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Karowe Diamond Mine: Geology and Diamonds of the South Lobe and Implications for Underground Mining

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Introduction

The AK6 kimberlite at Karowe Diamond Mine comprises three adjacent coalesced kimberlite pipes known as the South, Centre and North Lobes that have been mined by open pit methods since 2012. A feasibility study for an underground (UG) operation to extend the mine life by 13 years was completed in 2019 and construction commenced in 2020. A comprehensive review of the South Lobe geology that began in 2017 as part of a resource extension drilling program resulted in a significant update to the geological model. In combination with the updated resource estimate based on historic large diameter bulk sampling, discrete production samples, production and sales data, and drill core microdiamond data, this led to recognition and re-definition of the full volume extent and distribution of the higher-value EM/PK(S) kimberlite unit. The increased volume and value attributes of the EM/PK(S) positively impacted the potential for an underground mine. The model and estimate were subsequently updated as part of the UG feasibility study. Karowe Mine is one of the world's foremost producers of large, high-value diamonds including Type IIa and coloured diamonds. The AK6 kimberlite is also geologically distinct from the nearby AK1 and other Orapa field kimberlites in terms of its kimberlite texture despite their comparable age and geological setting.

AK6 Geology and Pre-2017 South Lobe Model

The AK6 kimberlite is part of the Orapa Kimberlite Field in the Central District of Botswana that includes at least 83 kimberlites of post-Karoo age. The country rock at Karowe is sub-outcropping flood basalt of the Stormberg Lava Group, underlain by a condensed sequence of Upper Carboniferous to Triassic sedimentary rocks of the Karoo Supergroup, below which is the granitic basement (Fig.1). The three coalesced pipes (lobes) of AK6 trend roughly north-south with a combined undepleted surface expression of ~3.3 ha and area of ~8 ha at 120 m below surface. Open pit mining of the economic extents of the North and Centre Lobes will cease in 2024 and they were not included in the UG study.

The South Lobe is broadly massive and more homogeneous than the North and Centre Lobes which exhibit greater textural complexity and more variable and higher proportions of internal country rock dilution. The names of the two main South Lobe kimberlite units, M/PK(S) and EM/PK(S), reflect the historical uncertainty in textural classification of the kimberlite as magmatic (M), now referred to as coherent, or pyroclastic (P). Prior to the model update in 2017, the EM/PK(S) was thought to occur only in the east of the pipe (hence 'E') as a vertical, cylindrical, low-volume domain within M/PK(S) (Fig.1).

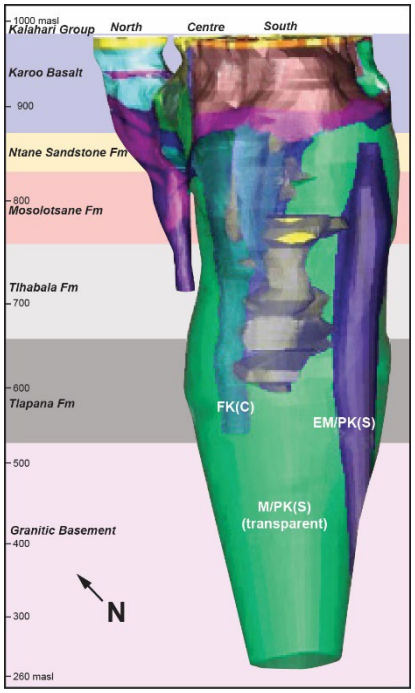

Fig. 1: Pre-2017 AK6 geological model (Lynn et al. 2014 and references therein)

South Lobe Geology and Resource Development

The key exploration and evaluation activities involved in the South Lobe geology and resource development and evolution are summarised in Table 1, highlighting the main updates and advances from 2017 onwards.

Table 1: Summary of key South Lobe evaluation activities and outcomes

Year	Program	Exploration / Evaluation Activities	Geological Model outcomes	Resource Model outcomes
2005-2008	Advanced exploration	15,583 m delineation drilling (46 holes); 7,964 m 23" LDD drilling (25 holes); trench bulk sampling; DMS processing and diamond recovery 4,010 t	M/PK(S) is main unit; EM/PK(S) volume 1.31 Mm^3; base of model at 520 masl	Base of Indicated at 600 masl; Centre and North same SFD and Value; South Lobe finer SFD and lower Value
2017-2018	Resource extension (upgrade)	12,272 m delineation and geotech drilling (15 holes); geology review (all historical and current drill holes); petrography (227 samples); pit mapping; micro-diamond sampling (7,315 kg); controlled production run 79,052 t in EM/PK(S)	EM/PK(S) is main unit below ~550 masl and volume increased to 7.47 Mm^3; base of model at 256 masl	Base of Indicated extended from 600 to 400 masl; single SFD and value model for EM/PK(S) and M/PK(S). South Lobe coarser SFD and higher Value than Centre and North
2018-2019	UG feasibility study	23,958 m delineation and geotech diamond drilling (37 holes, 13 in kimb); petrography (128 samples); pit mapping; microdiamond sampling (1,232 kg)	EM/PK(S) and M/PK(S) volumes refined; KIMB3 increases with depth; base of model at 66 masl	Base of Indicated extended from 400 to 250 masl; separate SFD and value models for EM/PK(S) and M/PK(S)
2023	UG feasibility study updated	n/a	n/a	SFD model for M/PK(S) coarsened to actual production data; value models adjusted to recent sales data

South Lobe Kimberlite Units and Current Geological Model

Below the upper 70-100 m of weathered and basalt-rich kimberlite (mined out), the South Lobe comprises M/PK(S) and EM/PK(S), the two volumetrically dominant kimberlite units, and six minor units, one of which (KIMB3) becomes more prevalent with increasing depth in the pipe. M/PK(S) and EM/PK(S) are both fine to coarse grained, olivine-rich, generally country rock xenolith-poor, broadly massive to crudely stratified, macrocrystic apparent-coherent kimberlites. The main distinguishing features include the country rock xenolith contents, populations, size distributions and characteristics, the relative abundances of mantle ilmenite and garnet, groundmass mineral relative proportions, and average magnetic susceptibility. The high abundance and inhomogeneous distribution of olivine and high proportion of angular olivine crystals, combined with the presence of crude stratification and rare probable relict melt-bearing pyroclasts, suggest EM/PK(S) and M/PK(S) were formed extrusively, and can be described as having a clastogenic or apparent-coherent texture.

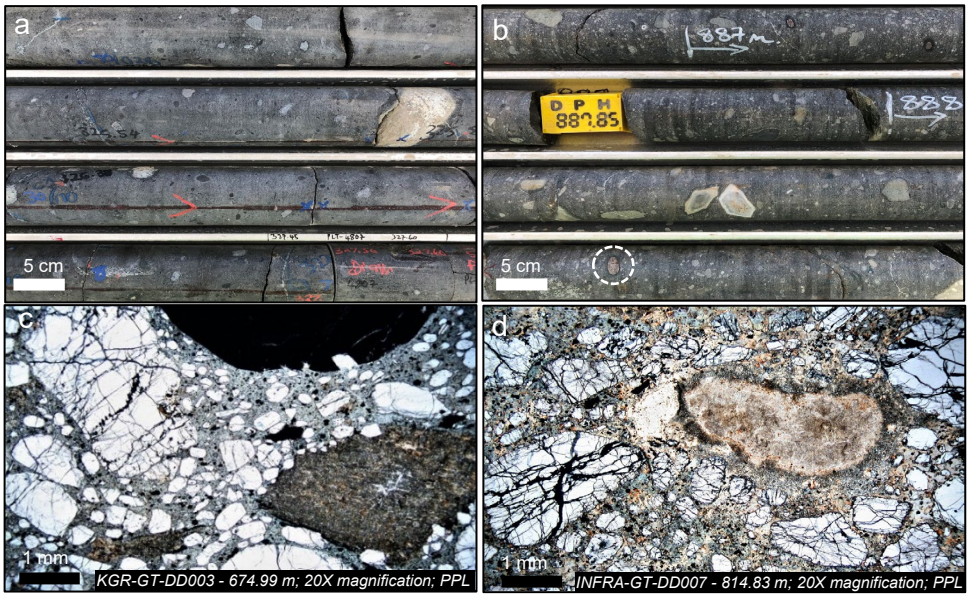

Fig. 2: Typical appearance of (a, c) M/PK(S) and (b, d) EM/PK(S) in HQ drill core (top) and thin section (bottom). Both of the units contain common ultra coarse-grained (> 16 mm to 5 cm) garnet (circled), ilmenite, olivine, ortho-pyroxene, and phlogopite that likely belong to the mantle megacryst suite.

In contrast, KIMB3 is texturally and mineralogically distinct, displays sharp intrusive contacts with EM/PK(S) and M/PK(S) and locally contains autoliths of these two units, supporting its interpretation as a hypabyssal phase that post-dates and intruded into the EM/PK(S) and M/PK(S).

Prior to 2017, the EM/PK(S) was thought to occur only in the east of the pipe (Fig. 1). Based on data collected during 2017-2019, the revised model has the EM/PK(S) now as the volumetrically dominant South Lobe infill below ~550 masl (Fig. 3). M/PK(S) is the volumetrically dominant infill above this elevation. The KIMB3 model encompasses areas where the KIMB3 sheet intrusions are most common.

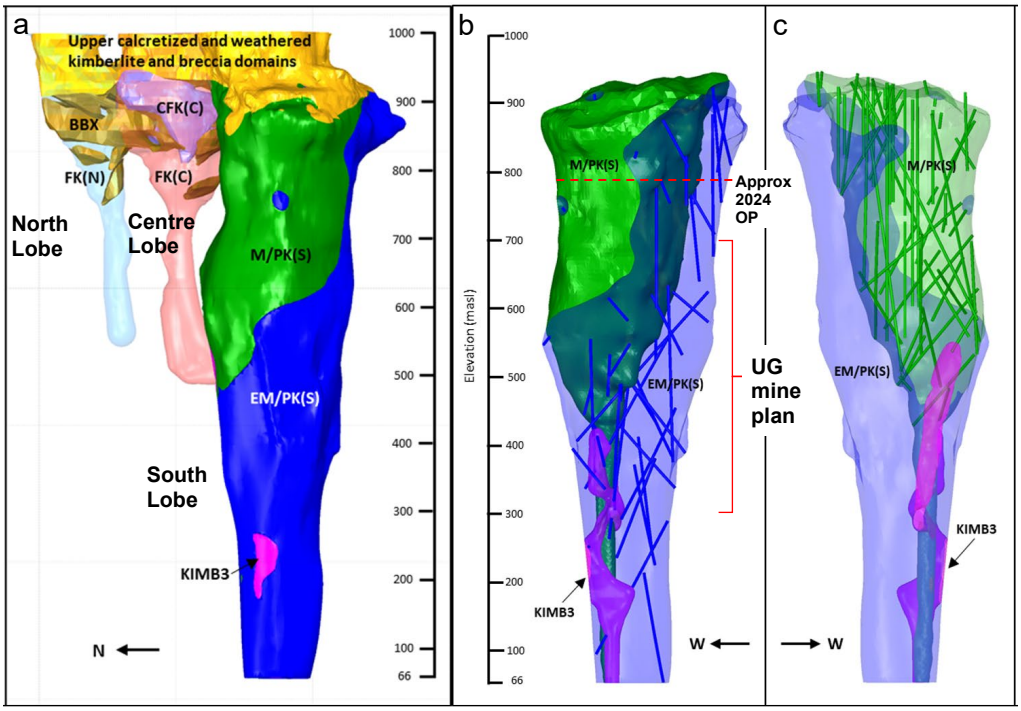

Figure 3: (a) The current AK6 geological model; (b, c) South Lobe model with diamond drilling. The North and Centre Lobes taper more sharply than the South Lobe which is more cylindrical at depth and is modeled to 934 m below surface (from ~1000 to 66 masl). A pronounced bulge in the pipe margin of each lobe roughly corresponds with the contact between the Stormberg basalt and Ntane sandstone country rocks (870-900 masl) as defined by in-pit mapping of the pipe wall contacts.

South Lobe Diamond Grades, Size Distributions and Significant Recoveries

The M/PK(S) and EM/PK(S) each have distinct diamond grades, size frequency distribution (SFD) models, average $/ct diamond values and significant stone recoveries. The SFDs are considered as coarse with roughly 60 to 70% of the mine's revenue being generated by +10.8 ct diamonds (Specials) that make up greater than 6% of the carats produced. Since 2015, 30% of the +10.8 ct diamonds produced have been in excess of 100 cts in weight. To the end of 2023, 321 diamonds in excess of 100 cts have been recovered, including four in excess of 1,000 cts, all from the South Lobe (Doerksen et al., 2024). The South Lobe has consistently recovered high-value diamonds in excess of 200 cts and several of the exceptional stones (+$10M single stones) have come from the EM/PK(S), including the 1,109 ct Lesedi La Rona. With the M/PK(S) and EM/PK(S) having grades of 10.8 and 21 cpht, average $/ct values of 707 $/ct and 828 $/ct, and weight percent Specials of 6.3 and 8 wt% respectively, the significant contribution of the EM/PK(S) to the underground expansion is clear.

Conclusions

Geological models typically evolve through the life of a diamond project. At Karowe, over the last 10 years progressive updates to the South Lobe geological model, size distribution and value models, and resource estimate have defined the true extent of the higher-value EM/PK(S) with positive implications for the economics and mine design of the underground expansion.

References

Doerksen et al. (2024). Karowe Diamond Mine 2023 Feasibility Study Technical Report, March 12, 2024.
Lynn et al. (2014). Karowe Diamond Mine NI 43-101 Independent Technical Report, February 4, 2014.