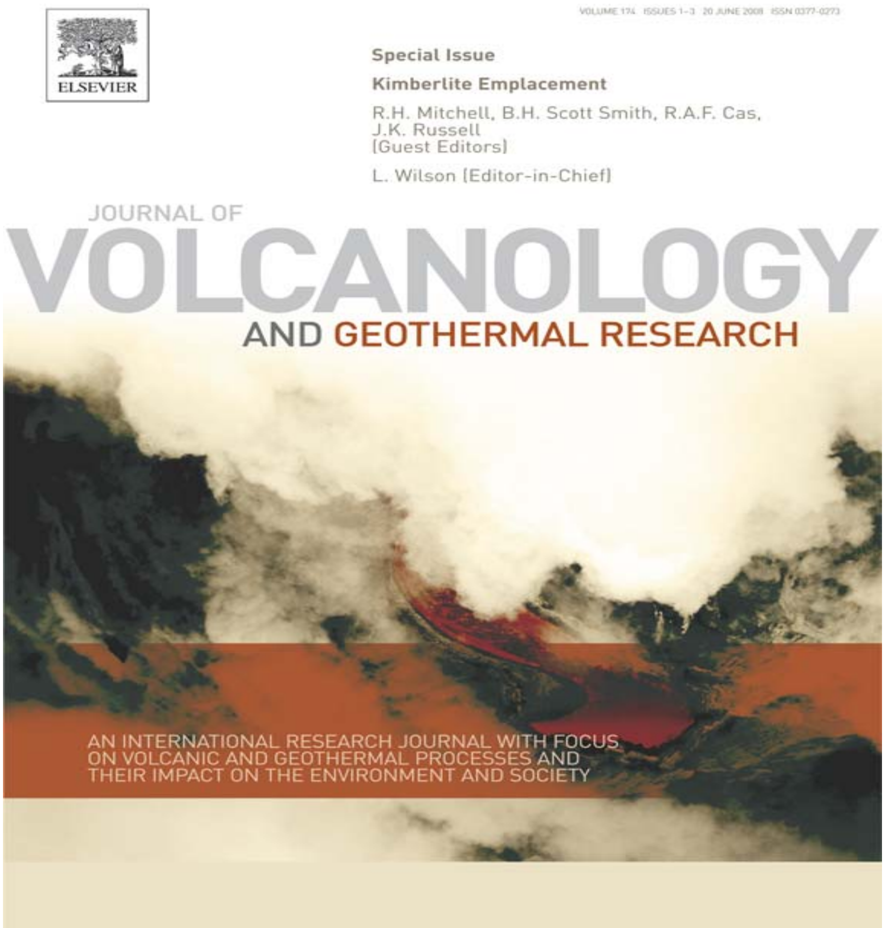
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The Pimenta Bueno kimberlite field, Rondônia, Brazil: Tuffisitic kimberlite and transitional textures

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Abstract

The Pimenta Bueno kimberlite field of Rondônia State, Brazil is located near the edge of the Amazon Craton and contains more than thirty bodies. A late to mid-Triassic emplacement age has been obtained for two kimberlites. The Pimenta Bueno kimberlite field includes pipes of up to 15 ha and a few apparently flat-lying hypabyssal kimberlite sills. In the three pipes and one sill examined, three textural end member types of kimberlite are recognized: hypabyssal kimberlite (HK), tuffisitic kimberlite (TK), and resedimented volcaniclastic kimberlite (RVK). There are gradations in textures between the three types. The overall gradation with depth is VKB, VK, TK, TKt, HKt to HK (where “t” denotes transitional varieties), and the textural gradations are apparent at all scales, megascopically to microscopically. Importantly, these gradations appear to occur within single phases of kimberlite. TK and the associated transitional varieties observed in the Pimenta Bueno field have striking similarities to those of many kimberlites of southern Africa and Canada. The Pimenta Bueno kimberlite field thus represents a newly recognized example of southern-African-style kimberlite pipes occurring on a third continent. The TK-bearing pipes of Pimenta Bueno, southern Africa, and Canada are markedly different from those found in the Canadian Prairies and Lac de Gras, Northwest Territories, which indicates that pipes containing TK and related textures are repeated in space and time but only form in certain circumstances. There is an apparent correlation between kimberlite texture and pipe size. In the larger pipes (>5 ha), the TK is overlain by VKB. In the small pipes (<3 ha) there is a textural gradation with depth from TK to HK and VKB is not present. One TKt–HKt transition appears to be ~60 m thick. The nature of the TK–TKt–HKt–HK textural transition suggests that TK developed by the textural modification of magmatic kimberlite within the pipe. The textures may reflect increased degrees of magma disruption associated with volatile exsolution.

Keywords: kimberlite; tuffisitic; diatreme; emplacement; transitional textures; Brazil

1. Introduction

At least 15 kimberlite fields and more than 1000 kimberlites have been discovered throughout Brazil since 1966. Kimberlites of the Pimenta Bueno field were discovered between 1974 and 1982 in the diamond district of Rondônia State in western Brazil. The kimberlites occur in the 1.5–1.3 Ga Rondônian-San Ignácio Province of the Guaporé Shield in the southwestern Amazon Craton (Fig. 1 inset). More than thirty kimberlite bodies, 15 of which are diamond bearing, are currently known in a 25×20 km area (Fig. 1). The Pimenta Bueno kimberlite field is situated both within and adjacent to the Pimenta Bueno fault graben, which is the western extension of the Parecis basin, an intercratonic rift-sag type basin. The graben is filled with Paleozoic sediments. Surface outcrops of bodies are limited and comprise oxidized, weathered material.

Nine of the kimberlites, including pipes up to 15 ha, were evaluated by Rio Tinto Desenvolvimentos Minerais Ltda. and joint venture partners Vaaldiam Resources Ltd. through a combination of diamond core drilling and mini bulk sampling. Limited information suggests that two of those bodies are small flat-lying tabular sills up to 2 m thick. The geology of four of these bodies (Fig. 1), three pipes (Cosmos-01, Pepper-04, Pepper-13, Fig. 2), and one sill (Pepper-06) is discussed below. The four kimberlites were emplaced into sediments within the Pimenta Bueno graben. Pepper-04 appears to be one of the larger pipes in

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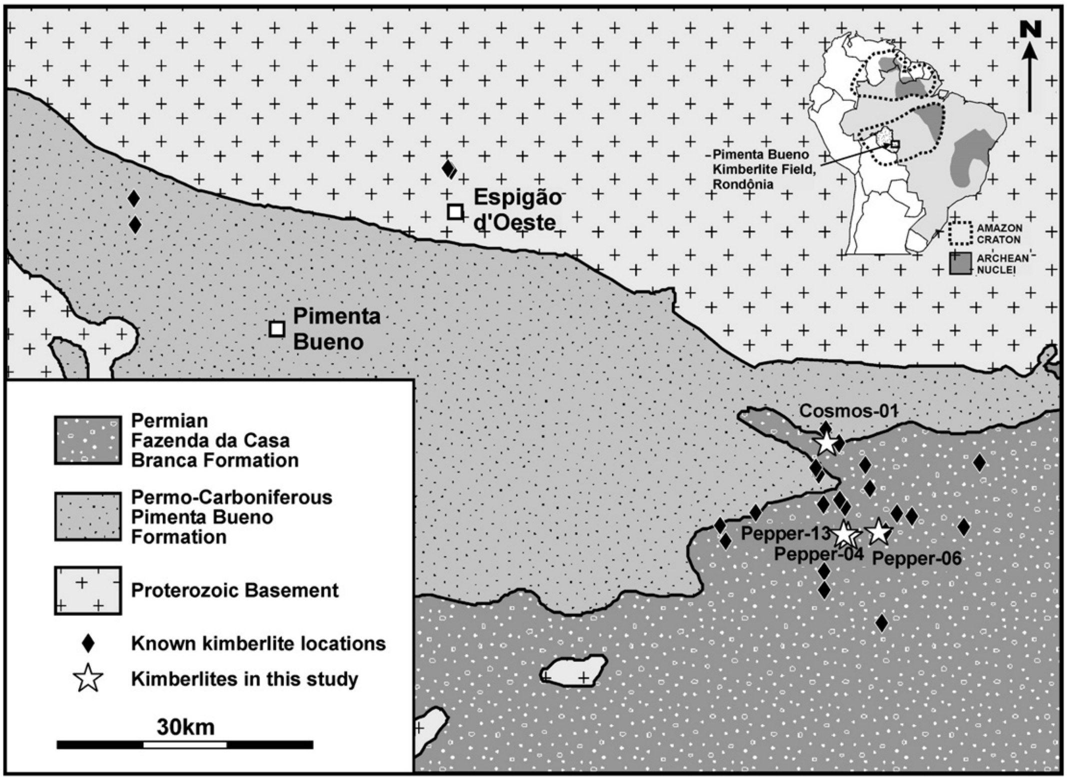

Fig. 1. Location and geological setting of the Pimenta Bueno kimberlite field in the Amazon Craton, Rondônia State, Brazil.

the Pimento Bueno field. Sedimentary cover over these bodies is variable (Fig. 2). A late to mid-Triassic age of emplacement (226.6±7.2 Ma) has been determined for the Cosmos-01 kimberlite using Rb–Sr methods on phlogopite (Creaser pers. comm., 2006) and a mid-Triassic age of emplacement (237±9 Ma) has been determined for Pepper-13 using U-Pb on perovskite (Heaman pers. comm., 2007). Magmaclastic textures (terms after Field and Scott Smith, 1998) are common in all the pipe-like bodies. The term magmaclastic indicates that the rock is composed of discrete bodies of ductile or molten kimberlite with no genetic connotation. Importantly, the term does not imply any extrusive process. Magmatic (or coherent) textures occur only in Pepper-13 and Pepper-06.

2. Rock-type classification

The magmatic rocks in the Pimenta Bueno field are characterized by macrocrystic textures (HKs in Figs. 3 and 4). Anhedral olivine macrocrysts (generally <5 mm to >10 mm) are common. Some of these grains can be seen to have polycrystalline textures consistent with mantle-derived xenocrysts. Other mantle-derived xenocrysts include ilmenite, less common peridotitic garnet, and rare eclogitic garnet. These grains' compositions are typical of mantle-derived xenocrysts commonly found in kimberlites. The garnets sometimes have kelyphite rims. Chrome diopside is rare, often occurring as small inclusions in olivine. Chrome-spinel is rare to absent, and mantle-derived xenoliths are relatively common in Cosmos-01 and rare in Pepper-13. Finer-grained olivine occurs as subhedral to euhedral primary phenocrysts (generally <0.5 mm to, rarely, 2 mm). In some instances, the olivine phenocrysts are mantled by necklaces of opaque oxides. Fresh olivine is not observed, and these grains are typically replaced by serpentine, chlorite, and carbonate. The well crystallized but fine-grained groundmass minerals include spinel, perovskite, phlogopite, apatite, and probable primary carbonate and serpentine (mineralogy confirmed by Mitchell, 2005). The Pimenta Bueno rocks can be classified as kimberlite (Woolley et al., 1996). Many of these features are also present in the less well crystallized magmaclastic rocks (HKt, TKt and TK) described below.

3. Main textural types

The four bodies studied are composed of texturally variable kimberlite. Three main textural end members are recognized (terminology after Field and Scott Smith, 1998):

1. Magmatic kimberlite (hypabyssal kimberlite or HK, see Section 3.1);
2. Magmaclastic kimberlite (tuffisitic kimberlite or TK, see Section 3.2); and
3. Xenolith-rich magmaclastic kimberlite (volcaniclastic kimberlite breccia or VKB see Section 3.3).

The xenolith assemblage present within the pipes is dominated by country-rock sediments (Paleozoic sediments of the Pimenta Bueno Formation) and contains lesser amounts of basement granitoids and mafic volcanic rocks, dolomite (probably Cacoal Formation), and deeper crustal rocks (listed in decreasing order of abundance).

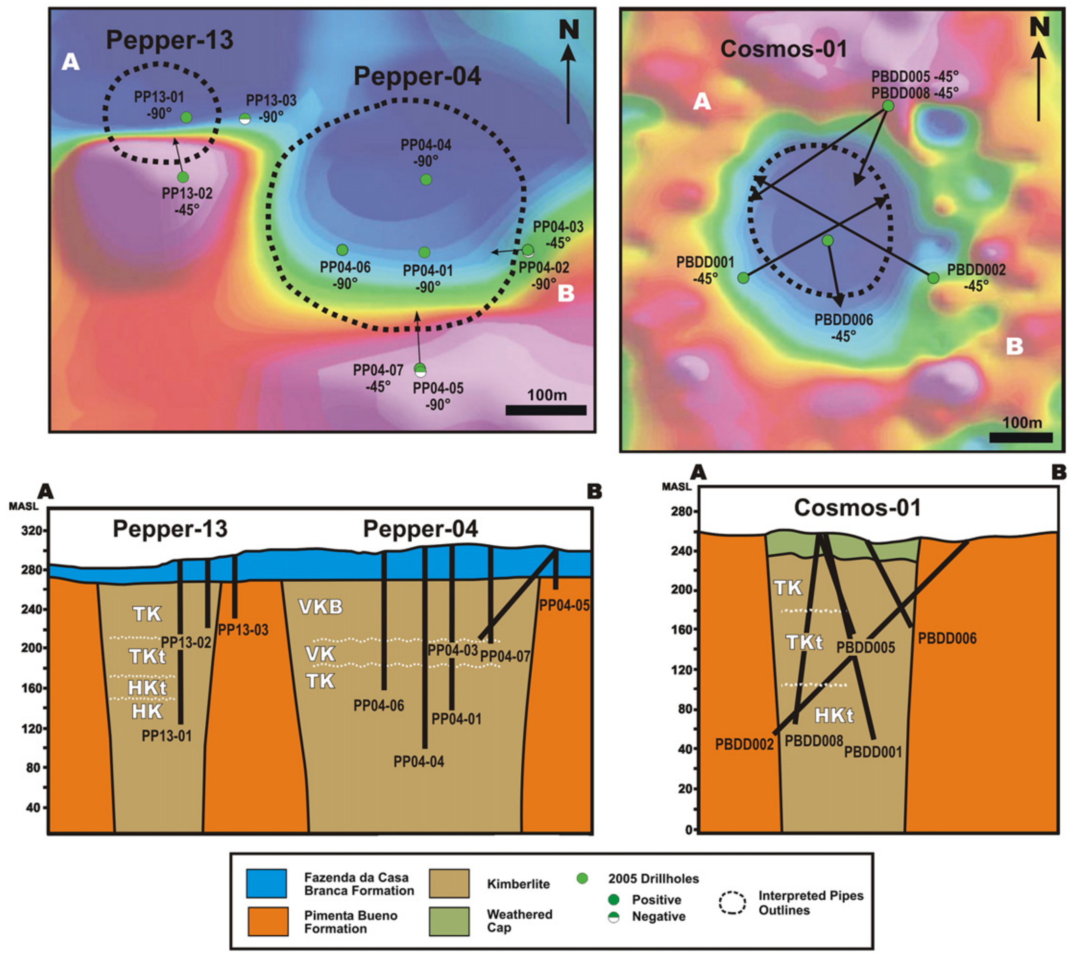

Fig. 2. Schematic illustrations of the three pipe-like bodies in this study. Plan views: top left shows the ground magnetics for Pepper-04 and Pepper-13; top right shows ground gravity for Cosmos-01. The cross sections present the drill hole locations and schematic pipe shapes and summarize the textures determined using samples of the drill cores.

3.1. Magmatic kimberlite (HK)

The magmatic kimberlites are described in the rock-type classification above (Section 2.) and can be texturally classified as macrocrystic hypabyssal kimberlite (HK; Figs. 3 and 4). The HKs vary from uniform to fine segregationary textured. Primary carbonate and serpentine are present in small (<1 mm) irregular-shaped pool-like segregations. HK occurs in one of the pipe-like bodies (Pepper-13 in Figs. 2–4) and the sill (Pepper-06). Although country-rock xenoliths are typical of this rock type they are not common. The xenoliths show significant digestion by the host kimberlite magma and have rounded shapes and diffuse margins.

3.2. Magmaclastic kimberlite (TK)

The second main rock type is uniform-textured and contains fresh, angular, locally-derived sedimentary xenoliths and common olivine pseudomorphs set in a lightish buff to grey-coloured matrix (Fig. 3). Except for dilution by xenoliths, the olivine abundance and size distribution is very similar to that described for the HKs. Most of the xenoliths and olivine grains are rimmed by thin, cryptocrystalline, often optically-irresolvable, selvages of kimberlite interpreted to be magmaclasts (Fig. 4 PP04-01 64.8 m and Fig. 5). Examination of the selvages of kimberlite using backscatter electron imaging with a scanning electron microscope shows that they are composed of diopside, chloritized mica, and apatite (Mitchell, 2005). These magmaclasts are referred to as pelletal lapilli (after Clement and Skinner, 1985). Rare magmaclasts comprise multiple olivine grains with a thicker selvage that contains spinel and perovskite (Fig. 5b). Open, matrix-supported textures are common (Fig. 5). The inter-lapilli matrix is composed of felty patches of material similar to the microlitic rims, widely scattered single crystals of altered perovskite, and rare spinel in a base of serpentine, diopside, and brown chlorite (Fig. 5c, mineralogy confirmed by Mitchell, 2005). The rock has an overall brown colour in thin section. Carbonate is absent.

The observed features are diagnostic and show that these rocks can be classified as macrocrystic tuffisitic kimberlite (TK) or tuffisitic kimberlite breccia (TKB if ≥15 vol.% xenoliths >1 cm in size). The xenolith assemblage includes diverse locally-derived, angular sedimentary rocks. Minor crystalline basement clasts occur as TK progresses towards transitional textures that are invariably altered and rounded, and they can be partially replaced by kimberlite minerals.

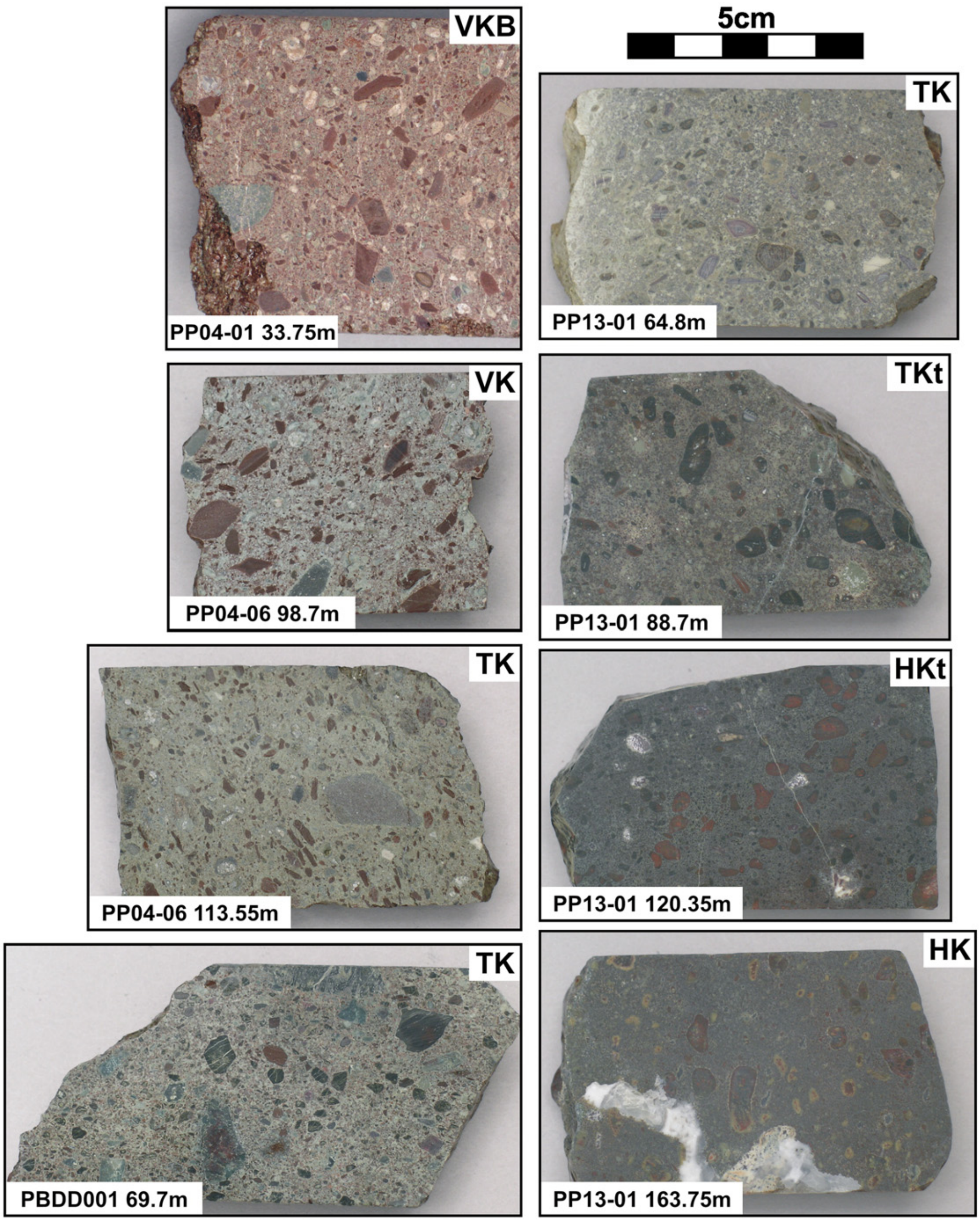

Fig. 3. Polished slabs illustrating the different textures observed in the three pipes. Three samples from Pepper-04 (holes PP04-01 and PP04-06) show the gradation with depth from VKB to VK to TK, the most obvious feature at this scale being the reduction in xenolith content and change in colour. TK is illustrated from all three pipes, Pepper-04 (hole PP04-06), Cosmos-01 (hole PBDD001) and Pepper-13 (hole PP13-01). The textural gradation from TK through TKt and HKt to HK with increasing depth is shown in one drill hole (PP13-01) from Pepper-13. The petrography of the Pepper-13 samples is illustrated in Figs. 4, 5 and 7. See Fig. 2 for hole locations.

3.3. Xenolith-rich magmaclastic kimberlite (VKB)

The third main rock type is altered and contains more common xenoliths (up to >75%), xenocrysts of quartz, feldspar, mica and rare amphibole derived from the sedimentary country-rocks, common olivine, and other mantled-derived xenocrysts set in a brown–red matrix (Figs. 3 sample PP04-01 33.75 m, 6a). Olivine grains are completely replaced by serpentine, chlorite ± reddish material. In some examples, the olivine grains can have thin selvages and thus resemble the pelletal lapilli in the TK (Fig. 6b). Clast-supported textures are dominant, and country-rock clasts, olivine crystals and pelletal lapilli are tightly packed with irregular pore spaces that consist of serpentine and hematite or serpentine with carbonate in some areas. This material can be distinguished from TK based on the abundance of xenoliths, clast-supported and close packed textures, subhorizontal fabrics of the elongate sedimentary xenoliths and olivine macrocrysts, olivine and xenolith sorting, grading and overall colour, and alteration. Rock type (3) is termed volcaniclastic kimberlite breccia (VKB).

4. Transitional textures

The observed locations of the textures described above are illustrated in Fig. 2 and indicate a vertical sequence from VKB to TK in Pepper-04, TK to HK in Pepper-13, and TK to almost HK in Cosmos-01. Transitional textures occur between these end members. The textural gradations are summarized in Figs. 3 and 4 and Table 1. VKB was only observed in the largest of the bodies in Pepper-04. With depth, the VKB shows increasing proportions of kimberlitic constituents over xenolithic material, more common kimberlite selvages on xenoliths, and increased development of microlitic textures in the matrix, thus grading into a rock type termed volcaniclastic kimberlite or VK (Figs. 3 sample PP04-06 98.7 m, 6b). The VK has distinct similarities to TK, and with depth it grades into TK (Fig. 3).

In Cosmos-01 and Pepper-13 (Fig. 2), changes in the textures of TK with depth include a distinct grain-size coarsening and a decrease in the proportion of pelletal lapilli or magmaclasts. The transition from pelletal textures with cryptocrystalline matrices in TK to magmatic kimberlite in HK is visible in thin section (Figs. 4, 6 and 7). The gradational textures are similar to those observed by Hetman et al. (2003, 2004), and similar terminology is used here (TK, TKt, HKt, HK). The complete textural range was observed in a single drill hole, as shown in Figs. 2, 3, 4 and 7 (PP13-01). In the transitional rocks, TKt and HKt, areas with pelletal textures occur adjacent to irregular patches of magmatic kimberlite (Figs. 4 and 7). On a macroscopic scale, these textures appear as irregular-shaped patches of lighter and darker kimberlite. The microlites in the more magmatic patches are coarser grained than in the pelletal patches, and the interstitial areas resemble the pool-like segregations of serpentine present in HK. As the textural gradation progresses with depth, the grain size in the magmatic patches increases and the large (up to several millimeters) irregular magmatic patches start to dominate until the groundmass becomes essentially uniform, magmatic, and crystalline in character as it grades into HK (Fig. 4). Groundmass minerals in the well crystallized HK include spinel, perovskite, serpentine and carbonate. Phlogopite may be present, but clinopyroxene is notably absent.

5. Kimberlite geology

5.1. Pepper-04

Red–grey VKB (Figs. 2 and 3, sample PP04-01 33.75 m and 6a) infills the upper part of this >7 ha pipe. This rock type is composed of closely-packed pseudomorphs of olivine macrocrysts, pelletal lapilli, common country-rock xenoliths, and

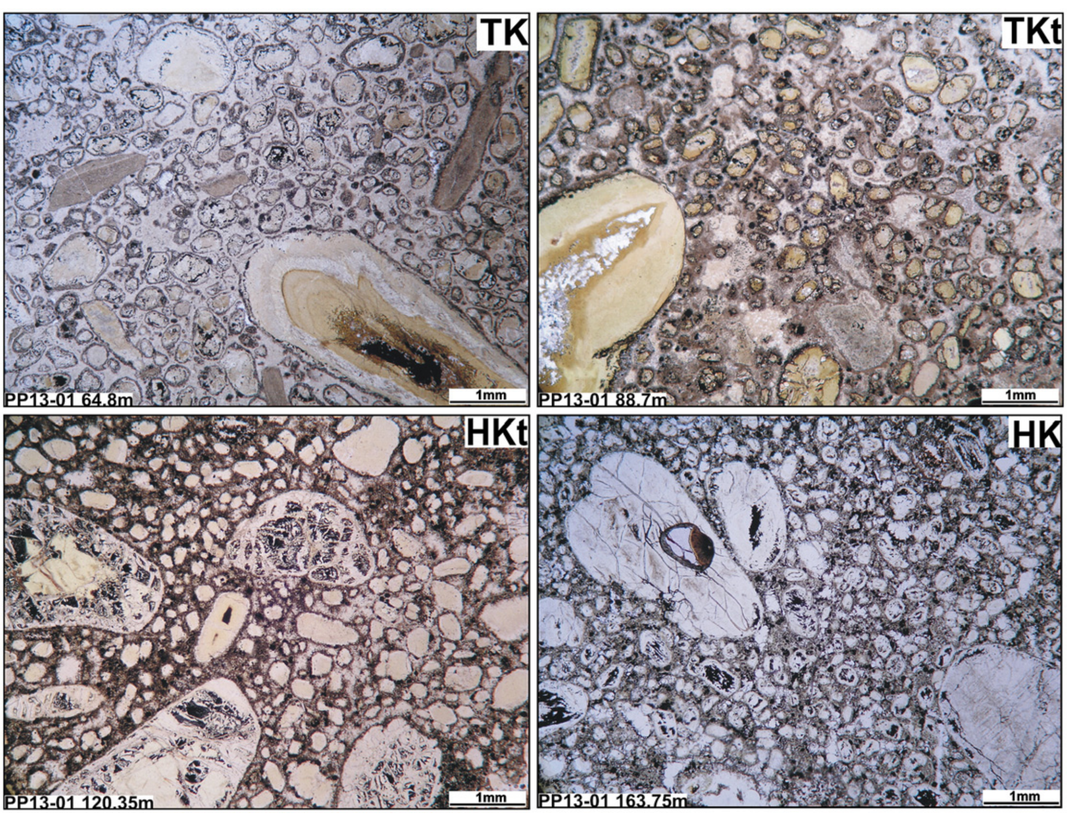

Fig. 4. Petrography of the TK to HK transition illustrated using the samples from drill hole PP13-01 as illustrated in Fig. 3 (see Fig. 2 for hole location). TK from 64.8 m is composed of loosely packed pelletal lapilli. The pelletal lapilli comprise olivine pseudomorphs rimmed with thin selvages of cryptocrystalline kimberlite. The few sediment xenoliths can have similar selvages. The inter-lapilli matrix is serpentine. Microscopic features of this sample are illustrated in Fig. 5. TKt from 88.7 m is similar to the TK, but the pelletal lapilli are not fully separated and the kimberlite selvages are slightly thicker and coarser grained. HKt at 120.35 m has a magmatic texture with segregationary-to-incipient pelletal textures developed in some areas (bottom right). Microscopic features of the transitional textures from 88.7 and 120.35 m are illustrated in Fig. 7. Although not evident at this scale, the TK, TKt and HKt have microlitic textures (see Fig. 5c). The HK from 163.75 m has a uniform magmatic texture and relatively coarse-grained spinel and perovskite.

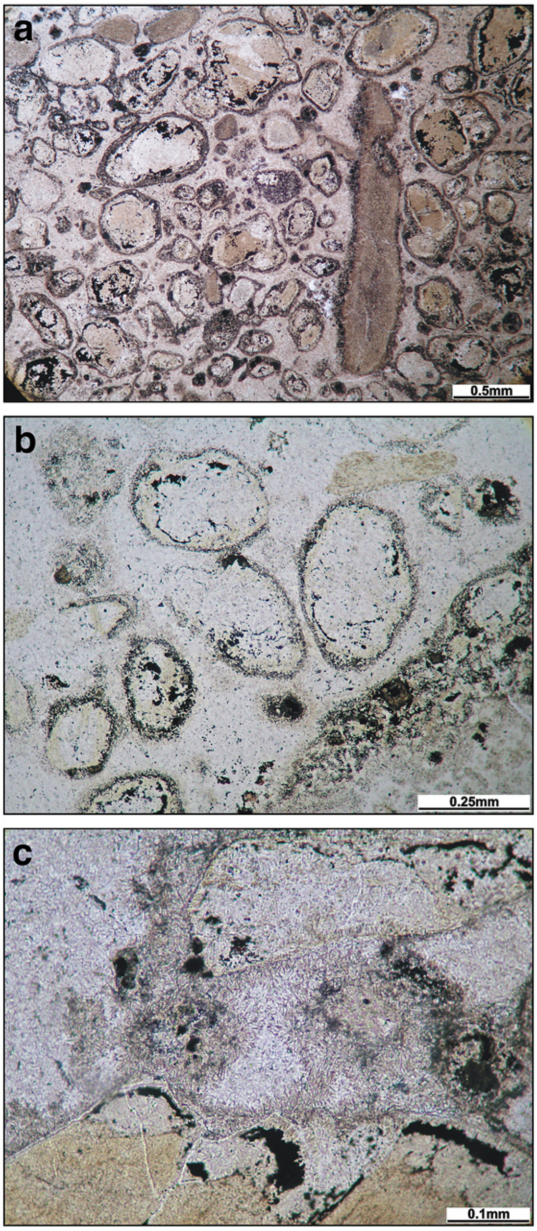

Fig. 5. Tuffisitic kimberlite (TK) from Pepper-13, sample PP13-01 64.8 m as shown in Figs. 3 and 4 illustrated in thin section at different scales (see Fig. 2 for drill hole location). a. Matrix-supported, evenly distributed, pelletal lapilli composed of olivine pseudomorphs with a thin skin of very fine grained kimberlite set in a serpentine matrix. The single dark brown sedimentary xenolith also has a thin kimberlite selvage. b. Pelletal lapilli as in A. In the lower right, a somewhat thicker selvage contains fine-grained perovskite and spinel. c. Microlites of diopside and phlogopite occur within the selvages on olivine and within the interclast matrix.

xenocrystic quartz; and it resembles resedimented material. With depth, at ~100 m from surface (Fig. 2), there are fewer xenoliths and more pelletal lapilli, and the VKB grades into VK (Figs. 3, 4, PP04-06 98.7 m and 6b). As observed in drill hole PP04-06 (Fig. 2), the VK appears to grade into grey TK (Fig. 3, PP04-06 98.7 and 113.55 m). In drill hole PP04-01, with depth VKB appears to be intercalated with VK, and below ~110 m from surface, VKB is absent and the greenish, juvenile-rich VK grades into more apparent massive TK. RVK does not directly overlie TK in this pipe.

5.2. Cosmos-01

This 2.3 ha pipe is infilled with massive uniform grey TK (Figs. 2 and 3, PPDD001), which has been identified in three drill cores to ~200 m from surface. Below 100 m, however, the kimberlite is somewhat different. Small, darker, more magmatic textured areas become macroscopically more common with depth, and in addition, the degree of xenolith digestion increases. Some are only relicts below 150 m. Some of the samples also display microscopic TKt textures where the pelletal lapilli are not fully separate, which suggests that there is a textural transition to TKt below ~100 m. Harder, darker, and more magmatic patches become more common than pelletal textures below ~140 m, marking a transition to HKt. HK was not encountered in the available drill cores.

5.3. Pepper-13

The upper part of the 1.5 ha Pepper-13 pipe is composed of TK (Fig. 2). In drill hole PP13-01, diffuse megascopic textural

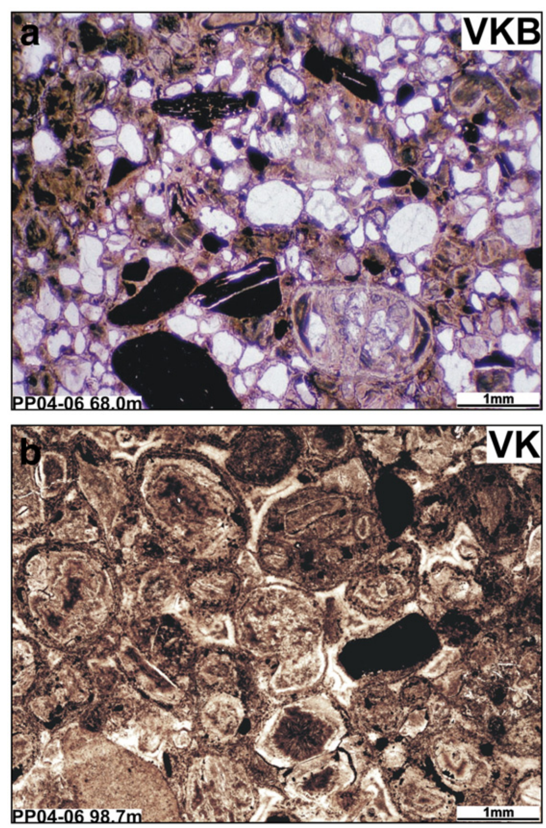

Fig. 6. Contrasting samples of VK from Pepper-04. a. Sample PP04-06 68.0 m. The sample of VKB is dominated by rounded detrital quartz grains, dark oxidized country-rock xenoliths, and minor kimberlitic material. The nature of the exotic constituents suggests that the rock is RVK. b. Sample PP04-06 98.7 m. This sample of VK contains common kimberlitic constituents that are mainly clast-supported, pelletal lapilli and minor sedimentary country-rock xenoliths set in an altered matrix.

Table 1
Summary of the macroscopic and microscopic features of the main textural types of kimberlite observed at Pimenta Bueno

	VKB	VK	TK	TKt	HKt	HK
Colour	Red brown	Pink–grey	Pink–grey to grey–green	Grey–green	Dark grey–green	Dark grey–black
Clay minerals	Abundant	Abundant	Common	Present	Low	Low
Xenolith abundance	20–50%+	10–40%	<10–20%	<15%	<5%	<5%
Xenolith size	To 200 cm	0.2 to 30 cm	0.2 to 50 cm	0.2–50 cm	<10 cm	<5 cm
Xenolith reaction	Fresh	Fresh	Minor	Minor	Partial digestion	Significant digestion
Xenolith lithology	Angular CRS	Angular CRS	Angular CRS, rare CRB	Angular-to-subangular CRS, rare subangular CRB	Subangular to subrounded CRS>subrounded CRB	Subangular to subrounded CRS, common subrounded CRB
Kimberlite texture	Magmaclastic	Magmaclastic	Magmaclastic	Magmaclastic>magmatic	Magmatic>magmaclastic	Magmatic
Pelletal lapilli	Low	Present	Abundant	Present	Rare	Absent
Microlitic textures	Not observed	Present, variable	Abundant	Common	Rare, coarse	Absent
Structure	Grading, pronounced subhorizontal orientation	Diffuse grading, subhorizontal orientation	Absent	Absent	Absent	Absent

CRS = country-rock sediments; CRB = country-rock basement.

changes, together with the petrography of samples, suggest the following sequence of lithologies: light grey TK (to 81.3 m), light to medium grey TKt (81.3–116.9 m), darker grey HKt (116.9–138.8 m), and dark grey HK (below 138.8 m). The area between 81.3 and 138.8 m thus appears to be a textural transition from TK to HK (Figs. 3, 4 and 7).

5.4. Pepper-06

The Pepper-06 body is a sill ~20 m from surface and ~1–2 m thick that is composed of carbonatized sparsely-to-moderately macrocrystic HK with a groundmass that appears to be well crystallized (spinel/perovskite up to 0.1 mm). Segregationary textures are present, resulting from irregular pools of carbonate and isotropic serpentine. A few elongate local sedimentary xenoliths are aligned and flow zoning may be present.

5.5. Other Pimenta Bueno bodies

Probable TK has been observed in three of the four other larger (>2 ha) pipes, including Pepper-03, which is >15 ha. VKB overlies TK in the four bodies >5 ha, and a kimberlite-poor breccia overlies the VKB only in the largest pipe, Pepper-03. The contacts between VKB and probable TK are sharp.

6. Composite geological model

The repeated relationships of the observed textures, as described above and illustrated in Fig. 2, were used to compile the schematic geological model shown in Fig. 8. The pipe shape is not constrained by drilling, but for the purpose of the model, it is assumed to be a steep-sided pipe with a slight inward taper with depth. With respect to the gradations from TK to HK, extremely similar textural gradations have been described in the Gahcho Kué pipes (Hetman et al., 2003, 2004) and a number of southern African kimberlite pipes (Clement, 1982; Clement and Reid, 1989; Field and Scott Smith, 1998; 1999; Skinner and Marsh, 2004). By analogy with these localities, it appears that the Pimenta Bueno pipes can be sub-divided into different textural zones. The upper areas dominated by VKB and VK may represent a crater zone, beneath which is the diatreme zone infilled with TK. The transition zone from TK to TKt and HKt grades with depth into a root zone composed of HK.

7. Origin of textures

The kimberlite textures observed in the Pimento Bueno pipes are summarized in Table 1 and Fig. 8. With respect to the VKB, the abundance and size of the xenoliths, the presence of common single rounded grains of quartz, and the development of grading and pronounced horizontal fabrics suggest that these rocks may be post-eruptive resedimented volcaniclastic kimberlite breccia (RVKB). Contacts are sharp where VKB overlies TK, and contacts between VKB and VK can be sharp or gradational. The VK has a much lower proportion of exotic material, and except for the presence of diffuse bedding and some fabrics, it resembles the underlying TK. Where the VK is intercalated with VKB, the material may represent juvenile-rich RVK. Given that the contacts between VK and TK are gradational, it is possible that some deeper parts of the VK represent pyroclastic TK, possibly comparable to that which occurs in the northern Orapa kimberlite pipe (i.e., Northern Pyroclastic Kimberlite;Field et al., 1997). If so, this kimberlite unit is contemporaneous with the TK, but if deposited later, it would be expected to have a sharper contact with overlying RVKB.

The repeated textural gradation of TK to HK and the similarity to deposits in Canada and southern Africa (Clement, 1982; Clement and Reid, 1989; Field and Scott Smith, 1998; 1999; Hetman et al., 2003; 2004; Skinner and Marsh, 2004; Hetman, 2008-this issue; Scott Smith, 2008-this issue) indicate that such transitions have been repeated in space and time. The vertical textural changes, the intimate association of pelletal and

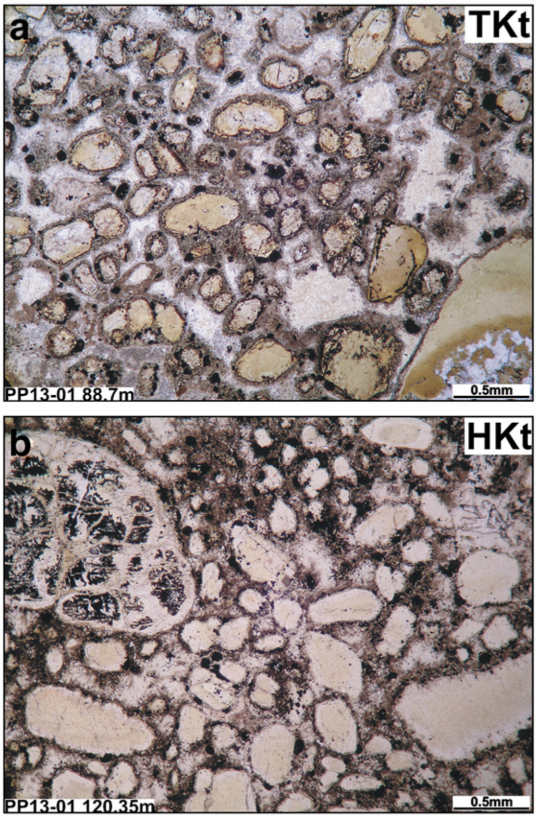

Fig. 7. TKt to HKt transitional textures from drill hole PP13-01 in Pepper-13 (see Fig. 2 for hole location). a. Sample PP13-01 88.7 m as shown in Figs. 3 and 4. This portion of the TKt sample includes partly developed pelletal lapilli and a somewhat greater degree of crystallization than that of TK (as shown in Fig. 5). b. Sample PP13-01 120.35 m as shown in Figs. 3 and 4. This portion of the HKt sample displays magmatic textures in the lower part of the plate, and above that, segregationary textures and the incipient development of pelletal lapilli. The textures shown in these two areas of TKt and HKt are similar. Overall, the TKt contains more common and better developed pelletal lapilli and the HKt contains less common and poorly developed pelletal lapilli.

magmatic textures that correlate with increasing reaction of the xenolithic material, suggests that the transition from TK(B) through TKt and HKt to HK reflects variations within one pulse of magma. The nature of the olivine and mantle-derived xenocrysts, features commonly used to separate different pulses of kimberlite magmas, are constant. Repeated vertical textural gradations occurring within single phases of kimberlite support previous interpretations that they are formed by the textural modification of the magma during emplacement (Clement, 1982; Clement and Reid, 1989; Field and Scott Smith, 1998; 1999; Hetman et al., 2003; 2004; Skinner and Marsh, 2004; Hetman, 2008-this issue; Scott Smith, 2008-this issue).

The HK resembles most other examples of hypabyssal kimberlite elsewhere in the world, including dykes and sills. The typical consistently fine grained textures must result from rapid en masse late stage crystallization of the former melt to a holocrystalline groundmass beginning at typical magmatic temperatures of 800–1000 °C (for spinel, perovskite, monticellite, phlogopite) followed by later lower temperature minerals (carbonate at >650 °C and serpentine >300 °C (Mitchell, 2008-this issue; Skinner, 2008-this issue). The overlying textures appear to reflect continuous gradational stages of an in situ, subvolcanic, magmatic process within the pipe. The TK textures and the associated transitions have not been observed in other igneous rocks and thus appear to be specific to kimberlites. Kimberlites are unusually volatile-rich magmas. The exsolution of volatiles from a magma column seems to be a likely process as suggested by Clement (1982), Field and Scott Smith (1999), Skinner and Marsh (2004), Hetman et al. (2004), and Skinner (2008-this issue). The development of pelletal lapilli towards surface reflects increased degrees of fragmentation of the magma associated with degassing.

In most instances, extrusive kimberlites, as found in the Canadian Prairies and Lac de Gras, whether resedimented or pyroclastic, show clear signs of sorting not only through bedding but also in other features such as the widespread loss of fine olivines and ash (e.g., Field and Scott Smith, 1999; Webb et al., 2004; Nowicki et al., 2008-this issue). Importantly, except for dilution by the addition of locally derived xenoliths, the olivine population at Pimento Bueno is constant through the HK to TK textural changes. Thus, there is no evidence to suggest that TK components were formed by the extrusive pyroclastic processes suggested by Sparks et al. (2006). The pelletal lapilli contrast with the magmaclasts or juvenile lapilli formed in partly bedded pyroclastic kimberlites as found in the Canadian Prairies and Lac de

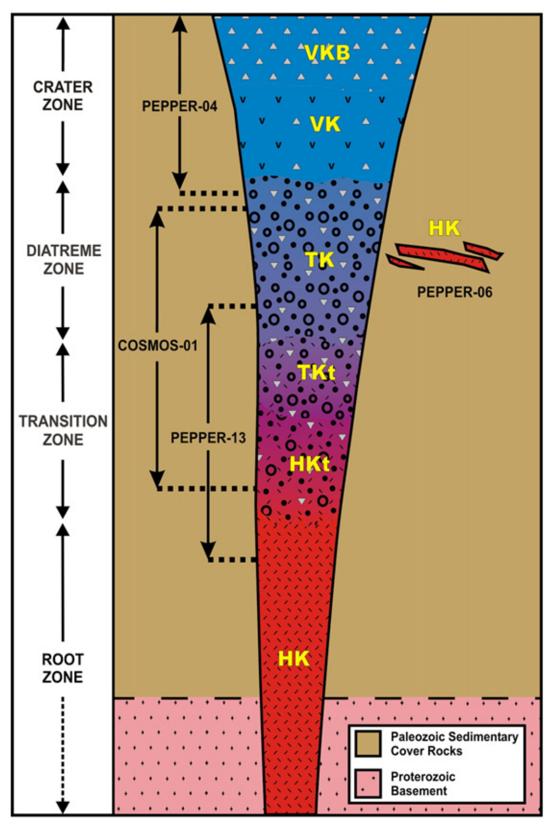

Fig. 8. Composite schematic geological model of the Pimenta Bueno kimberlites. The geology observed in the available drill holes of the four kimberlites examined in this study is represented. The top of each kimberlite range represents the present surface for that body. The differences between these surfaces reflect different stages in the geological evolution of the pipes, not different ages of intrusion or contrasting levels of pipe erosion.

Gras (e.g., Scott Smith, 2008-this issue) and thus should have a different origin. Also, if the pelletal lapilli in the TK were formed by more normal pyroclastic processes, the thin selvage pyroclasts would be cool and solid prior to deposition and any subsequent fluidization would have temperatures well below that required for welding to form typical hypabyssal igneous textures as proposed by Sparks et al. (2006). Instead, the TK features that resemble the effects of later hydrothermal fluids noted by Sparks et al. (2006) could be exsolved juvenile fluids from the contemporaneous underlying HK.

8. Conclusions

The Pimenta Bueno kimberlite field includes pipes (<2 to >15 ha in size) and a few apparently flat-lying hypabyssal kimberlite sills. All but one of the pipes contain tuffisitic kimberlite (TK) that has striking similarities to many kimberlites of southern Africa and Canada (cf. Hetman, 2008-this issue). The association of TK with HK (in sills and the deeper parts of the pipes) is also comparable to many southern African kimberlites and the Gahcho Kué field. The Pimenta Bueno kimberlite field thus represents a newly recognized example of southern-African-style kimberlite pipes occurring on a third continent. The Pimenta Bueno, southern Africa and Canadian TK-bearing kimberlites are markedly different from those in other provinces, such as those found in the Canadian Prairies and Lac de Gras, NWT. This shows that pipes containing TK and related textures are repeated in space and time but only form in certain circumstances. Although the information is preliminary, there is a correlation between kimberlite texture and pipe size. In the larger pipes (>5 ha), TK is overlain by VKB. In the small pipes (<3 ha), there is a textural gradation with depth from TK to HK similar to that described by Hetman et al. (2003, 2004). One TK–HK transition appears to be ~60 m thick. The nature of the TK–HK textural transition suggests that TK was developed by the textural modification of magmatic kimberlite (or HK) within the pipe. The gradual development of pelletal lapilli towards surface may reflect increased degrees of magma disruption associated with volatile exsolution.

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