Kimberlites: Descriptive Geological Nomenclature and Classification

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THE SCHEME

Stages 1 and 2, the observation, provide the basic information required for the development of economically relevant geological models. Importantly, Stages 3 to 5, the progressive interpretation, are applied only where sufficient data are available.

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<tr><th>Stage 1</th><th>Stage 2</th><th>Stage 3</th><th>Stage 4a</th><th>Stage 4b</th><th>Stage 5</th></tr>
<tr><td colspan="2">OBSERVATION</td><td colspan="4">PROGRESSIVE INTERPRETATION</td></tr>
<tr><td>Background Information</td><td>Rock Description</td><td>Petrogenetic Classification</td><td colspan="2">Textural-Genetic Classification</td><td>Genetic / Process Interpretation</td></tr>
<tr><td rowspan="5">Setting: geographic; tectonic; geological; structural; igneous association; age relationships; emplacement styles; host deposit geology
Sample details: type; attributes; location
Scope of study: context and aim of investigation
Contacts: preservation; dip; nature; relationship and timing of units</td><td rowspan="5">Alteration: intensity; distribution; mineralogy; imposed textures; timing; preservation; xenolith reaction
Structure: e.g. massive; inhomogeneous; stratified; flow zoned
Components: olivine (macrocryst, phenocryst); other crystals; magmaclasts; xenoliths; autoliths; accretionary clasts; interstitial matrix
Texture: component distribution; size distribution (e.g. well sorted; inequigranular); packing; support (e.g. clast or matrix supported)</td><td rowspan="5">Parental magma type: e.g. kimberlite; lamproite; melnoite; alnoite; olivine melilitite
Mineralogical classification: e.g. monticellite; phlogopite; carbonate; serpentine</td><td rowspan="2">Coherent: [descriptors] coherent kimberlite (CK)</td><td>Intrusive: [descriptors] intrusive coherent kimberlite (ICK)</td><td>e.g. hypabyssal (HK); intra-crater; intra-diatreme</td></tr>
<tr><td>Extrusive (effusive): [descriptors] extrusive coherent kimberlite (ECK)</td><td>e.g. lava lake; welded; agglutinated spatter</td></tr>
<tr><td rowspan="3">Volcaniclastic: [descriptors] volcaniclastic kimberlite (VK)</td><td>Pyroclastic: [descriptors] pyroclastic kimberlite (PK) <u>or</u> [descriptors] kimberlitic [standard pyroclastic rock name]</td><td>e.g. fall; flow; surge; column collapse; fluidised diatreme zone</td></tr>
<tr><td>Resedimented Volcaniclastic: [descriptors] resedimented volcaniclastic kimberlite (RVK) <u>or</u> [descriptors] kimberlitic [standard sedimentary rock name]</td><td>e.g. debris flow; grain flow; avalanche; turbidite; lacustrine</td></tr>
<tr><td>Epiclastic (EK) or Kimberlitic Volcanogenic Sediment (KVS)</td><td>Use standard terminology</td></tr>
<tr><td>Example names: glacial boulder; outcrop sample; drillcore intersection bounded by sharp parallel contacts</td><td>Example names: fresh, uniform, xenolith-poor, medium-grained, olivine macrocryst-rich rock; intensely serpentinised, massive, xenolith-rich, fine to medium grained, olivine-poor rock</td><td>Example names: olivine macrocryst-rich carbonate phlogopite monticellite kimberlite; phlogopite leucite lamproite; olivine macrocryst-poor phlogopite orangeite</td><td>Example names: xenolith-poor, flow zoned, variably macrocrystic CK; xenolith-rich, well bedded VK</td><td>Example names: uniform ICK; bedded PK; olivine-rich kimberlitic lapilli tuff; xenolith-dominant Wesselton-type VK (WVK); inhomogeneous RVK; well-sorted olivine-rich kimberlitic sandstone; kimberlitic mudstone</td><td></td></tr>
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STAGE 1 - BACKGROUND INFORMATION

The scheme is applied to distinctive lithological units or samples and Stage 1 establishes the background information for the rock in question.

STAGE 2 - ROCK DESCRIPTION

Provides a systematic framework for the description of the rock with a progressive decrease in scale of observation (mega-, macro- to microscopic).

ALTERATION

The aim is to establish the original nature of the rock but some understanding of the alteration is required to assess the degree of confidence of interpretations.

Parameter	Comments / Examples
Intensity	subtle, weak, moderate, strong, intense, complete
Distribution	pervasive, patchy, veins, vein-like, vein-haloes, contact zone, xenolith halo
Replacement mineralogy	serpentine, carbonate, magnetite, chlorite, clay minerals, talc, quartz, sericite
Replacement texture	imposed texture resulting from alteration / replacement of primary material, e.g. pseudomagmaclastic texture, pseudocoherent texture, post-consolidation breccias
Timing	sequence of alteration, e.g. replacement of deuteric serpentine by clay minerals in response to weathering
Preservation of mineralogy and texture	degree of preservation, e.g. poorly preserved mineralogy but enhanced original textures
Wall-rock / xenolith reaction	degree and type of modification of mineralogy and texture through interaction of kimberlite with country rock and/or xenoliths, e.g. halo of clinopyroxene and phlogopite.

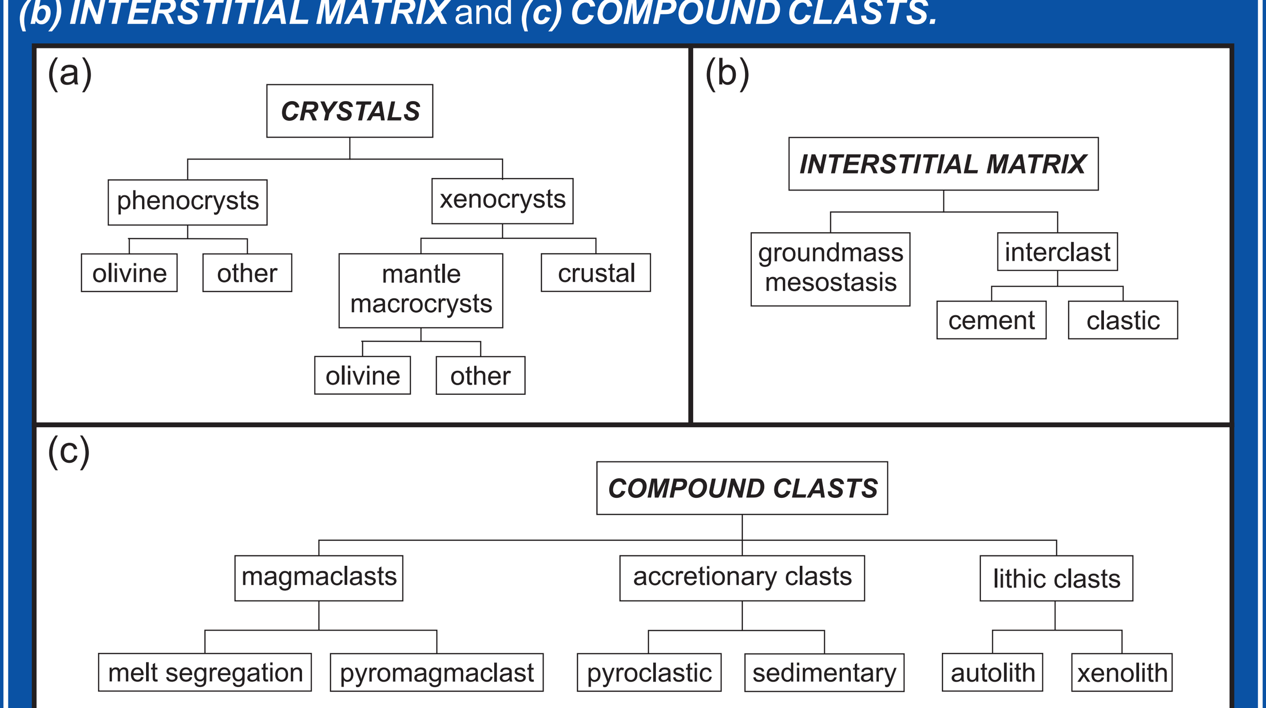
STRUCTURE

Structure encompasses the megascopic features or internal organisation.

Category	Examples
Non-genetic general	massive, structureless, homogeneous, inhomogeneous, monotonous, chaotic, layering, fabric, clast alignment
Coherent rocks	flow banding, flow zoning, cooling contraction joints
Volcaniclastic rocks, mainly depositional features	stratification, bedding (which can be qualified with more descriptors such as thick, thin, laminated, diffuse, vague, distinct, sharp, planar, graded), sorting, slumping, bomb sags, flame structures, imbrication, erosional structures (e.g. scour), cross-bedding
Post-emplacement	welding, jointing, foliation, fluid/gas escape structures, flattening, mud-cracks, compaction
Contact-related	in situ jig-saw fit breccia

COMPONENTS

The components are divided into three main classes ***(a) CRYSTALS***, ***(b) INTERSTITIAL MATRIX*** and ***(c) COMPOUND CLASTS.***



Two new terms *pyromagmaclast* and *pyrocryst* distinguish melt-bearing and melt-free pyroclasts, respectively. Pyrocrysts are discrete crystals liberated from the magma by pyroclastic processes; other types of melt-free crystals are hosted by subsurface juvenile fluids or are liberated during reworking.

COMPONENTS *continued*

CRYSTALS (a)

Crystals are those observable by the unaided eye or under a binocular microscope. New size and abundance descriptors apply to all crystals, regardless of the nature or origin of the rock. Different descriptors can be used for different crystal types within the same rock. Abundance descriptors can be applied to the general crystal content or, preferably, to specific crystal types (e.g. olivine-rich). Olivine macrocryst is synonymous with "macrocryst-rich". Aphanitic describes coherent rocks free of macrocrysts. Further interpretation of crystals includes paragenesis and modes of occurrence.

CRYSTAL SIZE DESCRIPTORS

Size (mm)	Descriptor	Abbreviation
<0.125	ultrafine	uf
0.125-0.25	superfine	sf
0.25-0.5	very very fine	vvf
0.5-1	very fine	vf
1-2	fine	f
2-4	medium	m
4-8	coarse	c
8-16	very coarse	vc
>16	ultracoarse	uc

CRYSTAL ABUNDANCE DESCRIPTORS

Percentage	Descriptor
0	[crystal]-free
0 – 1	very-[crystal]-poor
1 – 15	[crystal]-poor
15 – 50	[crystal]-rich
50 – 75	very-[crystal]-rich
> 75	[crystal]-dominated

Olivine (commonly pseudomorphed): should be considered first. It is important to distinguish between the two sub-populations (i) phenocrysts (crystallised from the kimberlite magma) and (ii) macrocrysts (derived from mantle peridotite). Variations on these generalisations do occur.

DISTINGUISHING OLIVINE MACROCRYSTS AND PHENOCRYSTS IN KIMBERLITES

Feature	Macrocryst	Phenocryst
Typical size range	>0.5 - 10 mm	< 0.5 mm
Maximum size	generally ~ 20 mm	~ 1.5 mm
Shape	anhedral rounded	simple euhedral-subhedral
Mono or polycrystalline	mixed	monocrystalline
Deformation features	present undulose extinction deformation lamellae neoblasts	absent
Inclusions	garnet, clinopyroxene, spinel, rutile, millerite	uncommon rutile
Associated minerals	garnet, clinopyroxene, spinel, ilmenite, phlogopite, rare opx	phlogopite, spinel
Origin	mantle xenocryst	melt crystallisation

Crystals other than olivine: Other phenocrysts are seldom abundant in kimberlites but a wide range of minerals occur in related rocks. Other macrocrysts (e.g. pyrope garnet, chrome diopside) are xenocrysts derived mainly from mantle peridotite, eclogite and the megacryst suite (used here in petrogenetic sense; commonly >10 mm). For descriptive purposes megacrysts are termed macrocrysts with appropriate size descriptor modifiers. Crustal xenocrysts derive from the country rock or surface deposits.

COMPOUND CLASTS (c)

Compound clasts (assemblages of crystals) include: accidental lithic clast inclusions of pre-existing rocks (*xenoliths* - country rock; *autoliths* - previously consolidated kimberlite), *magmaclasts* (physically distinct, fluidal-shaped bodies of solidified magma comprising former melt plus any entrained solids and fluids) and *accretionary clasts* (clastic aggregates of fine-grained volcanic and/or non-volcanic constituents). The non-genetic term magmaclast is replaced, where possible, by more specific terms: melt segregation or pyromagmaclast. New size and abundance descriptors are applied to xenoliths. Breccia is used to describe rocks formed by a particular brecciation process rather than rocks that contain >15 % xenoliths.

XENOLITH SIZE DESCRIPTORS

Size (cm)	Descriptor	
< 1		microxenolith
1 - 10	small	macroxenolith
10 - 100	large	macroxenolith
100 - 500	small	megaxenolith
500 - 2500	medium	megaxenolith
> 2500	large	megaxenolith

XENOLITH ABUNDANCE DESCRIPTORS

Percentage	Descriptor
0	xenolith-free
> 0 - < 15	xenolith-bearing
15 - 50	xenolith-rich
50 - 75	very xenolith-rich
>75	xenolith-dominated

INTERSTITIAL MATRIX (b)

Interstitial matrix (not confined to clastic material) occurs between crystals and/or compound clasts and includes *groundmass* (fine-grained minerals or material which consolidate from the late-stage melt in coherent kimberlites and within magmaclasts), *mesostasis* (the final fraction of melt to consolidate) and *interclast matrix* (crystalline cement, clastic or other material occurring between magmaclasts, discrete crystals or other clast types).

TEXTURE

Texture summarises the physical characteristics and arrangement of, or relationships between, the components in a rock and includes: grain size (e.g. inequigranular, macrocrystic, porphyritic, aphanitic), groundmass crystallinity (e.g. glassy, holocrystalline, welded, vesicular), grain rounding, component distribution, fabric, size distribution (e.g. poorly-sorted, normally-graded), packing density (e.g. closely packed) and framework type (e.g. grain-supported, groundmass-supported, clast-supported, matrix-supported, matrix-poor).

DESCRIPTIVE ROCK NAME

The Descriptive Rock Name, essentially a lithological classification, highlights the significant and characteristic features of the rock without further interpretation.

STAGE 3 - PETROGENETIC CLASSIFICATION

Parental Magma Type (rock type e.g. kimberlite, lamproite): uses characteristic mineral assemblages (Scott Smith et al., in prep.). If not possible, then "rock" or other non-specific name is used. ***Mineralogical Classification:*** subdivides rocks of one parental magma type using the main constituent minerals or their pseudomorphs, listed in the order of increasing modal abundance. The resulting terms are combined into a ***Petrogenetic Classification Name***.

STAGE 4 - TEXTURAL-GENETIC CLASSIFICATION

When possible, Stage 4a assigns a rock to one of two broad categories, coherent or volcaniclastic, involving basic genetic interpretation with flexible descriptive prefixes. When there is sufficient evidence, Stage 4b involves more detailed classification of the type of coherent or volcaniclastic rock.

COHERENT KIMBERLITE

Stage 4a: The standard volcanological term coherent replaces "magmatic" to describe rocks formed by the solidification of magma which has not been fragmented by volcanic processes and includes rocks with segregationary textures. **Stage 4b** subdivides coherent rocks into two main categories: *intrusive* or *extrusive*. Intrusive coherent kimberlites include non-volcanic or subvolcanic hypabyssal and higher level late-stage intrusions into unconsolidated volcaniclastic material for which the term "hypabyssal" might not apply.

VOLCANICLASTIC KIMBERLITE

Stage 4a: Volcaniclastic is a general non-genetic term for rocks composed of a substantial proportion of volcanic particles, and is preferred to "fragmental" (which has many meanings). **Stage 4b:** Volcaniclastic rocks are subdivided into three categories: *pyroclastic* (from explosive volcanic eruptions), *resedimented volcaniclastic* (from sedimentary re-deposition of unconsolidated pyroclastic and other near-surface materials) and *epiclastic or kimberlitic volcanogenic sediment* (from consolidation of components produced from pre-existing volcanic rocks). Alternative approaches to the naming of clastic rocks are (i) pyroclastic, resedimented volcaniclastic, epiclastic kimberlite, or (ii) using standard volcanological and sedimentological rock names prefixed by the magma type. Most of the criteria of both Clement and Skinner (1985) and Field and Scott Smith (1998) continue to be applicable. One specific distinctive textural variety of volcaniclastic kimberlite which appears to have no counterparts in common volcanic rocks is *"tuffisitic kimberlite"*, an inappropriate term. Finding a suitable replacement term has proven problematic. Here we suggest *Wesselton-type volcaniclastic kimberlite* (WVK). Wesselton Mine in Kimberley, South Africa is a well-studied type area for both holocrystalline and tuffisitic kimberlite.

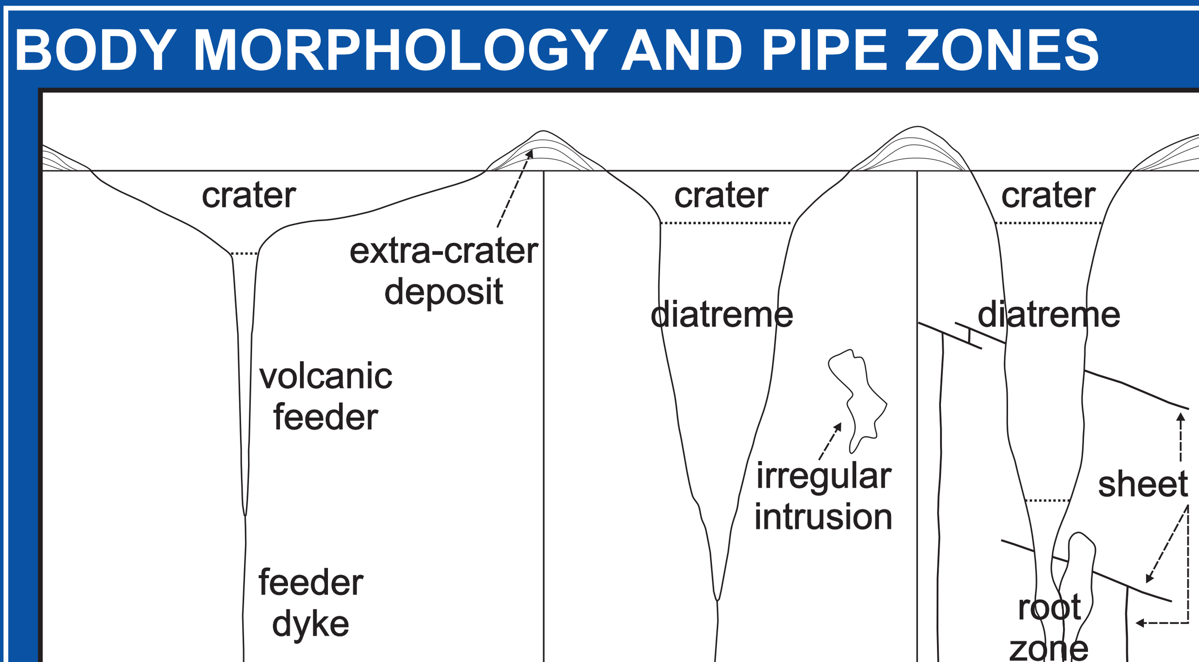
TEXTURAL-GENETIC ROCK NAME

Different levels of textural-genetic rock names combine the results of Stages 4a and 4b and use the same descriptors as the Descriptive Rock Name.

STAGE 5 - GENETIC / PROCESS INTERPRETATION

Advanced interpretation of the rock formation process is achieved by integrating the detailed information obtained in Stages 1 to 4. Due to the unusual characteristics of kimberlite magmas certain unique kimberlite-specific deposit types occur and the focus on subsurface rocks can be expected to reveal processes and products that are not well-known.

BODY MORPHOLOGY AND PIPE ZONES



Kimberlite bodies comprise volcanic pipes, extra-crater deposits, tabular (dykes, sill) and irregular or plug-like intrusions. Pipe zones (crater, diatreme, root) describe the morphology and relative vertical location of a portion of the pipe and not the type of infill or process of formation. The term diatreme is restricted to describing the steep-sided portion of a pipe that can occur between a crater and any root zone, irrespective of the nature of the infill.

APPLICATION

The scheme focuses on important descriptive criteria that permit reliable and relevant application, potentially by geologists that are not necessarily kimberlite experts. It is very important that each stage of the scheme is applied only if the nature of the rock and the scale of observation permits. The level to which the scheme can be applied, and thus the degree of confidence in the outcome, depends on the nature of the rocks, the experience of the user with these rock types and the level of detail of the investigation. Understanding the different and varying degrees of confidence in the conclusions is important, particularly in the economic application of the results. Although primarily descriptive, Stage 2 does require a broad understanding of these rock types, particularly the identification of the primary components. It is important to note that geological models can be established using Stages 1 and 2, without the further interpretation in Stages 3 to 5. Further accurate interpretations will significantly improve the degrees of confidence in the geological models as well as in the predictions of diamond distributions. Importantly, the scheme should be applied together with Scott Smith et al., (2008, in review and in prep.) and any update of this poster.

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