE, A.E., BLENKINSOP, T. & COTTERILL, F.W. 2008. Controls on post-Gondwana alkaline volcanism in Southern Africa. *Earth and Planetary Science Letters*, **268**, 151-164.

PRETORIUS, D.A. 1978. The contribution of the aeromagnetic interpretation to an assessment of the mineral potential of Botswana. *In: Reconnaissance Aeromagnetic Survey of Botswana 1975-1977: Final Interpretation*. Botswana Geological Survey, A1-A63.

John E. Lee
Indicator Explorations Ltd.
57 – 151 Greenway Crescent E
Winnipeg, MB
R2Y 2G8
Canada
johnlee@mts.net

John L. Blaine
68, 15th Street
Menlo Park
Pretoria
0081 South Africa
jblaine@absamail.co.za

Christopher M. H. Jennings
3 Wildwood Haven
P.O. Box 31466
George Town, Grand Cayman
KY1-1206
Cayman Islands
cjennings@icon.co.za