The Liqhobong kimberlite cluster: a perspective on the distinct geology, emplacement, dilution and diamond grades for each intrusion

Mafusi Rapopo[1], Paul Sobie[2]
[1] *Liqhobong Mining Development Company, Butha Buthe, Lesotho, mafusie@gmail.com*
[2] *MPH Consulting Limited, Toronto, Canada, psobie@mphconsulting.com*

Introduction

The Cretaceous Liqhobong kimberlite cluster comprises at least six known diamondiferous Group 1 kimberlite bodies; namely the circular Main Pipe (8.5 ha), ovoid Satellite Pipe (1.6 ha), Discovery Blow (0.15 ha), Blow (0.1 ha), the Main Dike adjoining the blows and pipes, and one other recently exposed dike. The kimberlites intrude Jurassic Drakensberg lavas and outcrop at ~2650 masl in rugged Maluti Mountain terrain, and are emplaced along a strike of about 2.5km. The cluster represents at least three episodes of structurally controlled kimberlite intrusion; the first which comprised the dike(s?) and the two blows (the blows being dike enlargements emplaced 1km apart) and later the two separate emplacements of the Main and Satellite Pipes.

Relative emplacement of the pipes, blows and dikes

The two pipes and blows are spread over 1.75km with the adjacent Satellite and Main Pipes being 300m apart and both lying NW of the blows (Fig. 1). Both pipes show typical Southern African diatreme kimberlite morphologies with steep-sided walls. A precursor 'Main Dike', intruded by both pipes, trends 300° and is characterised by two to four parallel vertical dikes that are 10 to 60cm wide and separated by a few centimetres of country rock. The other dike trends in the same WNW direction as the Main Dike.

Figure 1. The respective locations of the kimberlites of the Liqhobong cluster.

This newly identified dike is ~45cm wide and was exposed during the current Cut 1 waste stripping at the Main Pipe. Its intrusive relationship within the cluster is unknown at present, however it outcrops ~20m away from the easternmost margin of the Main Pipe and some 120 metres to the south of the Main Dike.

Distinct lithofacies' infill and dilution of the pipes and blows

A local magnetic geophysical survey and interpretation (performed in 1997) points to several other pipe-like features within the mining lease, as well as the position of possible other dikes. It was noted that only limited sections of the Main Pipe display a magnetic response; the bulk of the pipe showing no susceptibility contrast in relation to the country rock. The Satellite Pipe was not surveyed as it was undergoing artisanal production and LMDC ("Liqhobong Mining Development Company") bulk sampling at the time. The Blows on the other hand have very distinctive magnetic anomalies.

Data available for the known Liqhobong kimberlites' classification include surface exposures and >10km of core in 60 drillholes from the Main Pipe, 1.4km in 22 drillholes from the Satellite Pipe, one drillhole from the Blow, eleven drillholes from the Discovery Blow, as well as 790m in 5 drillholes that intersected the Main Dike over short intervals.
Both of the Main and Satellite Pipes are filled with mostly tuffisitic (massive volcaniclastic) kimberlite breccias and marginally with hypabyssal kimberlite. A comparatively more diversified infill is characteristic of the Main Pipe. The dominant infill lithofacies of the Main Pipe, K2 and K5, are massive tuffisitic breccias with distinct black to dark brownish olivine macrocrysts and conspicuous pelletal lapilli (sensu Brown *et al.*, 2009), carbonate veining and, uniquely, basement clasts in K2

(Fig. 2a-b). The two subordinate volcaniclastic kimberlite breccia (VKB) lithofacies, K4 and K6, represent the older pulses and account for less than 15% of the Main Pipe's volume. K6 has distinctive abundant fresh cream coloured olivine macrocrysts whereas K4 has abundant moderate to highly serpentinised darkish green to golden yellow olivine macrocrysts (Fig. 2c), as well as prominent kimberlite indicator mineral ("KIMs") xenocrysts. The macrocryst populations in both K4 and K6 are generally more like that of the Satellite Pipe and the Blows.

The Satellite Pipe and both Blows have conspicuous peridotitic garnet, Cr-diopside, ilmenite, phlogopite xenocrysts, olivine macrocrysts and mantle xenoliths and in decreasing order of abundance range from the Blow, Discovery Blow to the Satellite Pipe. The Satellite Pipe's olivine macrocrysts are mostly cream in colour but have developed moderate to intense serpentinisation (Fig. 2d). The olivine macrocrysts in both Blows are cream to crystal green coloured and mostly fresh (Fig. 2e). Pyrope garnet in both Blows has commonly developed a kelyphitic rim. In general, both the Blow and Discovery Blow are compositionally similar except that the Discovery Blow has comparatively fewer quantities of KIMs xenocrysts. Both Blows commonly display military green tinged alteration of the kimberlite matrix.
Country rock dilution in both the Main and Satellite Pipes ranges up to 30% whereas both Blows generally have less than 10% dilution.

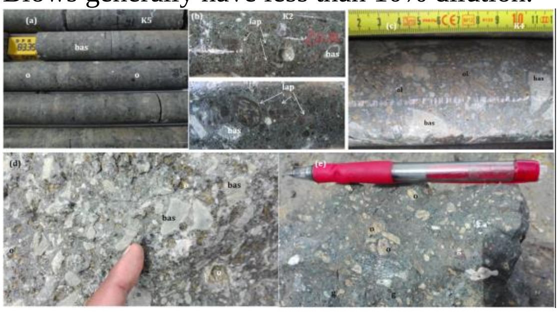

Figure 2. Samples of the Main and Satellite Pipes and Blows at the Liqhobong Property; (a) is K5, (b) is K2 and (c) is K4 - all from the Main Pipe. Sample (d) is from the Satellite Pipe and (e) is from the Blow kimberlite. (bas=basalt, o=olivine, g=garnet, lap=lapilli).

Mode of emplacement of the different kimberlites

All of the Liqhobong kimberlites contain basalt ± basement, mantle peridotite ± eclogite xenoliths and mantle xenocrysts and despite having intruded through the Karoo sedimentary rocks which underlie the country rock basalt, host no sedimentary xenoliths.

Both pipes show multifaceted volcaniclastic intrusions exhibiting subvertical to inclined internal contacts. The intrusion characteristics pertinent to the Main Pipe are the evidence of thorough vertical mixing (Fig. 3a), the development of pelletal lapilli in K2 (one of the major lithofacies) and comparatively more abundant development of carbonate veining and segregations, followed by more diversified infills ranging from hypabyssal to massive tuffisic (volcaniclastic) breccias. The Main Pipe exhibits less mantle sampling than the smaller Satellite Pipe and Blows.

The mined out Satellite Pipe's two major lithofacies, S1 and S3/S4, are distinguished by compositional variations, with the dominant S1 MVK more dilute with country rock. Although not always present, S3/S4 exhibits flow alignment wherein clasts are elongated in a common direction, as well as clast segregation evidenced by interlayering of country rock-rich and virtually undiluted kimberlite layers (Fig. 3b). The Satellite Pipe had a large basalt raft (~30m) internal within S1, whereas the Main Pipe has mostly dispersed zones of basalt breccia with the largest megaxenolith exposed thus far measuring ~19m in the K4 lithofacies.

Both Blows are characterised by no lapilli development and virtually no carbonate veining. The presence of kimberlite 'bubbles', typically cored by a small lithic clast (Fig. 3c-d), is observed in both Blows with especially well-established bubbles visible in the Discovery Blow (Fig. 3d). The Blow has similar, but less developed kimberlite bubbles (Fig. 3c). Such 'bubbles' are filled with dark coloured kimberlite matrix, olivine phenocrysts and rare olivine macrocrysts; they do not resemble lapilli.

The Liqhobong Pipes and Blows share a common structural-controlled aspect to their emplacement; all are emplaced along the WNW striking 'Main' Dike which is parallel to the major pervasive jointing in the country rock. The two pipes most likely represent separate events and are each emplaced in the locus of a network of intersections of at least three pairs of pervasive joints. Each pipe hosts a distinctive macrocrystic kimberlite dike intersected at depth by drill core,which is distinct from the Main dike observed at surface, but which orientation has not been accurately determined. The two Blows are emplaced as enlargements of the 'Main Dike' at their respective positions. The other recently discovered dike is oriented parallel to the Main Dike, and although in its immediate environs no pervasive jointing has been exposed yet, is also parallel to the regional major jointing in the basalt.

Figure 3. The different emplacement mechanisms of (a) Main Pipe showing thorough mixing of clasts, (b) Satellite Pipe showing compositional 'banding', (c) Blow showing poorly-developed kimberlite 'bubble' and (d) Discovery Blow showing well-develop kimberlite bubbles.

Diamond sampling

The Satellite and Main Pipes run of mine production has yielded grades of 68.7cpht and 25cpht respectively with the Main Pipe producing better average stone size and value. There has not been formal bulk sampling or production of the Blows and Dikes. However, the 1996 microdiamond analyses of the Blow, Discovery Blow and 'Main' Dike suggested preliminary +1mm grades of 340, 55 and 37cpht respectively.

Discussion

The similarity in the nature of olivine macrocrysts between the two Blows, the Satellite Pipe and (the earlier) K4 and K6 facies of the Main Pipe, suggests a probable relationship of the associated kimberlite melts and/or sampling of identical mantle. The dispersal and concentration of such near 'identical' mantle was likely governed by the volume of magma influx, structurally controlled accommodation space and the fluids' budget. Generally, the Main and Satellite Pipes are more diluted with country rock than the Blows. Both Blows are dike enlargements and therefore possibly intruded through a narrow fissure and consequently incorporated smaller amounts of country rock. Also, the Blows' magmas seemed to have been comparatively dry, as witnessed by the 'dry' bubbles therein.

Judging by the similarity in the nature of olivine macrocrysts in K5, K2 and K1 of the Main Pipe, it appears that these lithofacies represent similar or related magmas and sampled identical mantle and one that differs from that sampled by all other Liqhobong kimberlite intrusions. The presence of pelletal lapilli in K2, accompanied by modest carbonate veining, suggest a more fluidised environment than in K5.

Conclusion

The observed diversity in the mode of emplacement, mantle sampling and associated diamond grades of kimberlites so closely spaced at Liqhobong suggests a period of aggressive kimberlite intrusion. All evidence suggests the emplacement of the Liqhobong kimberlites was controlled primarily by pre-existing structures (United Nations, 1984) and secondarily by the nature of the intruding kimberlite including the fluid budget and accommodation space. The differential fluid budget amonst the Liqhobong kimberlites is tesified by the differing degree of serpentinisation of olivine macrocrysts and phenocrysts, the absence or presence of carbonate veining and segregations, by the presence of brecciated basalt or kimberlite, and by the presence or absence of pelletal lapilli.

References

Brown RJ, Tait M, Field M, Sparks RSJ (2009). Geology of a complex kimberlite pipe (K2 pipe, Venetia Mine, South Africa): insights into conduit processes during explosive ultrabasic eruptions. Bull Volcanol 71:95-112

United Nations (1984) Geology and mineral resources of Lesotho – exploration for diamonds (phase I) and exploration for minerals (Phase II). Technical Report.