Letšeng Diamond Mine, Lesotho: Recent Advances in the Open Pit Geology of the Main Kimberlite Pipe

Mohapi Mohapi[1], Casey Hetman[2], Jock Robey[3], Barbara Scott Smith[4] and Teboho Nkotsi[1]

[1] *Letšeng Diamonds (Pty) Ltd., Letšeng-la-Terae, Lesotho,* mohapim@letseng.co.ls
[2] *SRK Consulting, Vancouver, BC, Canada,* chetman@srk.com
[3] *Rockwise Consulting, Kimberley, South Africa,* jjrobey@telkomsa.net
[4] *Scott-Smith Petrology Inc., North Vancouver, BC, Canada,* barbara@scottsmithpetrology.com
[1] *Letšeng Diamonds (Pty) Ltd., Letšeng-la-Terae, Lesotho,* nkotsit@letseng.co.ls

Introduction

The Letšeng Diamond Mine comprises two adjacent steep-sided kimberlite pipes; Main and Satellite. The results of the recent geological evaluation work undertaken by Letšeng Diamonds within the open pit of the Main Pipe have revealed more complex geology than was previously recognised. The in-pit investigations included geological mapping of recent mining exposures, logging of ahead-of-face percussion drill chips and petrography of pit floor samples. The results of these investigations have been integrated with macrodiamond production data and drill core information to establish an updated geological model of the pipe that will be used for ongoing mining (Fig.1). Different phases of kimberlite within the pit floor exposures have been identified based on features such as contrasting textures, olivine populations, groundmass mineralogies, country rock xenolith contents, degree of xenolith to kimberlite reaction as well as mantle-derived indicator mineral abundances.

General Pipe Geology and History

The ~90 Ma Main Pipe has a surface expression of approximately 17.2 ha and was emplaced into ~1800-2000 m of Karoo basalts. These basalts dominate the observed xenolith population within the Main Pipe. The majority of the pipe infill is classified as Kimberley-type pyroclastic kimberlite (KPK) formerly referred to as tuffisitic kimberlite breccia (TKB; Scott Smith et al. 2013). Recent mapping has revealed the occurrence of resedimented volcaniclastic kimberlite (RVK) extending to the present pit floor at approximately 180 m below the original surface of the pipe. Historic mapping of surface exposures and underground tunnels as well as drill core logging during early evaluation activities undertaken by Rio Tinto Exploration (1967-1972) suggested eight kimberlite “varieties” (K1-K8; Nixon and Bloomer 1973). Mining by De Beers from 1977 to 1982 focused on the single phase of kimberlite called “K6” that forms only a small part of the Main Pipe. Letšeng Diamonds is currently mining all kimberlite phases within the Main Pipe.

Main Kimberlite Rock Types

The Main Pipe (Fig.1) is dominated by one phase of kimberlite, K1 (previously referred to as KMAIN), with the other significant pipe infills: K6, RVK-A, RVK-B and K4.

K1 comprises a relatively uniform KPK containing large megaxenoliths of basalt and a minor but distinctive population of small white garnet-bearing basement xenoliths as well as less common conspicuous mantle-derived garnet peridotite and MARID xenoliths. The country rock xenolith content of K1 is visually estimated as 30%. The pseudomorphed olivine macrocrysts typically range in size from 1-4 mm and display irregular shapes indicative of resorption. Other mantle-derived macrocrysts (indicator minerals) are absent to extremely rare. The olivine phenocrysts are characterised by complex growth aggregate shapes. Magmaclasts are conspicuous throughout K1; they are spherical and can have kernels of an olivine grain or a country-rock xenolith. Basalt megaxenoliths (BB) occur in the north and south of the pipe and, in some cases, are characterised by extensive brecciation and related carbonate and/or kimberlite veins (up to 2-5%).

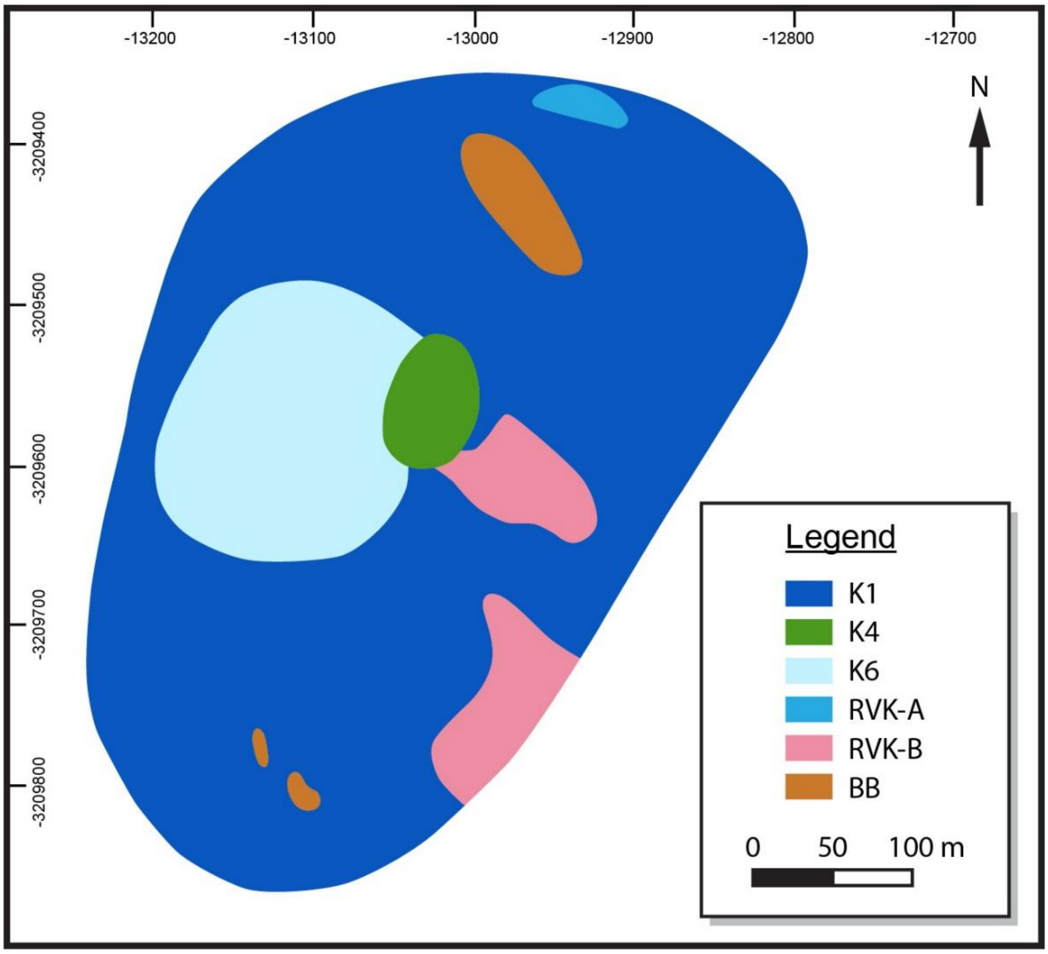

Figure 1: Schematic map of the Main Pipe geology (based on mining levels 3004 to 2864 masl).

Within areas previously considered to be K1, two new kimberlite units have been identified. Significant and apparently related remnants of diverse types of resedimented volcaniclastic kimberlite (RVK-A) occur along much of the pipe margin within the open pit. RVK-A pre-dates K1 indicating an earlier, and presumably initial, major pipe formation event. This pipe must have included an upper crater that remained open for a considerable period to allow gradual infilling by resedimentation of previously-erupted crater rim material. Different depositional processes resulted in contrasting varieties of RVK-A, some of which are well-bedded.

Another less well-defined RVK unit termed “RVK-B” is present in the 2017 pit floor and sidewalls. RVK-B contains conspicuous fresh basalt xenoliths that comprise about 30%-60% of the kimberlite as well as blocks of consolidated K1, indicating RVK-B postdates K1. The matrix is highly altered, very friable and pale brown in colour, with pseudomorphed olivine macrocrysts that are typically 1-4 mm in size. Although other mantle-derived macrocrysts are extremely rare, garnet peridotite and MARID xenoliths are observed. Magmaclasts are present but can be difficult to discern in hand specimen. The juvenile constituents in the matrix of RVK-B are similar to those in K1 and are presumed to be related.

K6 (Fig.2) is internally variable with textures ranging from segregationary coherent kimberlite to more pyroclastic textures. The occurrence of common conspicuous, fine to medium-grained mantle derived garnets clearly distinguishes K6 from other kimberlites within the Main Pipe. The garnets are dominated by peridotitic varieties often with thick kelyphite rims and orange eclogitic and megacrystic garnets are also abundant. Peridotite xenoliths are common. K6 contains 35% of country rock basalt xenoliths (visual estimate).

K4 (Fig.2) is volumetrically the least significant pipe infill of the Main Pipe and occurs as late stage irregular intrusions and thin sheets of hypabyssal kimberlite which cross cut both K6 and K1. Mantle-derived garnets are common as found in K6 but, in contrast, are usually completely kelyphitised.

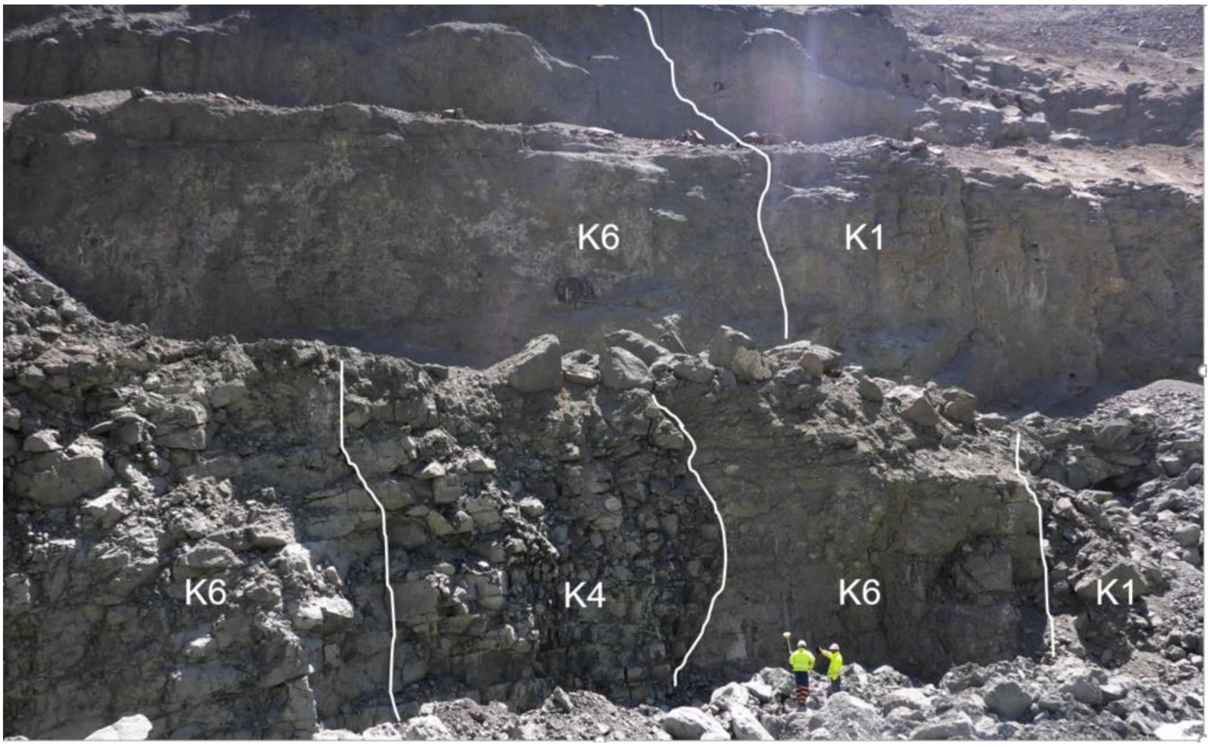

Figure 2: Main Pipe open pit exposures (east wall, 2864 masl) showing the relationship between K1, K6 and K4.

Conclusions

Mapping and petrography of the Main Pipe open pit has established an emplacement sequence that includes multiple episodes of volcanic eruption, intrusion and resedimentation. The first volcanic eruption formed a major pipe which must have included an upper crater that remained open for a considerable period during which infilling by resedimentation formed RVK-A. The latter occurs only as remnants along the upper pipe margins because it was cross-cut by K1, a massive homogeneous KPK resulting from a second major eruption. RVK-B postdates and overlies at least part of K1 and appears to be crater-fill composed of resedimented K1-derived material. Subsequently, K6 was emplaced as a smaller central pipe nested within K1 and infilled with inhomogeneous coherent to more pyroclastic kimberlite. Finally, small intrusion(s) of hypabyssal kimberlite, K4, cross cut both K6 and K1. Together, this shows that the Letšeng Main Pipe was formed by the emplacement of at least four distinct phases of kimberlite: pre-K1, K1, K6 and K4, apparently representing a progression of decreasing explosivity. The first two eruptions each had open craters that were infilled with RVK before subsequent events. The occurrence of KPK and crater-fill RVK is consistent with the estimated erosion at Letseng of 300-500 m and the southern African Hawthorne KPK-pipe model.

References

Bloomer AG, Nixon PH (1973) The geology of Letšeng-la-terae kimberlite pipes. In: Lesotho Kimberlites (Ed. P.H. Nixon), Lesotho National Development Corporation. p.20-38.

Scott Smith BH, Nowicki TE, Russell JK, Webb KJ, Mitchell RH, Hetman CM, Harder M, Skinner EMW, Robey JvA (2013) Kimberlite Terminology and Classification. Proceedings of 10th International Kimberlite Conference, Volume Two, Special Issue of the Journal of the Geological Society of India, Volume 2, 1-17. Springer India.