GEOLOGY OF THE GAHCHO KUÉ KIMBERLITE PIPES, NWT, CANADA: ROOT TO DIATREME TRANSITION ZONES

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INTRODUCTION

The Gahcho Kué kimberlites occur 280km NE of Yellowknife, Northwest Territories. This Cambrian age kimberlite cluster includes four main pipes: 5034, Hearne, Tuzo and Tesla. The kimberlites intrude basement granitoids of the Archean Slave Craton and there is no evidence for any sedimentary cover at the time of emplacement.

PIPE SHAPES AND INFILLS

The four pipes have contrasting external shapes and pipe infills (Fig. 1a-c). The pipe infills are dominated by two textural end members: hypabyssal kimberlite (HK) and tuffisitic kimberlite breccia as shown in Fig. 1d (TKB; sensu Clement and Skinner 1995; Field and Scott Smith, 1998). Tuzo has a circular plan view shape with smooth steep-sided pipe walls and is dominantly infilled with TKB (Fig. 1a). Hearne (Fig. 1b) consists of two bodies. Hearne South is circular and smaller than Hearne North which is a narrow elongate pipe. Both pipes have steep smooth sidewalls. Hearne South is dominantly infilled with TKB and Hearne North is infilled with approximately equal amounts of HK and TKB. Tesla is a circular pipe containing both TKB and HK at depth. The 5034 kimberlite has a very complex plan view shape and sub-surface structure with irregular pipe walls (Fig. 1c). Three lobes are exposed at the present surface and the fourth northern lobe is overlain, by approximately 80m of in situ country rock. 5034 is dominantly infilled with HK.

There is a correlation between pipe shape and the texture of the kimberlite infill (Fig. 1a-c). TKB occurs in the circular smooth sided pipes, Tuzo and Hearne South while HK dominates the complex irregular pipe at 5034. At Hearne North and Tesla, intermediate pipe shapes contain both TKB and HK. There is also a correlation between pipe shape and internal geology ranging from simple to complex from Tuzo, through Tesla and Hearne to 5034. The correlation of pipe morphologies and pipe infills is summarised in a composite geological model (Fig 1e). Each body within the cluster contains a significant amount of kimberlite displaying textures that are gradational from TKB to HK with increasing depth. The textural gradations are subdivided into four types TKB, TKtB, HKt (t=transitional) and HK as summarised in Table 1. The complete gradation occurs within the single dominant phase of kimberlite in Tuzo and Hearne North and is described below.

THE TUZO TRANSITION ZONE

Near the present surface, the Tuzo pipe infill consists of 'classic' TKB (Fig. 1d upper, Fig. 2a) displaying most of the hallmark features including a magmaclastic texture (sensu Field and Scott Smith 1998). The TKB is composed of matrix supported pseudomorphed olivine, common so-called pelletal lapilli (sensu Field and Scott Smith 1998) and autoliths set in a matrix dominated by serpentine (Fig. 2b). The pelletal lapilli are composed of a kernel of cognate or xenolithic material coated with thin selvages of kimberlite (Fig. 2b). Fine microlites, which include clinopyroxene, are common (Fig. 2c). At depth the TKB grades into inhomogeneous kimberlite consisting of patchy areas (Fig. 2d) of magmaclastic TKtB with pelletal lapilli (Fig. 2d and cf. Fig.3c) mixed with brown magmatic kimberlite (Fig. 2e). The magmatic patches are more crystalline containing coarser grained clinopyroxene (Fig. 2f). With depth, the kimberlite becomes more magmatic in appearance (HKt). Primary carbonate and serpentine are present as irregular segregations (Fig. 2f). At greater depth the kimberlite grades into typical HK characterised by a uniform crystalline groundmass (Fig 2g-i). The HK is composed of a uniform distribution of olivine macrocrysts and phenocrysts and a groundmass of monticellite, phlogopite, spinel, perovskite, primary carbonate and serpentine. Fresh olivine can be present. Pelletal lapilli and microlitic clinopyroxene are not present.

The abundance and degree of reaction of the country rock xenoliths varies with the kimberlite textures. In the TKB there are high, but variable proportions, of fresh xenolithic material (Fig. 1d upper). The size of xenolithic material is highly variable and ranges from fine (<5mm) crystals and shards (Fig. 2a) to blocks >5m. Immediately the textures become gradational (TKtB) as shown by the boundary in Fig. 1a, there is a marked reduction in the size and abundance of country rock xenoliths. The xenoliths also show greater reaction with the host kimberlite resulting in a darker colour than those within the TKB. The changes continue into the HK where xenoliths are low in abundance and show significant reaction with the host kimberlite (Fig. 1d bottom).

THE HEARNE TRANSITION ZONE

The TKB-HK textures within the dominant upper phase of kimberlite in Hearne North are extremely similar to those described above in Tuzo. Only the gradational textures will be discussed. There is a wide zone of gradational textures (yellow in Fig. 1b) in which the textures oscillate between TKtB and HKt. TKtB dominates the upper part, together with short intersections of HK. The lower part consists of HKt. The TKtB is extremely similar to that in Tuzo (compare Fig. 3b with Fig. 2d). As the kimberlite grades from TKB to TKtB the rock becomes harder, more competent and darker in colour. Other features include slightly altered country rock xenoliths, completely pseudomorphed olivine macrocrysts, common pelletal lapilli, autoliths of HK and a matrix dominated by serpentine. The inhomogeneous matrix (Fig. 3b) contains patches of more magmatic kimberlite (Fig. 3a) and areas characterised by more TKB-like textures (Fig. 3c). Microlites, which include clinopyroxene, are common and are often coarser and more abundant than those present within the TKB (cf. Fig. 2f). The magmatic areas contain a more uniform distribution of groundmass minerals and can contain common clinopyroxene.

CONCLUSIONS

The geology of the Gahcho Kué pipes is summarised in a composite geological model (Fig. 1e). This model, as well as the shape and infill of the individual kimberlite pipes, is similar to that of the kimberlites in the Kimberley area of South Africa, but extremely different from many other Canadian kimberlites such as those found at Fort a la Corne, Attawapiskat and Lac de Gras. The Gahcho Kué pipes are similar root to diatreme transition zones as described by Clement (1982) and Clement and Reid (1989). The pipes, therefore, must have undergone significant erosion. The Gahcho Kué transition zones are extremely well preserved. Each transition zone is a gradation in igneous textures from typical magmatic hypabyssal kimberlite (HK) to the overlying magmaclastic tuffisitic kimberlite (TK). The textures within the hypabyssal and tuffisitic kimberlites are relatively uniform and structureless. In the gradational transition zone the magmatic and magmaclastic textures both oscillate, and in many areas, they are intermixed on a small scale (cms). In turn these sections show that the Gahcho Kué kimberlites formed by intrusive magmatic processes. The tuffisitic kimberlites result from the disruption of the kimberlite magma.

The variations in pipe morphologies and infill displayed by the Gahcho Kué kimberlites reflect varying depths of diatreme development and are not simply a function of erosion. Interestingly, the geometry of the transition zone is quite different in Tuzo and Hearne and is likely related to the contrasting pipe shapes. In Hearne the transition zone is at least 115m wide and dips at approximately 45 degrees to the north (Fig. 1b). In Tuzo the base of the TKB is overall horizontal (Fig. 1a) but in 3D is basin-shaped and the transition zone is at least 60m wide.

With respect to emplacement, the observed textures are consistent with the interpretation by Clement (1982) and Clement and Reid (1989) in which the degassing of an intrusive magma column produces the diatreme-zone and the transition diatreme-root zone represents a “frozen” degassing front as discussed by Field Scott Smith (1998). The marked change in xenolith abundance correlates with the fluidisation front and the top of the transition zone offers strong support for this process.

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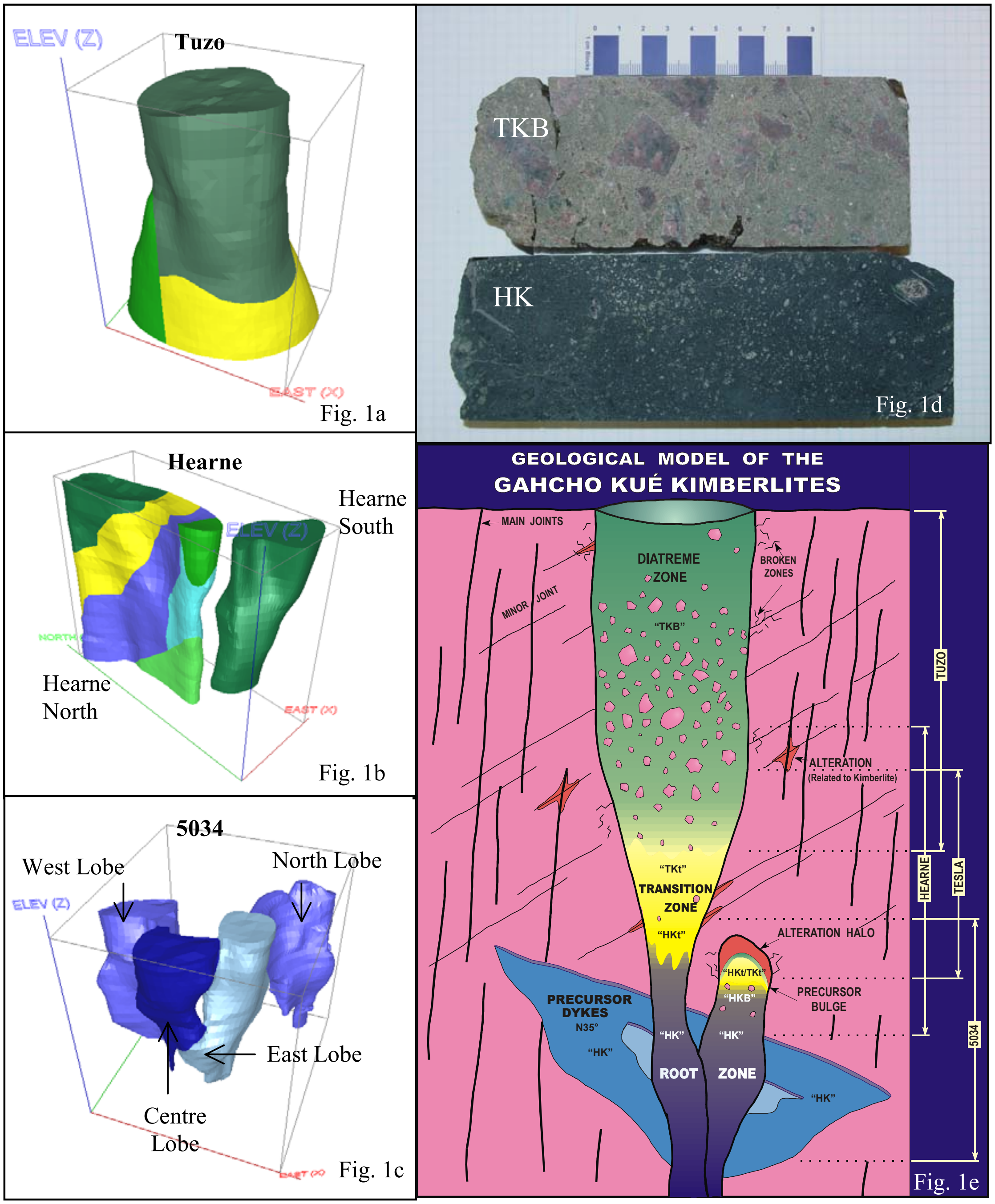
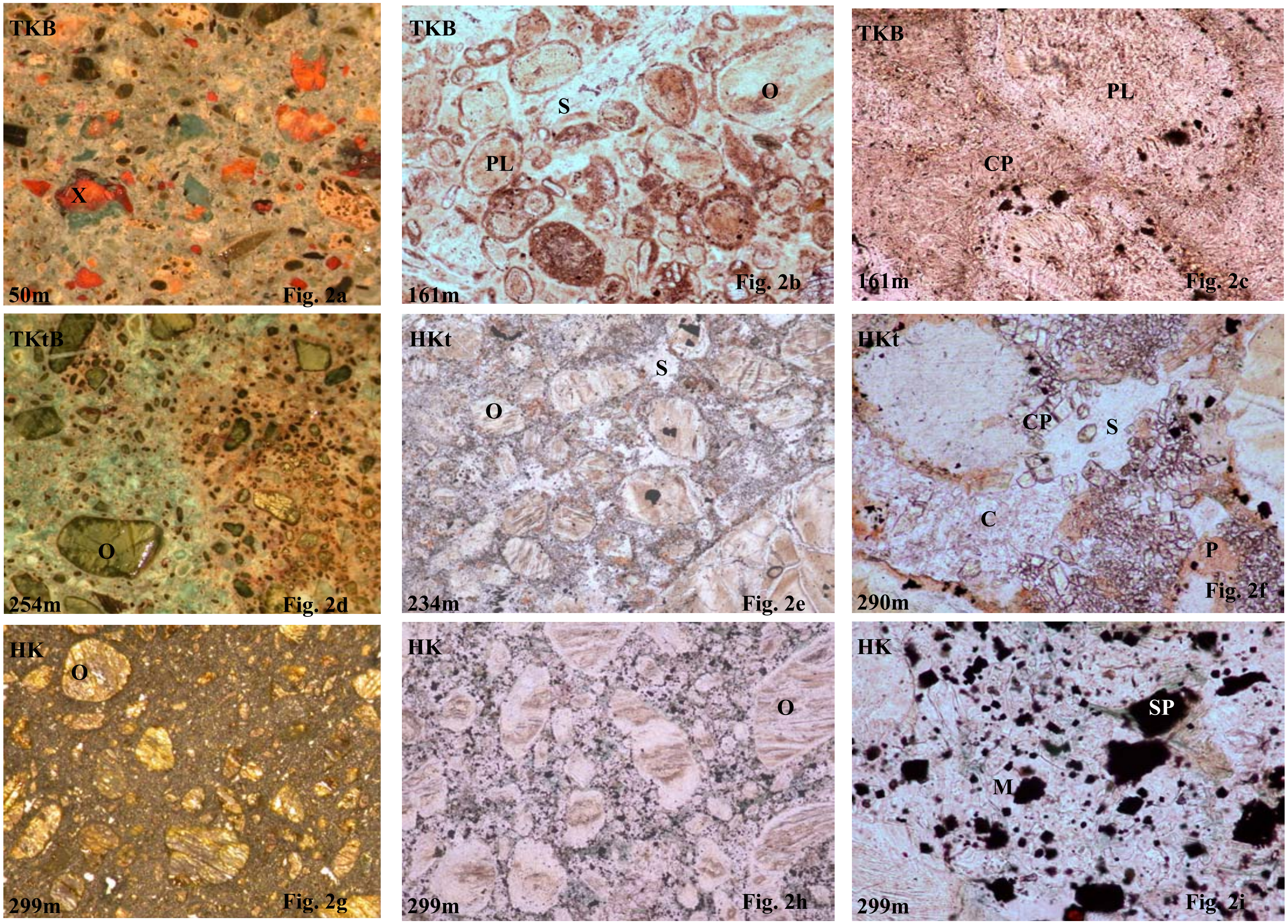


LEGEND: blues / grey = HK; yellow = gradational textures HKt and TKtB; greens = TKB (transitional = t)

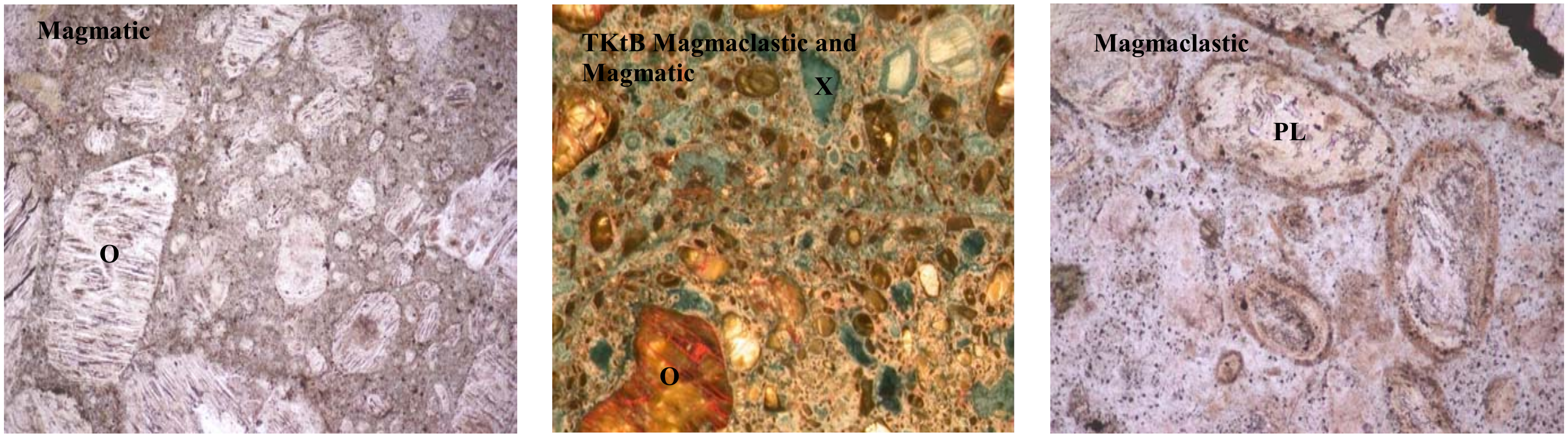
Fig. 1a 3D geological model of the Tuzo kimberlite (c. 130 X 120m)
Fig. 1b 3D geological model of the Hearne North (c. 245 X 50m) and Hearne South (c. 50 X 85m) kimberlites.
Fig. 1c 3D geological model of the 5034 kimberlite comprising the west lobe (c. 125 X 42m), central lobe (c. 115 X 70m), east lobe (c. 65 X 80m) and the north lobe (c. 200 X 40m)
Fig. 1d Polished slabs of TKB, MPV-02-111C, 97m (top) and HK, drillhole MPV-02-111C, 299m (bottom) from the Tuzo kimberlite. The TKB slab consists of light coloured altered kimberlite with common fresh pink, angular country rock xenoliths. The HK slab is dark in colour and displays a uniform macrocrystic texture. The olivine macrocrysts are light green and the oval shaped white-green area in the top right of the slab is a reacted country rock xenolith.
Fig 1e Composite geological model of the eroded Gahcho Kué kimberlites.

Polished Slabs | Thin Sections | Thin Sections



FOV = 10mm | *FOV = 2mm* | *FOV = 0.235mm*

Fig. 2 Textures present within the main phase of the Tuzo kimberlite that include hypabyssal kimberlite, tuffisitic kimberlite breccia and gradational textures from drillhole MPV-02-111C. Sample depths are listed in the bottom left corner of each plate.
Olivine = O, phlogopite =P, clinopyroxene = CP, monticellite = M, carbonate = C, serpentine = S, spinel = SP, country rock xenocryst = X, pelletal lapillus = PL.



Thin Section: FOV = 2mm Fig. 3a *Polished slab: FOV = 10mm* Fig. 3b *Thin Section: FOV = 2mm* Fig. 3c

Fig. 3 Textures from the Hearne transition zone, drillhole MPV-02-080C, 63m. Olivine = O, country rock xenocryst = X, pelletal lapillus = PL.

	TKB	TKtB	HKt	HK
COLOUR	Olive green: 1d top	Green-brown: 2d	Brown	Black-dark green: 1d bottom
CLAY MINERALS	Common: 2a	Less common	Low	Absent: 2g
XENOLITH ABUNDANCE	30-95%: 1d top	10-40%: 2d	5-25%	<10%: 1d bottom
XENOLITH SIZE	0.5cm to >500cm	0.5-200cm	0.5cm-50cm	< 25cm
XENOLITH REACTION	Minor: 2a, 1d top	Slight	Intermediate	Significant:1d bottom
OLIVINE REPLACEMENT	No fresh grains: 2a	No fresh grains: 2d	Minor fresh grains	Common fresh grains: 1d bottom
KIMBERLITE TEXTURE	Magmaclastic: 2a, 2b	Magmaclastic>magmatic: 3b	Magmatic>magmaclastic: 2e	Magmatic: 2g
PELLETAL LAPILLI	Common: 2b	Present: 3c	Rare: 2e	Absent: 2h
AUTOLITHS	Present	Present	Common	Rare
MICROLITIC TEXTURES	Common and fine: 2c	Variable and coarse: 2e	Rare and coarse: 2f	Absent: 2i
PRIMARY CARBONATE	Absent: 2b	Absent	Rare: 2f	Present

Table 1 Summary of the main macroscopic and microscopic features of the textural types of kimberlite present at Gahcho Kué (numbers refer to figures).

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LONG ABSTRACTS

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