

The role of *Hodotermes mossambicus* termites and background kimberlite indicators in the Kgalagadi

T.A. Dira and L.R.M. Daniels

Geocontracts Botswana (Pty) Ltd, Botswana

A termite species study in the Malatswae area in the Central District of Botswana suggests that the dominant species capable of transporting kimberlite indicators from the kimberlite source through the Kalahari Formation to surface in the Malatswae area is *Hodotermes mossambicus*. This species constructs its nest and tunnel network underground. The points of material discharge at surface are small vent holes. Sampling in the *Hodotermes*-dominant area may result in single digit or zero indicators from the same size soil sample. It is probable that the widely reported 'background' scatter of kimberlite indicators in several areas of Botswana may in fact not be related to wind distribution but to the presence of weakly magnetic to nonmagnetic kimberlites and the inefficient transport mechanism from source to surface by *Hodotermes mossambicus*.

INTRODUCTION

The Kgalagadi, meaning 'the great thirst' in Setswana, is the geographical area in Botswana covered by desert sand. The Kgalagadi in Botswana has been extensively explored for diamonds over a period of more than fifty years. The Malatswae area is located approximately 100 km to the southeast of the Orapa Kimberlite Field (OKF) in the Central District of Botswana. The area is covered by sand with variable tree and shrub density. The general sub-Kalahari Formation geology is Karoo basalt with the occasional window of Ntane sandstone.

The Malatswae area has been subjected to kimberlite exploration by several exploration companies since 1984. The area is covered by a regional aeromagnetic survey flown in a NS direction at 250 m line spacing and 80 m flight height. Although several aeromagnetic anomalies, identified from these surveys, have been drilled by various exploration companies, none of these have resulted in kimberlite discovery.

The failure of present interpretation of these airborne magnetic surveys to locate kimberlites has resulted in systematic soil sampling programmes being employed by companies as a primary exploration tool in the Malatswae area. Over the past 34 years most of the Malatswae area has been regionally sampled on a 1 km × 1 km basis. To date none of the various regional soil sampling programmes have resulted in the identification of kimberlite indicator soil anomalies considered to be 'anomalous' by exploration companies. The scatter of indicators in the Malatswae area has in general been assigned to being a regional background scatter, the OKF being a possible source.

INDICATOR SOURCE

The overwhelming majority of the indicators recovered from soil samples in the Malatswae area are garnets. Picroilmenite is present but as a very minor component. In contrast, the majority of indicators in the OKF are ilmenites with garnet being a lesser component.

The dominant wind direction in this part of Botswana is from the east to the west (Figure 1). Currently, there is no evidence that the palaeo-wind regime was different to the current wind direction. The Malatswae indicator spread is located towards the southeast of the OKF.

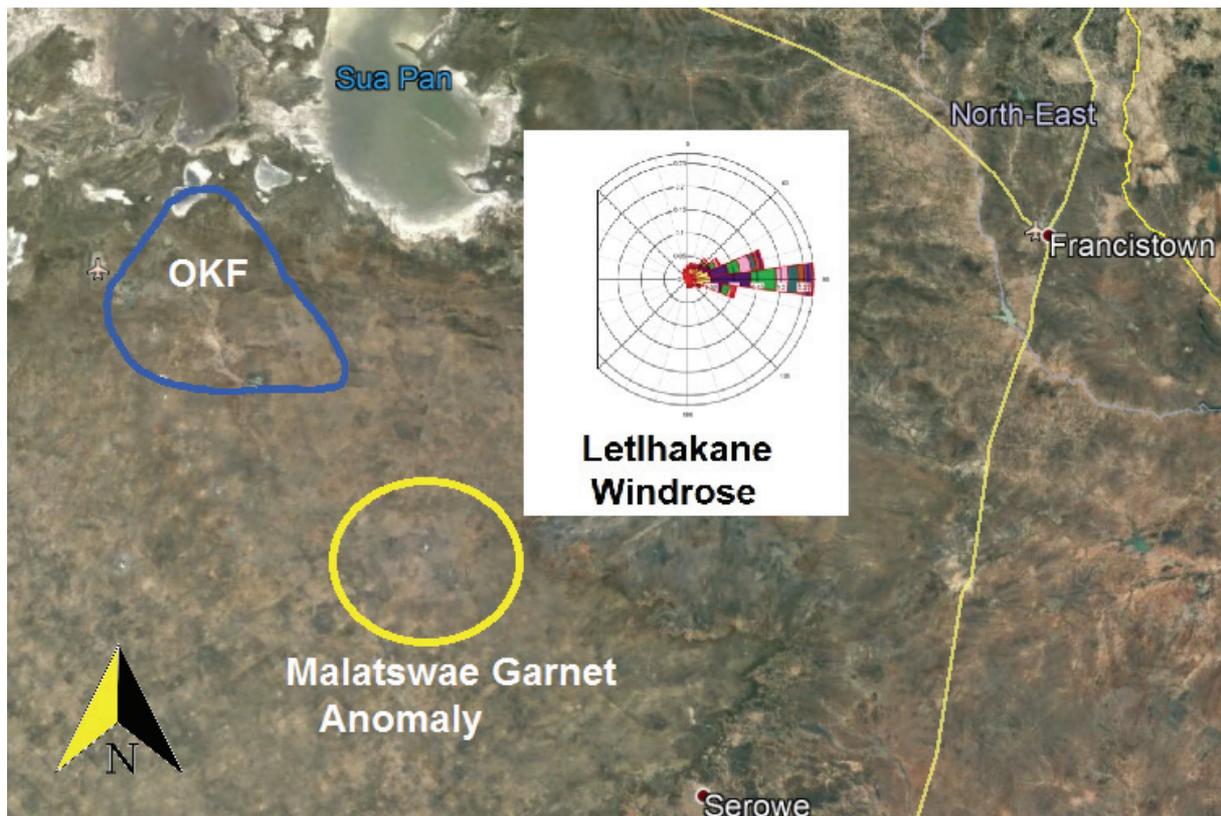


Figure 1. Location of the Malatswae garnet anomaly relative to the Orapa Kimberlite Field (OKF).
Lethakane is located within the OKF.

While most kimberlites in the OKF are characterized by a component of peridotitic garnets, the OKF is generally recorded as having a significant eclogitic garnet population (Reference?). The overall chemistry of the Malatswae garnet population is distinctly different to that of the OKF area. The vast majority of garnets analysed from the Malatswae area are peridotitic in composition. The eclogitic component of the garnet population in the Malatswae area is a very minor component (Figure 2).

In order for the OKF to be the source of the garnets recovered from the Malatswae area three conditions would have had to prevail:

- (a) The indicators would have had to be transported perpendicular to or against to the dominant wind direction
- (b) The dominant ilmenite population in the OKF would have been lost during transportation from the OKF to Malatswae. To date no significant ilmenite anomaly that would account for a separation between garnet and ilmenite concentrations during any form of transport has been reported between the OKF and the Malatswae area

- (c) The garnet population would have had to undergo a very significant overall compositional change during transportation from the OKF to Malatswae, increasing in peridotitic content while the eclogitic Cr-poor population almost disappeared.

Since all three of these conditions are considered to be unlikely, the conclusion is that the broad, background scatter of indicators in the Malatswae area is probably due to undiscovered kimberlites without prominent magnetic signatures in the Malatswae area.

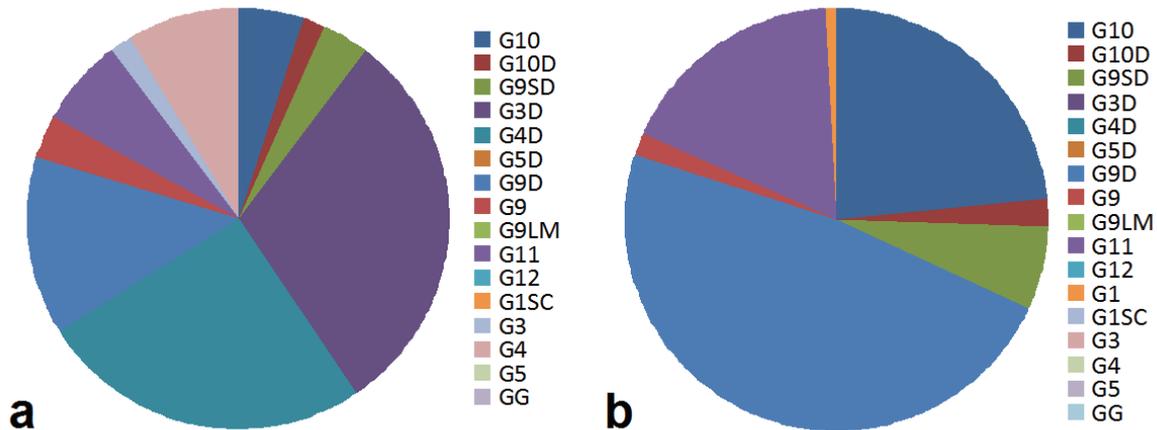


Figure 2. The garnet composition pie diagrams illustrate the difference between the compositions of the garnets from (a) the Orapa Mine kimberlite AK1 (eclogitic environment) and (b) the garnets from the Malatswae area. (peridotitic environment). The garnet classifications are based on a modified version of the garnet classification scheme of Grütter et al. (2004).

TERMITES

Termites are considered to be the sole transporters of kimberlite indicators from the source through the overlying Kalahari Formation to surface (Daniels, Dira, and Kufandikamwe, 2017). Termites need moisture for their saliva as well as for various activities like fungi farms and for breeding alates. In the Kgalagadi the termites have to go through the Kalahari Formation into the underlying geological formations to reach the water table. In order to construct their access pathways they have to discard the unwanted excavated material at surface (Marais, 1937; Uys, 2002). If they encounter a kimberlite it is likely that they will eventually discard kimberlite indicators at surface. At the Jwaneng diamond mine in Botswana, evidence of termites reaching depths of 70 m was uncovered during mining activities (Lock, 1985).

The OKF is characterized by the iconic, large termite hills representing the nests of the large termite species *Macrotermes michaelseni*. The head width of these termites is in the region of 2.8–3.15 mm based on field measurements. These termites are capable of concentrating thousands of indicators at a single nest (Dira and Daniels, 2018). In contrast, the vast majority of termite nests encountered above ground in the Malatswae area are the small nests of *Trinervoitermes trinervoides*. Isolated nests of *Macrotermes michaelseni* have only been encountered in three very small areas within the greater Malatswae area. No nests have been observed in the area of the MAL 001 case study area. Due to its narrow width of head (1.38–1.63 mm) and snout-like mandibles the *Trinervoitermes* termite is unlikely to transport any kimberlite indicators recoverable in soil sample screens. Standard screen sizes used in diamond exploration in the Malatswae area have a bottom square screen size of 0.425 mm.

An ongoing study of the active termite species in the Malatswae area has identified the *Hodotermes mossambicus*, commonly known as harvester termites, as the most active kimberlite indicator

transporter. Head widths of *Hodotermes mossambicus* of 2.63–4.25 mm have been recorded. These termites do not build their nests above the ground. Their presence in an area is generally recognised by the presence material dumps at vent holes at the surface (Braack, 1995). While the individual nests of the harvester termites are small (76 mm to 600 mm in diameter), the density of the nests may exceed 100 nests per hectare (Hartwig, 1965).



Figure 3. A *Macrotermes michaelseni* nest from the Orapa Kimberlite Field (A) and a vent hole of *Hodotermes mossambicus* (B) in the Malatswae area.

Volumetrically, little material is discarded at a vent hole in the Kgalagadi (Figure 3). Considering the small volumes of material discarded at a single vent hole, it is unlikely that a concentration of kimberlite indicators will be accumulated at an individual vent hole in cases where the termites had intersected kimberlite. Hartwig (1965) found that in areas of sparse vegetation, as are common in the Kgalagadi, the number of vent holes decreases significantly and may be as little as 130 vent holes per hectare.

CASE STUDY

A soil sampling programme was conducted over an area of 200 m × 200 m in the Malatswae area where a regional soil sample (MAL 001) produced a positive result of a single grain with surface textures interpreted as indicating a proximal source. The size of the sampling grid was arbitrarily selected as part of a pilot study. A detailed ground magnetic survey was conducted over the 4 ha area with a walk magnetometer integrated with a GPS at 50 m line spacing in a NS direction and repeated in an EW direction. The survey failed to reveal any magnetic anomaly that may be associated with a kimberlite intrusion. A soil sample programme was conducted over this 200 m × 200 m area which is dominated by *Hodotermes* over a period of 15 months. During this period 25 samples were collected monthly at 25 GPS-controlled points. Each sample consisted of 100 litres of pre-screened soil. The samples were collected within 5 m of the GPS control point from the upper 5 cm of the soil profile. The decision was made to sample the area monthly due to the low indicator count at surface and also to investigate the possible seasonal variation in indicator recovery (Daniels, Dira, and Kufandikamwe, 2017; Dira and Daniels, 2018). The sample size was increased to 100 litres to increase the probability of recovering indicators in this environment. The samples were screened to +0.425 mm –4 mm and processed through a 1 t/h dense media separator. The concentrates were sorted under a binocular microscope.

In addition, the surface texture of individual grains was assessed. “Orange peel” textures on garnets (Garvie and Robinson, 1984) and ‘sugar’ textures on ilmenite surfaces (Garvie, 1981), interpreted to be textures related to contact between indicator mineral and kimberlite, and angular surfaces were

considered to indicate a proximal source. Roundness was not considered material as Garvie (1981) reported round garnets recovered from several levels within the Jwaneng kimberlite.

The maximum number of indicators recovered from a single 100 litre sample was three. In total 37 500 litres of soil produced 114 indicators, including two diamonds, several G10 garnets, and a mantle-derived forsteritic olivine containing 0.51 wt% NiO. The maximum number of indicators recovered from all 25 samples in a single month was 14 and the minimum number a single indicator from 25 samples (2500 litres of soil). The presence of the forsteritic olivine argues against a distal or alluvial source for the indicators.

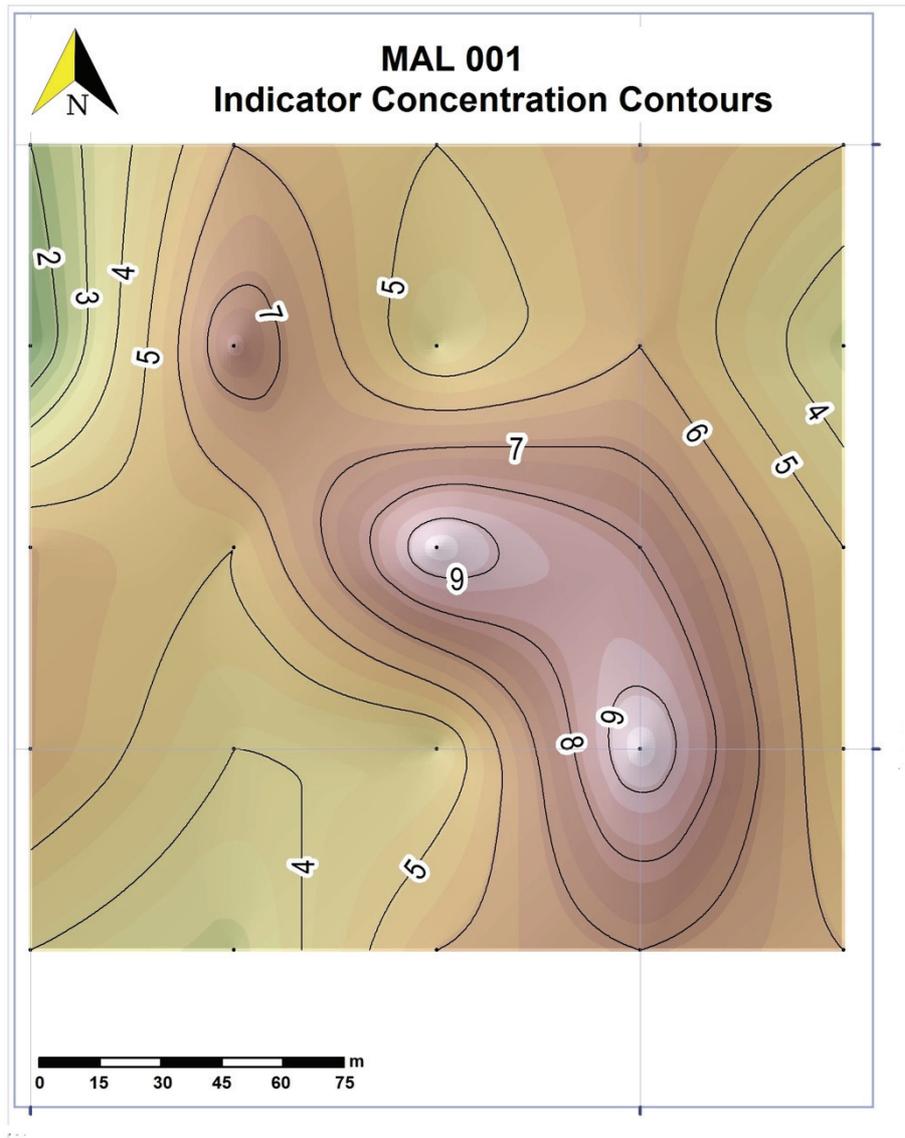


Figure 4. Accumulated indicator contours from the MAL 001 study area. The heavy red contour is placed between 5 and 6 accumulated indicator counts per sample. The background is the results from a ground magnetic survey conducted over the area. Distance between individual samples is 50 m.

The result from any single 100-litre sample would conventionally be interpreted as a 'background' result in a regional soil sample programme. The monthly results were therefore accumulated. The indicators recovered from individual soil sample sites were added to the number of indicators recovered from soil samples collected previously at the same sample site. After 12 months of repeating the process the

accumulation of monthly results from individual soil sample points produced a distinct soil sample anomaly with a well-defined zone of concentration within the grid area. The subsequent three months of sample results conformed to the established pattern. The maximum number of indicators recovered from a single sample station was 10 indicators from a total of 1500 litres of soil.

CONCLUSIONS

Current research has indicated that the concentration of indicators at the surface of the Kgalagadi, characterized by surface textures indicating a proximal source, may be directly related to the nest construction habits and physical capabilities of individual termite species (Daniels, Dira, and Kufandikamwe, 2017; Dira and Daniels, 2018). In the Malatswae area the dominant indicator transporting species has been identified as *Hodotermes mossambicus*.

The habit of *Hodotermes mossambicus* of constructing nests underground and using vent holes scattered over a wide area as 'waste' disposal points is suggested to be a major contributing factor to the generation of low indicator counts recovered from regional soil samples in the Malatswae area.

The results of the repetitive soil sampling programme embarked on at the MAL 001 site in the Malatswae area over a period of 15 months have demonstrated that repeated sampling over a period of time in an area of interest could elevate these 'background' grains to anomalous targets.

It is likely that the widely reported 'background' scatter of kimberlite indicators in several areas of Botswana may in fact not be related to wind distribution of indicators but to the presence of poorly magnetic to nonmagnetic kimberlites and the inefficient transport mechanism from source to surface by *Hodotermes mossambicus*, or any other species of termite that does not build surface nests but is capable of transporting kimberlite indicators.

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REFERENCES

- Braack, L.E.O. (1995). Seasonal activity of savanna termites during and after severe drought. *Koedoe*, 38 (1), 73-82.
- Daniels, L.R.M., Dira, T.A., and Kufandikamwe, O. (2017). The magnitude of termites to the future of kimberlite exploration in Botswana. *Proceedings of the 11th International Kimberlite Conference*, Gaborone, Botswana. Extended Abstract no. 11IKC-4555, 1-3.
- Dira, T.A. and Daniels, L.R.M (2018). The significance of termites on the future of kimberlite exploration in Botswana. *Proceedings of the 11th International Kimberlite Conference*, Gaborone, Botswana.
- Garvie, O.G (1981). The surface textures on garnet, picroilmenite and chrome diopside from kimberlite. MSc thesis, University of Cape Town. pp 131.
- Garvie, O.G. and Robinson, D.N. (1984). The formation of kelyphite and associated subkelyphitic and sculptured surfaces on pyrope from kimberlite. *Proceedings of the Third International Kimberlite Conference, Kimberlites and Related Rocks*. Kornprobst, J. (ed.). Elsevier, Amsterdam. pp. 371-372.

- Grütter, H.S., Gurney, J.J., Menzies, A.H., and Winter, F. (2004). An updated classification scheme for mantle-derived garnet, for use by diamond explorers. *Lithos*, 77, 841-857.
- Hartwig, E.K. (1965). Die nesstelsel van die gras draer termiet *Hodotermes mossambicus* (Hagen) (Isoptera) en aspekte rakende bestryding. *Suid Afrikaanse Tydskrif vir Landbouwet*, 8, 643-660.
- Lock, N. (1985) Kimberlite exploration in the Kalahari region of southern Botswana with emphasis on the Jwaneng kimberlite province. *Prospecting in Areas of Desert Terrain*. Raines, G.L. et al. (eds).. Institution of Mining and Metallurgy, London. pp. 183-190.
- Lamont, G. (2011). The quest for diamonds in the Bechuanaland Protectorate and Botswana. *Prospecting in Africa*. De Wit, M.C.J., Kostlin, E.O., and Liddle, R.S. (eds). De Beers Consolidated Mines Limited. pp. 171-201.
- Marais, E.N. (1937). *The Soul of the White Ant*. Methuan. p. 183.
- Uys, V. (2002) A guide to the termite genera of Southern Africa. Plant Protection Research Institute. *Handbook* no. 15, Agricultural Research Council, Pretoria. p. 116.

