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LEMPHANE KIMBERLITE DIAMOND PROJECT: PETROLOGY UPDATE

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Introduction

Lemphane pipe is a large (~6 ha) Jurassic kimberlite, located in the Maluti mountains in the Kingdom of Lesotho, roughly 9.8 km NNW of Kao kimberlite, and 5.6 km NW of Liqhobong kimberlite. The kimberlite has not been well studied since the work of Peter Kresten in the early 1970's (Kresten, 1973). Our study, as part of the ramp up to the establishment of the Lemphane diamond mine, shows that the Lemphane kimberlite pipe is a volcanic vent filled with what is provisionally indicated to be one or possibly two main eruptive phases of kimberlite magma mixed with xenolithic material dominated by surrounding basalts and lesser crystalline (granitoid) basement. All kimberlite materials studied are fragmental and essentially all represent diatreme facies volcaniclastic kimberlite (VK) and associated breccias (VKB).

Surface Geology

Study of 29 research pits dug into the Lemphane main pipe allowed the following important observations: 1. A meter-sized angular block of tuffaceous kimberlite sandstone discovered in Pit 3 likely represents a block of crater facies material down-rafted into the diatreme (Fig. 1). 2. The existence of a weak foliation demarcated by fracture patterns in the VK that dips fairly systematically toward the center of the vent. This pervasive foliation is not accompanied by any discernable layering or sorting and may represent a compaction feature from the original column collapse (Fig. 2A). 3. A small, roughly rectangular area measuring approximately 20 m x 15 m, known previously as the Lemphane satellite pipe, is in fact a lahar or pyroclastic flow deposit at the main vent edge (Fig. 2B). It may have been derived locally, but given the distinctive mantle xenocryst population it contains (Fig. 4D), was more likely derived from a nearby kimberlite eruption (Liqhobong satellite?) that cascaded down the sidewall of the open Lemphane vent.

Figure 1. Large block of kimberlitic tuffaceous sandstone outlined by pens at both contacts and GPS near the middle of the block, Pit number 3 (see Fig. 3 for location), looking ESE. GPS is 16 cm long.

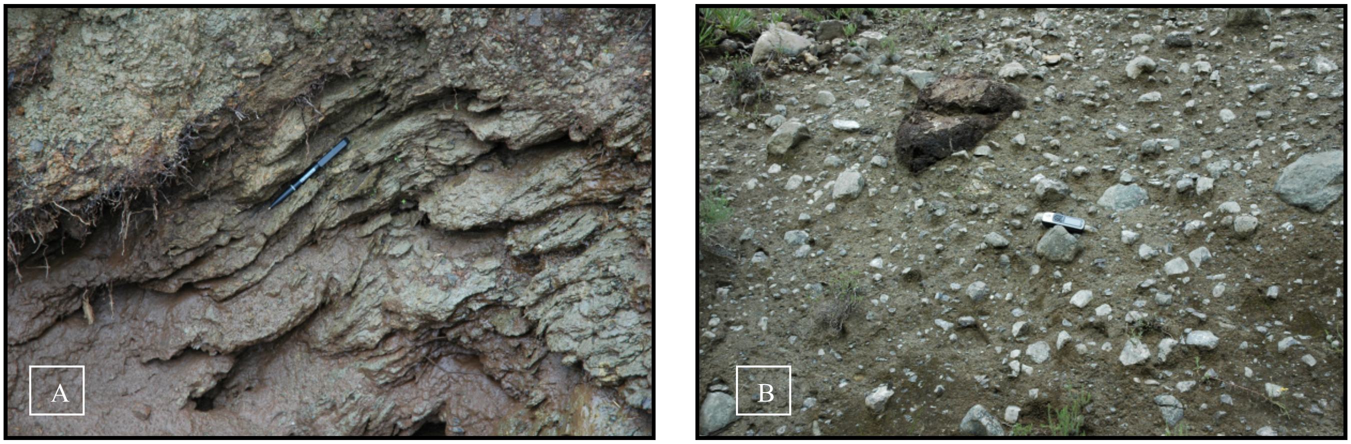

Figure 2. A. Relatively well developed foliation in VK, dipping toward the center of the pipe in nearly all pits. B. Cobble to sand sized, unsorted lahar or pyroclastic flow deposit of what was previously known as Lemphane Satellite.

Petrology

The following general characteristics of the VK material have been recorded from thin section:

1. Pelletal lapilli range from rare to very common, but this is a distinction that may be partly dependent on the level of alteration of the sample. Alteration tends to migrate along lapilli boundaries and as it obliterates these boundaries it becomes impossible to distinguish lapilli.

2. Olivine, which appeared to be relatively low in modal abundance in hand sample, due to extensive alteration, is in fact up to 52 modal % in some samples (Fig. 3).

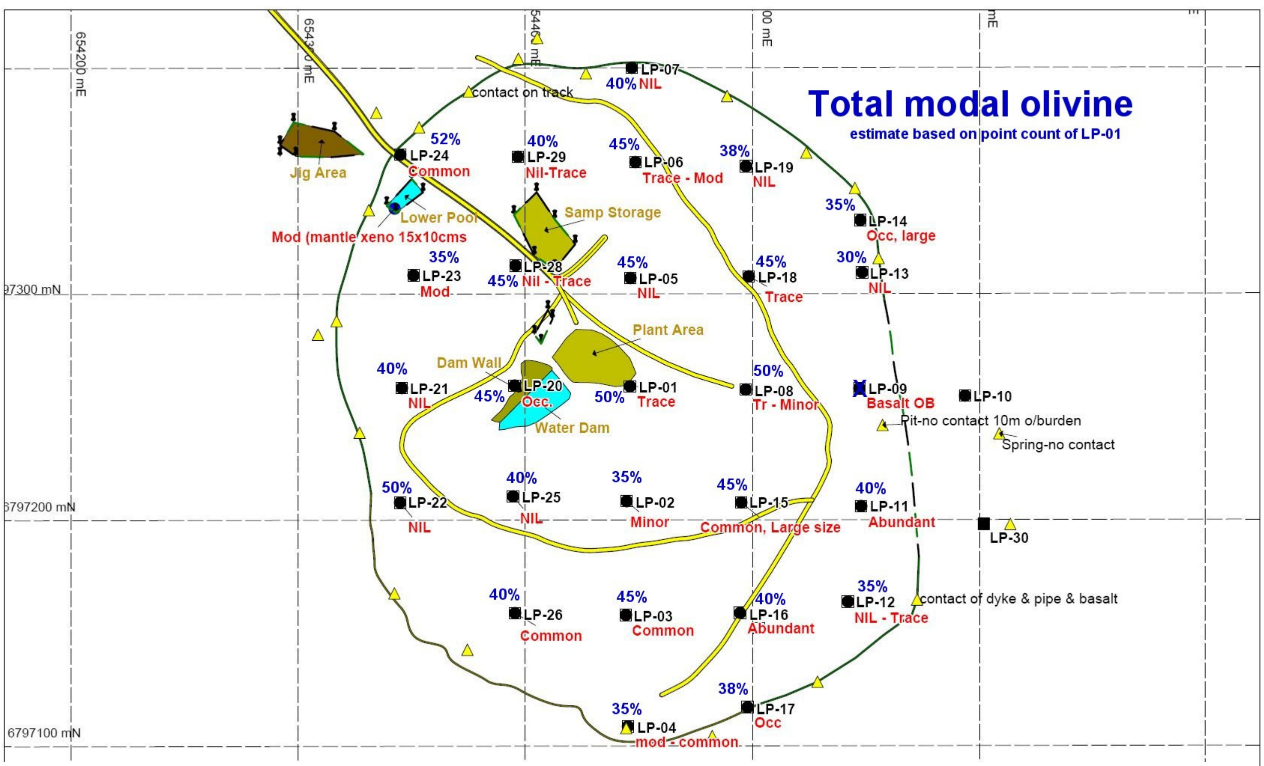

Figure 3. Total olivine content (xenocryst + phenocryst + lapilli cores and rims) from thin section for 29 pit samples from Lemphane kimberlite. Note these are estimates derived from a baseline point count on LP-01 thin section and extrapolated by eye to the remainder of the thin sections.

3. Differing levels of country rock dilution (especially basalt) is an important factor in total olivine contents, as would be expected. However, it is not the sole factor. There also appears to be simply less matrix in some of the high-olivine content samples. One possible explanation for this is variable amounts of fines-depletion in the eruption cloud by wind action (elutriation), producing some particularly olivine-rich portions of the collapsing eruption column that was deposited into the Lemphane vent.

4. Largest olivine grain dimensions in thin section are rather uniform throughout the samples, ranging from 2 to 7 mm, and averaging about 3.6 mm.

5. All of the largest olivine grains are subrounded to rounded, typical for olivine macrocrysts in kimberlite. Most likely this rounding is a chemical/dissolution effect since the magma is out of equilibrium with the high Fo olivine from mantle peridotites. This is exemplified nicely in Dike No. 9 samples, which has very little

6. Other mantle derived minerals, such as pyrope garnet, chromite and clinopyroxene are however, of low modal abundance, possibly a basic characteristic of this kimberlite but also likely due to the high degree of alteration in these surface samples. This is a similar situation to the nearby Liqhobong Main pipe, which is relatively low in indicator minerals except olivine, yet contains minable diamond grades. The latter are thought to correlate with the overall high olivine content.

7. Possible nonvesicular juvenile lapilli primary pyroclasts were discerned in a few samples (e.g., Fig. 4C), which, if confirmed in fresher material, could be further indicators of crater facies materials mixed into the diatreme.

8. In a number of the samples, larger olivine grains contain fresh domains, suggesting that the heavy mineral concentrate, even in the surface sampling, will be rich in olivine.

9. Phlogopite, although found in sparse quantities in nearly all samples, is more abundant in samples from the western portion of the pipe relative to the eastern portion. This may be a small piece of evidence for more than one pulse of kimberlite magma into this vent, but testing this hypothesis requires further studies.

10. Phlogopite also occurs in microxenoliths along with perovskite and olivine in a number of samples (see table 1). Further detailed petrography on these is required, but they appear to have a cumulate texture, and might represent cognate materials from magmas related to the

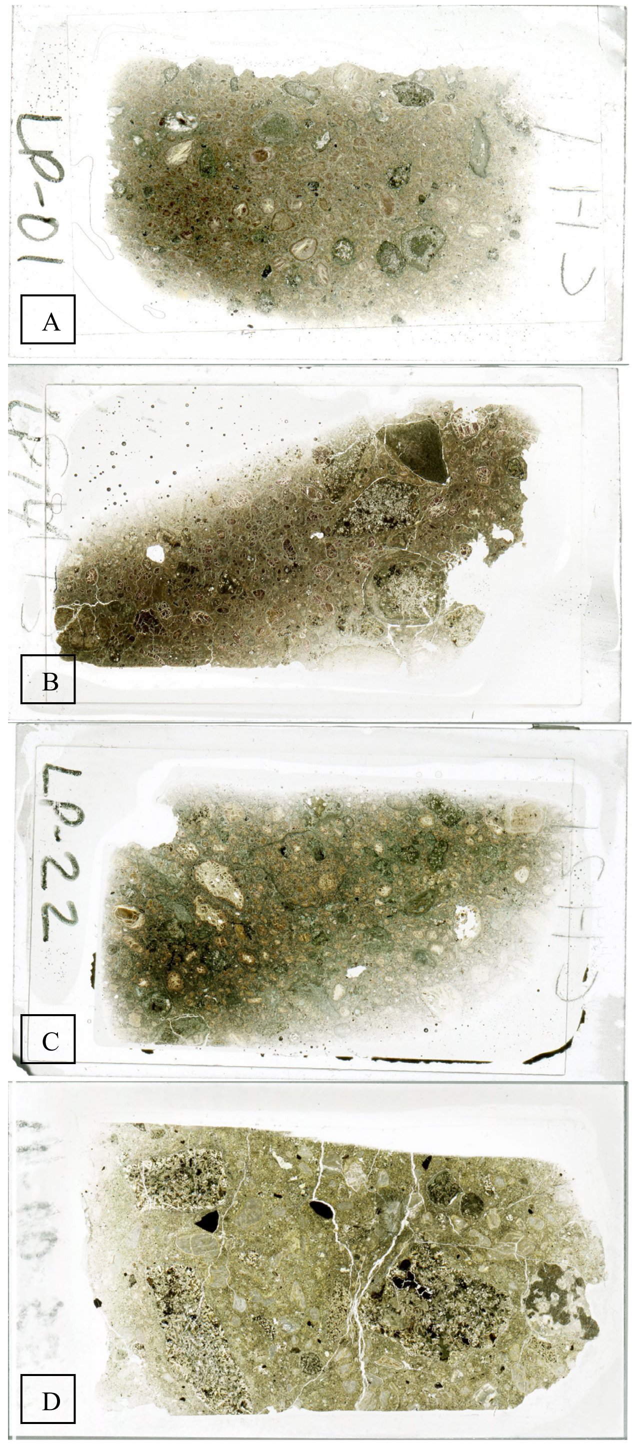

Figure 4. Thin section scans from Lemphane pipe rocks. A. Thin section from Pit 1 sample. Olivine-rich, with relatively few country rock clasts. B. Pit 14 sample, large pelletal lapillus visible lower right. C. Pit 22 sample, upper center, large what appears to be primary pyroclast. D. Pyroclastic flow/lahar deposit, formerly Lemphane satellite, sandy matrix is apparent. All slides 3 cm wide.

Table 1. Petrologic character of Lemphane Pit Samples by thin section observation

			mantle	largest ts	shape	fresh	quantity	% pelletal	possible	type		
		rock type	Ol%	olivine mm	olivine	olivine	phlog	lapilli	pyroclasts	other xenos	spinel	comment
LES-01-11		vk	20	3.5	round		0.5%	0		gabbro, KIMs		highly carbonated sample
LP-01	LP01	vk	51	2.9	eu to round	2%	tr	20%				
LP-02	LP02	vk	35	3.6	eu to round	1%	0.5%	10%				deceptive sample, highly altered, more ol than it first appears, veins of alteration
LP-03	LP03	vk	45	3.9	eu to round	1%	tr	40%				
LP-04	LP04	vk	35	3.0	eu to round	0%	rare	20%		phlog-ol-oxide		xeno has alteration minerals as well
LP-05	LP05	vk	45	2.9	eu to round	1%	tr	30%				
LP-06	LP06	ck or vk	45	2.3	eu to round	30%	tr	5%				nearly coherent rock, but few lapilli require that this be fragmental.
LP-07	LP07	vk	40	4.6	eu to round	5%	tr	30%				alteration following lapilli margins -- good example
LP-08	LP08	vk	50	3.4	eu to round	5%	tr	40%				
LP-11	LP11	vk	40	4.0	eu to round	0%	tr	60%		picro?		
LP-12	LP12	vk	35	5.7	eu to round	0%	tr	50%	yes	phlog-ol-oxide		possible altered pyrope in lapillus
LP-13	LP13	ck or vk	30	2.9	eu to round	0%	tr	5%		rare pyrope &r sp		only few ol macrocrysts
LP-14	LP14	vk	40	2.9	eu to round	0%	tr	60%			atoll	basalt diluation in section, otherwise ol=40-45% in most part of section
LP-15	LP15	vk	45	4.6	eu to round	0%	0.5%	55%				excellent degassing/late fluid structure
LP-16	LP16	vk	40	2.8	eu to round	0%	tr	45%		phlog-ol-cpx-oxide		basalt diluation in section, otherwise ol=40-45% in most part of section
LP-17	LP17	vk	40	6.9	eu to round	0%	1.5%	30%				phlog rich zone in 1 section, not in second
LP-18	LP18	vk	45	5.1	eu to round	5%	1%	20%	yes	gt		matrix extremely rich in cpx microcrystals
LP-19	LP19	vk	40	3.5	eu to round	10%	0.5%	10%	yes	phlog-ol-spinel		
LP-20	LP20	vk	45	2.5	eu to round	10%	2.5%	10%	yes	ol-phlog-perov, pyrope		
LP-21	LP21	vk	40	2.5	eu to round	2%	1%	60%		ol-phlog-perov		
LP-22	LP22	vk	52	5.0	eu to round	10%	tr	80%	yes, large ex.			pelletal lapilli cemented by chlorite
LP-23	LP23	vk	40	2.1	angular to rour	10%	tr	5%	yes	cpx-phlog		matrix contains abundant uniformally distributed basalt ol/cpx grains
LP-24	LP24	vk	52	4.0	eu to round	0%	2.5%	45%		gnt		obvious phlog macros
LP-25	LP25	vk	40	2.1	eu to round	5%	3%	65%		gnt		phlog + cpx rich segragation, or vein, nice ex mantle + olivine lapilli
LP-26	LP26	vk	40	4.4	eu to round	0%	1%	50%				ol + phlog magma as lapilli mantle
LP-28	LP28	vk	45	2.3	eu to round	12%	0.5%	30%		gnt rel. Common		
LP-29	LP29	ck or vk	40	4.6	eu to round	20%	tr	0%		gnt or? rel. Common	atoll	high relief brown mineral, isotropic but too common to be gnt--titanite??
LP-31	LP31	vk	45	3.9	eu to round	0%	0.5%	20%	yes	picro?		

pipe formation. Microprobe analyses of these micas still remain to be carried out in order to determine if these microxenoliths could instead represent MARID-like materials.

11. Samples LP-06, 13, 23 and 29 all share the textural similarity that no irrefutable lapilli can be seen in thin sections of these rocks. Whether this similarity is sufficient to hypothesize a subunit within the main phase kimberlite (connected in an arc-like belt) will require further sampling.

Discussion and Conclusions

The main goal of this preliminary petrologic study of samples from Lemphane was to try to determine the number of different kimberlite phases extant within the pipe and to determine best areas to bulk sample. Mineralogical criteria proved to be the basis for meeting these two goals, particularly total mantle mineral content, and for Lemphane this refers almost exclusively to olivine content. The conclusion is that the only systematic variation of olivine content in the pipe is lower amounts at the pipe edges, mostly as a consequence of increased dilution from the surrounding country rocks. Hardly a shocking result, but the consequences are that this pipe appears to be fairly homogenous (although some evidence exists for two main eruptive phases) and as such should contain relatively consistent diamond grades throughout, whatever those grades prove to be in the ongoing bulk sampling program.

References

Kresten, P., 1973, The Geology of the Lemphane Pipes and Neighboring Intrusions, In Nixon, P. Editor, Lesotho Kimberlites, p. 159-167.