An Excerpt of

A Glossary of Kimberlite and Related Terms

Barbara H. Scott Smith, Tom E. Nowicki, J. Kelly Russell, Kimberley J. Webb, Roger H. Mitchell, Casey M. Hetman and Jock vA. Robey

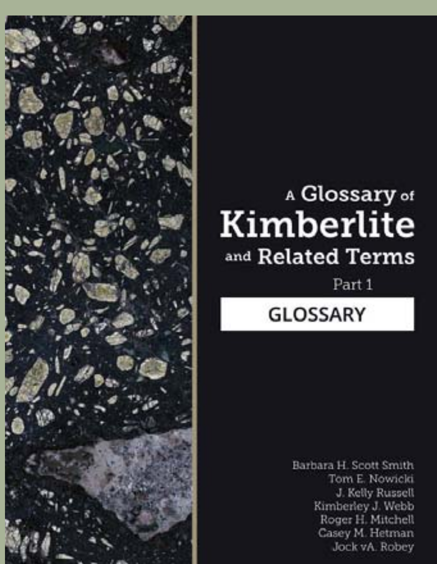
The Glossary is a comprehensive handbook for geologists in both the diamond industry and academia. The three-part Glossary, with summary figures, tables and guidelines, presents a standardised approach and nomenclature scheme for the investigation of kimberlites (and related rocks) during diamond exploration, evaluation and mining.

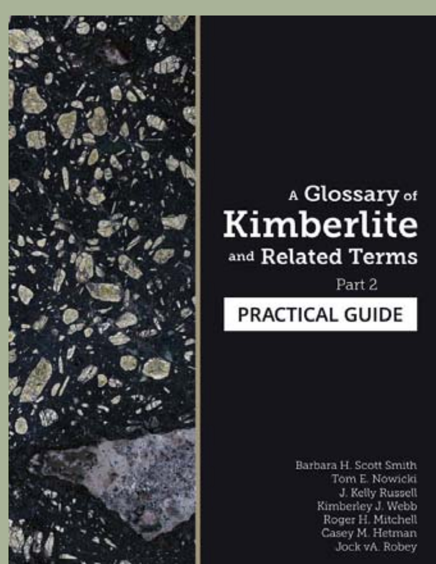
This 59 page excerpt provides a preview of the contents of each of the three parts of the 259 page Glossary as outlined below.

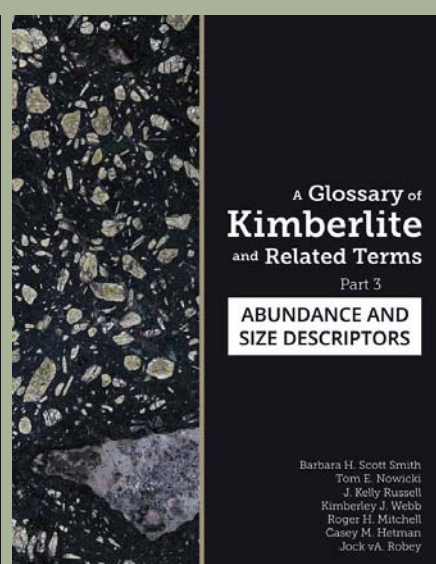
Part 1 The Glossary Excerpt (29 pages including front cover and inside front cover)
- Introduction (4 pages)
- Glossary - Table of Contents (14 pages) which is a list of all the defined terms
- Glossary - Examples Pages (9 pages) illustrating the format of the information presented for each of the 343 terms covered. Each term typically includes three sections: Definition, Recommendation and Further Clarification. This excerpt includes seven terms starting with *kimberlite* followed by *kimberlite alteration, kimberlite body, kimberlite body morphology, kimberlite breccia, kimberlite clan* and *kimberlite component*.

Part 2 Practical Guide Excerpt (18 pages including front cover)
- Introduction (3 pages)
- Tables 1 to 3 (7 pages)
- Figure 1 (2 pages)
- Glossary Subset Index (4 pages)
- Definitions – first page (1 page)

Part 3 Abundance and Size Descriptors Excerpt (16 pages including front cover)
- Introduction (2 pages)
- Index (1 page)
- Abundance and Size Descriptor Summary Guides
  - Index (1 page)
  - Example Summary Guide Table and Figures (11 pages)







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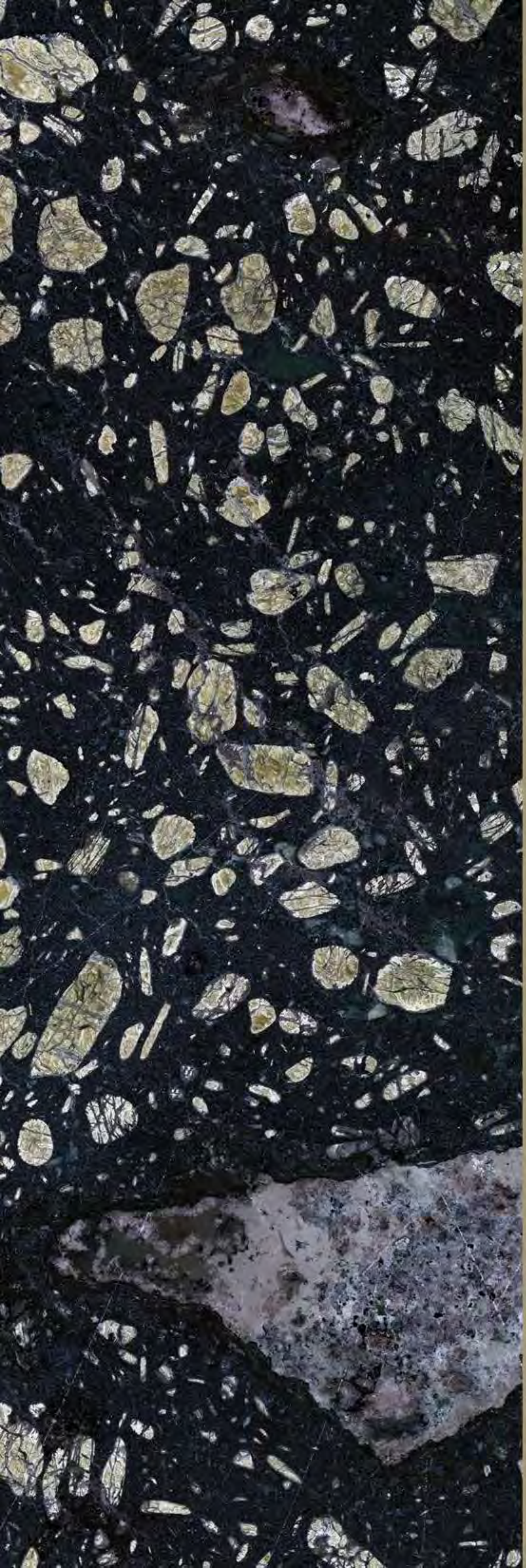

A Glossary of Kimberlite and Related Terms

Part 1

GLOSSARY

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Front Cover Photograph: polished slab of a typical xenolith-poor coarse macrocrystic hypabyssal kimberlite. Olivine macrocrysts form 25-30 modal % of the rock, range in size up to 10 mm and have been completely pseudomorphed by serpentine-like minerals resulting from deuteric replacement processes. The mineralogy of both the angular country rock basement xenolith and the surrounding kimberlite halo have been modified by reaction between the xenolith and the host magma prior to solidification. The dark grey interstitial matrix comprises fine grained melt crystallisation products including olivine microphenocrysts and groundmass minerals. Sample 3108 derives from an intrusive kimberlite unit Kimb3c that cross cuts the pipe-fill of the 640 Ma. Renard 3 pipe, Renard Mine, Quebec, Canada mined by Stornoway Diamond Corporation (Muntener and Scott Smith 2013). This unit has a global grade of 230 carats per hundred tonnes. The pipe-fill comprises Kimberley-type pyroclastic kimberlite (formerly tuffisitic kimberlite) and related textural types. Renard 3 forms part of the Renard Indicated Mineral Resource (106 carats per hundred tonnes). Sample courtesy of Stornoway Diamond Corporation.

Part 1 – GLOSSARY

Quote (Himus 1954)

"It is a common accusation that geologists, in common with other scientists, are guilty of inventing and using a barbarous and repellent jargon which is incomprehensible to the man in the street and may even be adopted as a protection against criticism.

The purpose of this dictionary is to interpret the special language of geology to the general reader, in the hope that, with its aid, he may be able to ascertain the meaning of geological terms when reading scientific literature, and may even be induced to enter on the study of this very fascinating science.

Many of the entries are short articles rather than definitions; the unfamiliar nature of the subjects rendered this necessary."

Introduction

Nomenclature for kimberlites was introduced shortly after their discovery in South Africa in 1869. The term *kimberlite* was coined by Lewis (1887, 1888), and the term *tuff* was applied to kimberlites by Cohen (1872). This was followed with terminology proposed in significant early contributions by authors such as Wagner (1914) and Williams (1932). Subsequent important advances were made by Dawson (1962, 1971b, 1980), Mitchell (1970, 1986, 1995a), Hawthorne (1975), Clement and Skinner (1985) and Field and Scott Smith (1998). Each publication built on the previous work. Much of this work was undertaken by, or in collaboration with, the De Beers Kimberlite Petrology Unit and was based on the investigation of many diamond mines across southern Africa and elsewhere. As the complexities and diversity of kimberlites were gradually recognised, the previous terminology was adapted but found in many aspects to be unsatisfactory.

Problematic aspects of the above described terminology resulted from several factors:

- kimberlites and related rocks have attributes that are not adequately addressed by standard igneous petrological or volcanological terminology;
- terms were inconsistently applied and in some cases misused;
- standard terminology does not adequately account for many aspects known to be important in exploration and mining kimberlites for diamonds resulting in industry-specific nomenclature that was not widely understood or accepted; and
- the historical terminology was based on the particular varieties of kimberlite known prior to the late 1980's which were prevalent in the mines of the type area Kimberley, South Africa and elsewhere (i.e. Kimberley-type pyroclastic kimberlite, formerly termed tuffisitic kimberlite, and associated root-zone hosted hypabyssal kimberlite); that terminology was inadequate for description and classification of other varieties of kimberlite that were recognised following the discovery of many kimberlite provinces across Canada between 1988 and 1991 (Fort à la Corne in Saskatchewan, Attawapiskat in Ontario, Mountain Lake in Alberta, Lac de Gras in Northwest Territories).

As a consequence of these Canadian discoveries it became apparent that a rationalisation of kimberlite terminology was necessary. This process is described in the section on Glossary Development below. The results of the rationalisation are presented by Scott Smith et al. (2013) and in this Glossary. These documents build upon the previous work discussed above.

A separate approach to revising kimberlite terminology was proposed by Cas et al. (2008b, 2009). This provides a useful framework for the description of kimberlite and aspects of that approach have been adopted for the revised nomenclature proposed by Scott Smith et al. (2013) and outlined in detail in this Glossary. However, in the opinion of the authors of this Glossary, the proposed approach does not address a number of key problems with kimberlite terminology. Kimberlites do require some specialised terminology to cater for the unique properties of kimberlite magmas and to address the particular demands of diamond exploration and mining. In addition, a critical practical limitation of the approach proposed by Cas et al. (2008, 2009), reflected also in previous published volcanological nomenclature (e.g. Cas and Wright, 1987; McPhie et al., 1993), is that the descriptive terminology to be applied is contingent on an initial textural subdivision into coherent or volcaniclastic facies. Further description of the deposit or rock depends upon this initial facies assignment and if this is changed after additional investigation, the original descriptors need to be replaced. Our experience is that the subdivision of kimberlite into either coherent or volcaniclastic commonly requires detailed investigation and, in some instances, may not be possible with any acceptable degree of confidence. On this basis, the textural-genetic classification is considered by Scott Smith et al. (2013) as a later stage in the rock naming process and the proposed descriptive nomenclature, as presented in this Glossary, is independent of such classification.

The Glossary

The Glossary consists of 343 terms (~66,000 words) presented in alphabetical order, each with a definition, a recommendation; in many cases a detailed further clarification and, where relevant, tables and figures. The Glossary includes commentary on most of the previously utilised terms and recommends that a number of these terms be discontinued, especially certain historical kimberlite-specific terms. Each definition is intended to be as simple and pragmatic as possible.

Terms that are recommended for kimberlites which are not in general use include the following:

Fort à la Corne-type pyroclastic kimberlite
Kimberley-type pyroclastic kimberlite
kimberlite indicator mineral
kimberlitic compound clast
liberated pyroclast
macrocryst / macrocrystic
macrophenocryst / macroxenocryst
magmaclast / magmaclastic kimberlite
megacryst / megacrystic
melnoite
microcryst / microcrystic
microphenocryst / microxenocryst
phase of kimberlite
pyrocryst
related rock

Terms for which the Glossary provides kimberlite-specific definitions or applications include the following:

abundance descriptors for crystals and magmaclasts
abundance descriptors for olivine macrocrysts
abundance descriptors for xenoliths (and autoliths)
accretionary clast
crystals
compound clast
diatreme zone
epiclastic kimberlite
epiclastic volcaniclastic kimberlite
internal geology of a kimberlite body
kimberlite
kimberlite body
kimberlite body morphology
kimberlite clan
kimberlite component
kimberlite pipe
kimberlite rock description
kimberlitic
kimberlitic compound clast
kimberlitic sediment
magmatic melt segregation

melt-bearing pyroclast
mineralogical classification
olivine crystal
pyroclastic kimberlite
resedimented volcaniclastic kimberlite
resedimented Fort à la Corne-type pyroclastic kimberlite
resedimented Kimberley-type pyroclastic kimberlite
root zone
size descriptors for crystals and magmaclasts
size descriptors for xenoliths (and autoliths)
volcaniclastic kimberlite.

Some underutilised terms include the following:

alloclastic breccia (applies to country rock breccias)
endomorphism (applies to country rock assimilation)
tephra (a general term for all volcanic ejecta).

The focus of this Glossary is kimberlite, the most common type of primary diamond deposit. The same concepts, but not always the details, are applicable to other diamond-bearing rocks such as lamproite.

To assist with the practical application of the terms defined in the Glossary and the nomenclature Scheme, this Glossary of Kimberlite and Related Terms comprises three stand-alone parts:

Part 1 *Glossary* – presents the complete Glossary, bibliography and references;

Part 2 *Practical Guide* – provides practical guidelines for the investigation of kimberlites and includes abbreviations for cumbersome terms, and a subset of the Glossary;

Part 3 *Abundance and Size Descriptors* – provides detailed guidelines for the application of kimberlite-specific descriptors for the main components in kimberlites.

Glossary Development

Kimberlites have magma properties (e.g. low viscosity, volatile-rich, crystal-rich) which result in the formation of unusual rocks with characteristics particular to kimberlites. Their characterisation and economic assessment requires special attention by geologists with extensive experience of the petrography of these rocks. Thus, a working group of diverse economic and academic kimberlite specialists, including petrologists and a volcanologist, was formed in 2004. The goal of the working group was to align kimberlite nomenclature and description with terms used in mainstream geology, while maintaining terminology that is applicable to the economics of diamond deposits. The first contribution of the working group was an improved, rationalised and staged approach to kimberlite terminology and classification which was presented as practical systematic framework, or nomenclature Scheme, by Scott Smith et al. (2013). The Scheme was based on earlier versions of this Glossary. The Glossary however required further development to achieve the intended meaningful, internally consistent and long-lasting conclusions.

In the spirit of Himus (1954, see quote above), the intent of this nomenclature and the Glossary is: (i) to be workable, particularly with respect to the economic assessment of kimberlites; (ii) to have a broader application to users who are not specialists; (iii) to clarify kimberlite features using improved terminology; (iv) to lead to more standardised description of kimberlites; (v) to support more reliable interpretations based on more accurate observations; and (vi) to promote better communication thereof. The main steps in the development of the Glossary are outlined below.

Step one was the selection of a number of published sources (2007 and earlier) which provide previous definitions of standard terms. This included a number of widely-used general dictionaries, plus standard geology, igneous petrology and volcanology texts listed in Bibliography. A wide spectrum of relevant terms was investigated, and many of these terms are included in the Glossary. The terms investigated, however, were not exhaustive. For example, features in rocks formed in subaqueous environments were not included because they have not been widely recognised in kimberlites. Other sources were used to provide further explanation and historical clarification especially of kimberlite-specific terms. Where available, multiple definitions for all selected, and many related terms, were compiled verbatim into a single document.

Step two had the intention of merging the multiple definitions for single terms in the above compilation attempting to retain as much of the previous definitions as possible without adding bias. Somewhat surprisingly, the definition merging process was not straightforward and not very successful. The multiple definitions for one term were not only diverse but also inconsistent, incomplete, out of date, or in some cases appeared incorrect.

Step three involved significant further research into many terms and their history which, in many cases, required discussions with relevant specialists. An important part of the process proved to be the extensive debate among the working group to arrive at a modified definition for each term attempting, as far as possible, to be consistent with modern standard terminology (e.g. general geology, volcanology, igneous petrology). The Glossary includes terms and definitions for which all the authors are in general agreement, although in a few cases some compromise was required. Interestingly, many of the more contentious terms were not kimberlite-specific terms (e.g. breccia, matrix). It also became evident that kimberlite and volcanological terminology were evolving simultaneously. In addition, there is limited consensus in volcanological terminology, as illustrated by the considerable differences between definitions given in published glossaries of volcanology. Further, recent nuances of many current volcanological terms were not readily available in standard dictionaries. This research also revealed some of the limitations inherent in the mainstream volcanological approach. These aspects affected the definitions of standard terms. Most of the recommended changes to the actual terms used, however, involved mainly kimberlite-specific features. Many of these kimberlite-specific changes were well-tested, sometimes over years, to ensure they were workable.

Step four required the development of non-genetic kimberlite-specific abundance and size descriptors which are relevant to the economics of kimberlites and applied to rocks irrespective of the textural-genetic classification (see Scott Smith et al. 2013). Standard size classes are generally different for igneous versus volcanic or for volcaniclastic versus coherent rocks.

Step five, when considered necessary, involved fine tuning definitions, providing recommendations for their application or not, and when applicable providing further clarification of their meaning, application and history. Importantly, it was also necessary to modify terms to ensure that the Glossary was internally consistent. At this stage other improvements were made using internet resources that had significantly advanced since the start of this working group. Explanatory tables and figures were also added where applicable.

Step six was the first published contribution of the working group by Scott Smith et al. (2013). This publication presented an overview of this rationalisation of kimberlite terminology and classification together with a practical, systematic framework, or nomenclature Scheme.

Step seven involved significant improvements to the previous version of this Glossary upon which Scott Smith et al. (2013) was based. Only one small but significant change from Scott Smith et al. (2013) was made to this Glossary. The important term macrocrystic is used to describe kimberlite with > 15 modal % olivine macrocrysts as per Field and Scott Smith (1998). The upper limit proposed by Scott Smith et al. (2013) has been removed.

Future work – Advancing a glossary such as this could be never-ending. Given that the Glossary development occurred over such a long period of time and was well tested, we hope that minimum modifications to the definitions will be required. Changes, however, may be necessary as a result of new discoveries or the evolution of terminology and understanding of kimberlite genesis and emplacement. Otherwise, our goal is to provide further support for this Glossary, for example, a digital version and summary guides (e.g. poster). Any updates will be made available at www.scottsmithpetrology.com.

GLOSSARY – Table of Contents

misused. Appropriate descriptors can be added to the term Kimberley-type pyroclastic kimberlite such as diatreme-fill and xenolith-rich. Most Kimberley-type pyroclastic kimberlites occur within diatreme zones but comparable deposits are found in the overlying crater, and can be referred to as crater-fill Kimberley-type pyroclastic kimberlite.

Further clarification: It has long been recognised that the terms tuffisitic kimberlite and diatreme-facies kimberlite are not appropriate but finding a suitable replacement has proven problematic. The previous suggestion for this Glossary of the term Wesselton-type volcaniclastic kimberlite (Scott Smith *et al.* 2008) was unpopular (see Further clarification of the latter term). The now more generally accepted term for this class of pyroclastic kimberlite is Kimberley-type pyroclastic kimberlite (Scott Smith *et al.* 2013), named after the kimberlites discovered and mined in the Kimberley area of South Africa. Kimberley is not only the type area for fresh archetypal holocrystalline kimberlite (Lewis 1887, 1888), but also for tuffisitic kimberlite (Clement 1982; Clement and Skinner 1979, 1985; Clement and Reid 1989). The Kimberley pipes in turn are broadly representative of pipes of other ages and in other areas of southern Africa and the world. This term is more appropriate than previous suggestions (e.g. Wesselton-type volcaniclastic kimberlite) as a replacement of tuffisitic kimberlite because: the locality is more widely known and its significance more generally understood; this class of pyroclastic kimberlite occurs in all the Kimberley pipes and thus a wider spectrum of geology is encompassed by the term; the information on Wesselton (Clement 1982; Clement and Reid 1989; Shee 1985; Mitchell *et al.* 2009) continues to be relevant; and the full term as well as the abbreviation (KPK) are more practical given that they are easier to pronounce.

kimberlite

Kimberlites are a group of volatile-rich (H_2O and CO_2 commonly up to or > 5 and 10 wt.%, respectively), potassic (low Na_2O/K_2O ratios < 0.5; < ~0.5 wt.% Na_2O; up to ~3 wt.% K_2O), ultrabasic, olivine-rich (~50 modal %), silica-undersaturated igneous rocks derived from a deep asthenospheric mantle source and typically exhibit a distinctive inequigranular texture resulting from the presence of macrocrysts (see below) set in a finer-grained matrix. The matrix to the macrocrysts consists of microphenocrysts of olivine and less common phlogopite and Mg-Cr-Ti-rich spinels set in a groundmass which might contain monticellite, phlogopite-kinoshitalite solid solutions, perovskite, spinel, apatite, carbonate (calcite and/or dolomite) and serpentine. Feldspar, feldspathoids, clinopyroxene and amphibole are not typomorphic minerals and are not found in contamination-free kimberlites. The main features of kimberlite are described below.

The macrocrysts are dominated by olivine that typically has anhedral- to- round morphology and a wide range of sizes characteristically including coarse and very coarse crystals (up to ~10 mm, less commonly up to ~20+ mm). Olivine macrocrysts (mode of ~Fo_{90-94}) are a characteristic constituent of hypabyssal kimberlite, typically comprising ~25 modal % (see figure in Further clarification). In addition to olivine, other less common (< 1 modal %) but distinctive macrocrysts may be present; these include Cr-poor or Cr-rich pyrope garnet, Mg-ilmenite, Cr-spinel, Cr-diopside, other types of clinopyroxene, orthopyroxene (enstatite), phlogopite, zircon and diamond. Diamonds may, or may not, be present, but only as a very rare constituent. The macrocrysts are commonly monomineralic but may contain inclusions of other minerals belonging to the macrocryst suite and can display deformation features. Olivine macrocrysts may contain fine-grained neoblasts resulting from recrystallisation. Olivine macrocrysts can have overgrowths of olivine which crystallised from the kimberlite melt. Macrocrysts can generally be shown, or inferred, to be mantle-derived macroxenocrysts (> 1 mm) which range to smaller and less conspicuous microxenocrysts (≤ 1 mm). The xenocrysts originate from two main sources: peridotite (olivine-rich) and eclogite (olivine-free or olivine-poor). Megacrysts (*sensu stricto*; see megacryst) comprise a particular subset of mantle-derived macrocrysts present in some kimberlites. These crystals characteristically range up to very coarse or ultra coarse grain sizes (> 8 mm, commonly up to 50 mm and rarely larger). The megacryst suite includes olivine, garnet, ilmenite, Cr-diopside, orthopyroxene, zircon and phlogopite. These minerals have specific compositional features that indicate they are genetically and compositionally distinct from the commonly observed mantle rock types (peridotite and eclogite) and the xenocrysts derived therefrom.

The matrix to the macrocrysts (and megacrysts) consists of primary microphenocrysts and a finer-grained groundmass both resulting from crystallisation of the kimberlite melt. The microphenocrysts are dominated by olivine although they may include less common phlogopite and Mg-Cr-Ti spinels. Microphenocrystic olivine is an essential mineral of kimberlite and forms ~25 modal % of a typical hypabyssal kimberlite. The olivine microphenocrysts (mode of ~Fo_{87-91}) are usually monocrystalline with relatively consistent habits and sizes. They are commonly < 0.5 - ~1.0 mm in size and have simple euhedral-to-subhedral orthorhombic forsteritic habits seldom with multiple growth aggregates, acicular, skeletal, or hopper morphology. The microphenocrysts can have cores with different compositions that can be interpreted to indicate a mantle-derived xenocryst origin.

The groundmass interstitial to the macrocrysts and microphenocrysts is very fine-grained (mainly < 0.2 mm except for phlogopite laths in some instances) and composed of one or more of the following typomorphic primary minerals: monticellite, phlogopite-kinoshitalite solid solutions, perovskite, spinel (qandilite - Mg-chromite - ulvöspinel - magnetite solid solutions), apatite, carbonate (calcite and/or dolomite) and serpentine. Opaque spinels, commonly with atoll textures, and translucent brown perovskite are early-formed groundmass minerals occurring as subhedral to euhedral crystals. Monticellite occurs as colourless to pale-yellow anhedral-to-subhedral crystals (< 0.2 mm). Phlogopite commonly occurs as pale orange-brown to colourless euhedral-to-subhedral laths, with colourless phlogopite-kinoshitalite occurring as plate-like, late-stage crystals which commonly poikilitically enclose earlier-formed spinel and perovskite. Late-stage overgrowths of tetraferriphlogopite can occur. Apatite typically occurs as late-crystallising subhedral to euhedral laths and/or sprays of prismatic crystals. Groundmass carbonate occurs mainly as: (i) lath-like crystals co-crystallising with the main groundmass minerals and as (ii) a very late-stage mineral together with serpentine as an interstitial mesostasis throughout the groundmass or concentrated in pool-like fluid segregations. Late-stage serpentines are primary polygonal or Povlen serpentines (Mitchell 2013). Nickeliferous sulfides and rutile are common accessory minerals. The deuteric replacement of earlier-formed olivine, phlogopite, monticellite and apatite by serpentine and calcite is common. Deuteric serpentine pseudomorphing olivine is lizardite that is genetically-distinct from primary groundmass serpentine which is commonly polygonal serpentine. Feldspars and feldspathoids are not present in kimberlites. Clinopyroxene and amphibole are absent in uncontaminated kimberlites.

Evolved, fractionated, extreme or marginal members of the kimberlite petrological clan include for example rocks: (i) poor in, or devoid of, olivine and other mantle-derived macrocrysts, (ii) poor in olivine microphenocrysts, (iii) containing groundmass melilite and Mn-bearing ilmenite and/or (iv) rich in carbonates and polygonal serpentine. See Further clarification below for more details.

The presence of common and diverse xenoliths (and xenocrysts derived therefrom) is a characteristic feature of kimberlites. The xenoliths include (i) mantle-derived rocks (e.g. peridotite, eclogite), (ii) deep crustal rocks (e.g. granulites) and (iii) shallow crustal rocks in particular near-surface country rocks incorporated during emplacement. The reaction between the melt and crustal xenoliths can lead to magma contamination resulting in the crystallisation of non-typomorphic groundmass minerals (e.g. diopside, pectolite, amphibole).

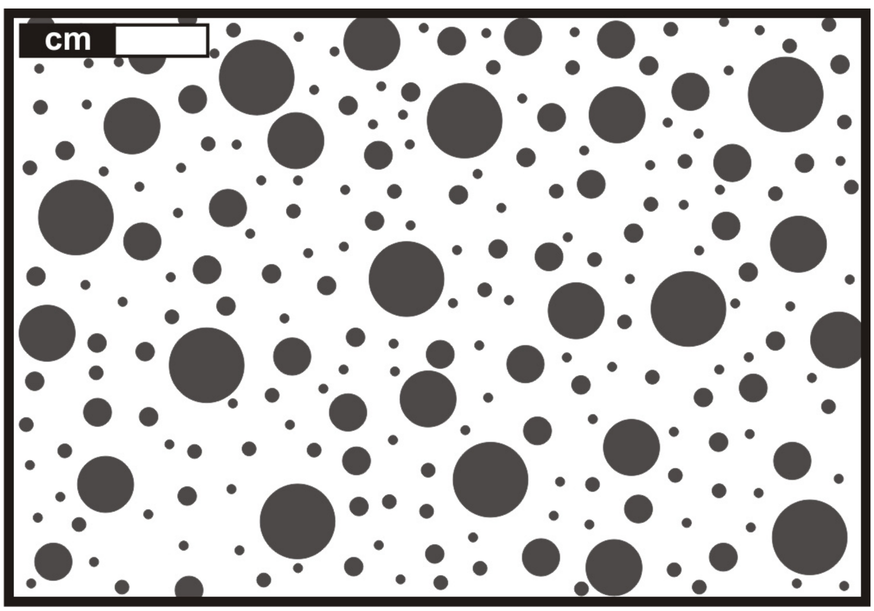
Kimberlites are post-tectonic intra-continental magmas, commonly occurring within Archaean cratons. Most kimberlite bodies are formed from multiple small volume batches of magma emplaced near surface as volcanic pipes and intrusive sheets (and less common plugs). Pipe infills include some kimberlite-specific textural-genetic types (e.g. Kimberley-type pyroclastic kimberlite). Many kimberlites are particularly susceptible to weathering, especially in tropical environments.

Recommendation: Appropriate use of this term following the definition above.

Further clarification: The term kimberlite (archetypal kimberlite) is based on rocks from the type area at Kimberley, South Africa. Following the discovery of alluvial diamonds near Hopetown in 1866, a prospector named Robinson heard of a farmer's wife who had found some 'pretty stones' on a farm named Du Toitspan some 30km east of the major Canteen Koppie alluvial dig at Barkly West. Suspecting these were diamonds, Robinson travelled in late 1869/early 1870 (date is uncertain) to the Du Toitspan farm and staked claims on what became the Du Toitspan kimberlite. This area that became known as the 'Dry Diggings' was rushed and the pipes of Bultfontein and De Beers were discovered in 1870. The Kimberley Mine (The Big Hole) was discovered in 1871 on the slopes of a hill on the Vooruitzigt Farm owned by the brothers Diederick and Nicolaas Johannes de Beer. Digging on the hill then named Colesberg Kopje started immediately. One year after digging started, the population of the camp of diggers grew to around 50,000 and this settlement became known as New Rush. The Secretary of State for the Colonies at that time found these names vulgar and insisted on a decent name for the new town growing up around the diggings. To accommodate his concerns, in 1873 the town was renamed after Lord Kimberley. Gradually the diggings got deeper and deeper and what is now known as the "Big Hole" developed. It was soon realised that the diamond host rocks were not alluvial deposits. As mining progressed (Kimberley Mine 1871 – 1914), the diamondiferous rocks were recognised as volcanic pipe infill. The term “kimberlite” was coined after the town of Kimberley to describe the “matrix to the diamond in this new type of deposit” (Lewis 1887, 1888). After petrographic investigation of fresher “hardebank” exposed at depth, the rock was described as serpentinised “porphyritic volcanic peridotite of basaltic structure” “dissimilar to any other known species” (Lewis 1887, 1888). Subsequently, two types of diamond-bearing rocks were recognised in the general area and initially termed basaltic and micaceous kimberlites (Lewis 1887, 1888; Wagner 1914). These rock types were later referred to as Group 1 and Group 2 kimberlites, terms introduced by Smith (1983) on the basis of the isotopic composition of the rocks, and subsequently entrenched in petrological literature by Smith *et al.* (1985), Skinner (1989) and Woolley *et al.* (1996). It is now known that Group 1 and 2 kimberlites are genetically-distinct parental magma types, i.e. separate petrological clans. The terms Group 1 and 2 kimberlite should be replaced at least by the terms kimberlite and orangeite, respectively (see orangeite; Mitchell 1995a). Preferably Group 2 kimberlite and orangeite should be replaced by the proposed term lamproite (var. Kaapvaal); for further details see: orangeite; lamproite; metasomatised lithospheric mantle magmas). The term kimberlite has been retained here and used as originally defined (Lewis 1987, 1988) with Kimberley as the type area and excluding orangeite. The hybrid nature of kimberlites precludes geochemical-based definitions. Detailed petrographic-based investigations are required because of the mineralogical complexity, the presence of common and characteristic entrained xenocrysts and the difficulties distinguishing them from primary minerals, widespread deuteric mineral replacement and common magma contamination. The above definition, or characterisation, of kimberlite is modified from Dawson (1971a), Clement *et al.* (1977, 1984), Mitchell (1986, 1995a, 1997) and the IUGS definition of Group 1 kimberlite as given by Woolley *et al.* (1996). Kimberlites are best identified using the typomorphic assemblage of primary minerals referred to in the above definition. This definition is strictly applicable only to holocrystalline coherent kimberlite and is more difficult to apply to volcaniclastic kimberlites which form from kimberlite magma that has been variably transformed by explosive volcanic and resedimentation processes and which in many cases bears no resemblance to kimberlite *sensu stricto*. Uncontaminated hypabyssal kimberlites are the most representative of the near surface pre-emplacement kimberlite magma. Plutonic kimberlites have not been recognised (see coherent kimberlite).

When attempting to identify kimberlite, it is very important to recognise that not all of the typomorphic minerals will necessarily be present, or evident by standard optical petrographic methods, in a single sample. Thus, examination of a suite of rocks is typically required before conclusive identification as kimberlite can be made. Because of the typical fine-grained character of the groundmass, the use of X-ray energy dispersive spectroscopy (EDS) and back-scattered electron (BSE) imagery is useful to distinguish kimberlites from petrographically superficially-similar related rocks and lamprophyres (Mitchell 1995b). It is also important to distinguish Cr-diopside macrocrysts from primary groundmass diopside as typical uncontaminated kimberlites do not contain the latter. When diopside (and/or pectolite) is present in the groundmass of hypabyssal kimberlite (*sensu stricto*) it is a ‘pseudo-primary’ mineral, the crystallisation of which is undoubtedly induced by the assimilation of siliceous xenoliths. Other minerals not typically found in kimberlite can also result from xenolith digestion and resulting magma contamination. Nepheline, feldspar, leucite and amphibole do not occur as primary minerals in kimberlites. Pseudomorphs after melilite occur in some *bona fide* hypabyssal kimberlites (e.g. Skinner *et al.* 1999) and in melt-bearing pyroclasts in some volcaniclastic kimberlites but melilite is not a typomorphic mineral of hypabyssal kimberlite. Only hypabyssal kimberlites have been extensively investigated regarding their mineralogy. The diversity of opinion and understanding of the nature of kimberlites as well as the inappropriate application of the term kimberlite have had unfortunate consequences. In particular many rocks have been termed kimberlite regardless of falling outside the range of characteristics exhibited by *bona fide* kimberlite. This has resulted in unwarranted scientific and economic implications, and thus confusion, regarding the nature of kimberlites. Failing to characterise rocks correctly has commonly resulted in significant exploration budgets being inappropriately used to investigate rocks of low diamond potential.

The above definition is based on representative worldwide hypabyssal kimberlites. The geographic distribution and age of emplacement of these occurrences show that kimberlite is a distinct parental magma which has been produced repeatedly in time (at least 55 – 1600 Ma.) and space (on most cratons worldwide) and is thus a petrological clan. Given that the original definition of kimberlite was “the matrix to diamond” and the diamond mines in Kimberley are the type area, it is economic kimberlites that are the representative type rocks and form the basis of the definition. The advantage of this approach is that if rocks under investigation fit the definition, they have the capacity to carry diverse amounts of diamond with the potential to be economic. If the rocks do not fit the above definition they may be either a more extreme variety of kimberlite with a lower potential to be economic or a related or unrelated rock type. Processes such as differentiation can produce diverse extreme or marginal varieties of kimberlite that do not fit the above definition. They may display petrographic overlaps with related rock types and less so with other more common rock types. Atypical features include: (i) macrocrysts which can be less common, finer-grained, differently shaped and/or comprising different minerals; (ii) olivine phenocrysts which can be coarser-grained and have more complex habits; and (iii) groundmass with coarser grain sizes and variations in the proportions of groundmass minerals. Further, the mineral assemblage is a direct reflection of the composition of the melt and more extreme varieties of kimberlite can result in the crystallisation of: (i) typomorphic minerals with different composition; (ii) increased proportions of certain typomorphic minerals (e.g. carbonate and/or serpentine); or (iii) additional minerals (e.g. melilite, clinopyroxene, Mn-ilmenite). Each comagmatic province usually contains typical kimberlites with the potential to be economic as well as other more extreme or marginal varieties with a lower economic potential. Petrological interest ratings based on the definition can be applied in the economic assessment of a province or even a single body. A key feature is the nature of the olivine (and other) macrocrysts. Diamondiferous hypabyssal kimberlites and extrusive coherent kimberlites have an average mode for olivine macrocryst abundance of ~25 modal % (schematically illustrated below where black circles mimic the characteristic round shape of olivine macrocrysts; after Figure 4 of Scott Smith *et al.* 2013). Greater abundances generally result from rheological concentration related to near surface emplacement processes.



kimberlite alteration

Alteration of kimberlite.

Recommendation: Appropriate use of this term. See also alteration. Alteration is one of the four main parts of Rock Description, Stage 1 of the Scheme of Scott Smith *et al.* (2013) for the description, classification and interpretation of kimberlites and related rocks, the others being structure, texture and components. Alteration should be considered at all scales: mega, macro- and microscopic. Alteration of each component and of the rock texture should be assessed.

Further clarification: Unlike many other mineral deposits, the description of alteration products is not the primary objective of most investigations of kimberlites and related rocks. The overriding intention of petrological investigations of kimberlite, especially during the evaluation of primary diamond deposits, is to determine the original nature of the rocks. Alteration processes and products can be significant complicating factors masking primary features and imparting variability that is not related to primary processes. Alteration affects the ability to determine the original structure, texture and components. Thus, some description and understanding of rock components resulting from alteration is necessary to assess the degree of confidence in the description, interpretation and classification of the original rock (Stages 1 to 3 of the Scheme of Scott Smith *et al.* (2013). Under certain circumstances, alteration can preserve and even enhance the visibility of primary textures, sometimes aiding in the interpretation of the original rock. The extent and nature of alteration has a major effect on the physical rock properties of kimberlite and, therefore, is very relevant to mine planning and mining (e.g. ore treatability, geotechnical and metallurgical properties, waste management) and can require detailed studies. Most of the widespread types of alteration processes (see Further clarification of alteration) are uncommon in kimberlites. Mineral replacement in kimberlites occurs mainly during (i) pre- or syn-emplacement deuteric alteration processes involving internal magmatic fluids (see deuteric); (ii) post-emplacement hydrothermal processes associated with external kimberlitic fluids from later degassing magmas or meteoric water heated by magmatic activity (see hydrothermal alteration); and (iii) weathering in response to surface processes and external non-kimberlitic fluids such as groundwater, the severity of which depends on the climate and original mineralogy of the rock (see weathering). The latter are well known processes (e.g. silicification, montmorillonite clay mineralisation). Compared to many other magma types, kimberlites are extremely rich in juvenile volatiles, in particular CO_2 and H_2O, at the time of emplacement. Consequently, deuteric serpentinisation and carbonatisation are common types of alteration (e.g. after olivine). Serpentine-rich kimberlites (including primary, deuteric and/or secondary serpentine) are particularly susceptible to clay mineralisation during weathering (e.g. yellow ground). Carbonate can dissolve but not weather and consequently kimberlites rich in primary or deuteric carbonate more commonly remain fresh. Alteration or modification of the mineralogy also results from interactions between the hot host magma and the country rock whether occurring as xenoliths or *in situ* at a contact (see endomorphism). The country rock can be partly or completely replaced. Varying degrees of reaction depend on the duration and degree of chemical disequilibrium and can lead to variable replacement mineralogy, sometimes occurring in ill-defined concentric zones. Reaction haloes commonly occur within the kimberlite at the interface with the country rock; compared to the unaffected kimberlite, haloes can display different mineralogy, mineral abundances or characteristics. The minerals commonly resulting from country rock-kimberlite reaction include clinopyroxene, pectolite and phlogopite. Clinopyroxene and pectolite are not primary minerals in uncontaminated kimberlites (Group 1 or archetypal kimberlites; clinopyroxene is a primary mineral in orangeites or Group 2 kimberlites). The following table summarises the main aspects of alteration and reaction, and parameters for their description.

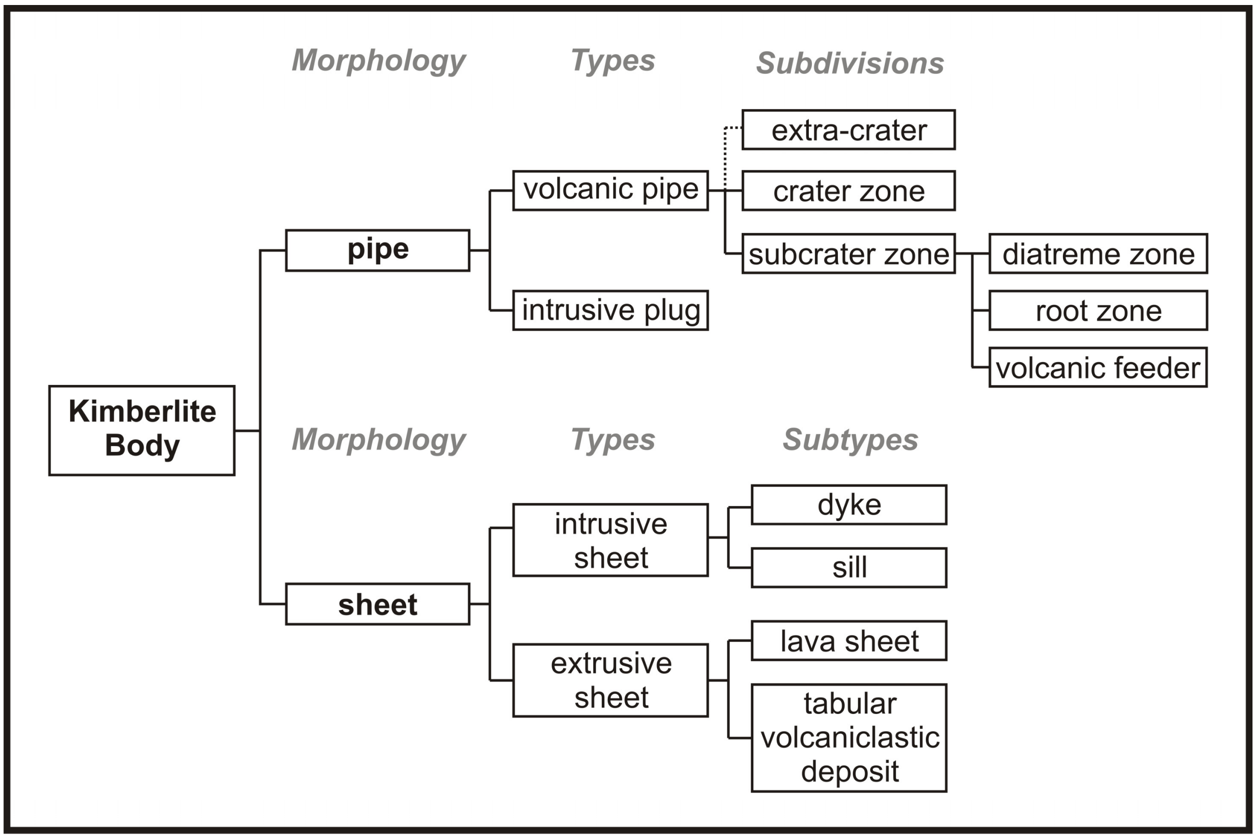
Parameters for Description of Kimberlite Alteration

Parameter	Comments / Suggested terms / Common examples
Intensity	subtle, weak, moderate, strong, intense, complete
Distribution	pervasive, patchy, veins, local 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 or xenolith and host magma interaction or reaction (endomorphism)	degree and/or type of modification of mineralogy and texture through interaction of kimberlite with country rock and/or xenoliths, e.g. concentrically metasomatised basalt xenolith with reaction halo of clinopyroxene and phlogopite.

kimberlite, basaltic - *see basaltic kimberlite*

kimberlite body

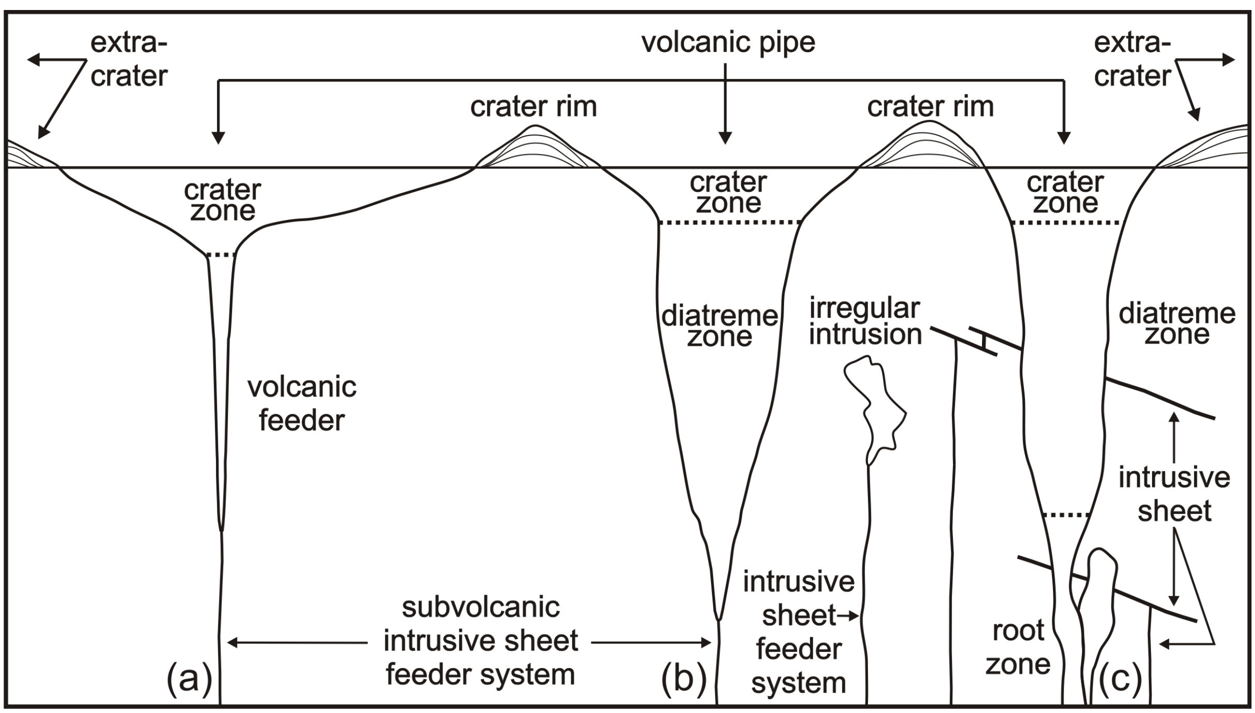
A general term applied to an igneous body or mass of kimberlite with no implied morphology or emplacement process. Kimberlite bodies comprise the erosional remnants of volcanoes and/or intrusions. Kimberlite bodies are subdivided based on their overall morphology into two main categories: (i) pipes and (ii) sheets (as illustrated below). Kimberlite pipes include volcanic pipes (formed by volcanic processes) and non-volcanic intrusive plugs. A volcanic kimberlite pipe can be subdivided into a crater zone and a subcrater zone, the latter including diatreme zone, root zone and volcanic feeder, one or more of which may be present (see pipe zone). Extra-crater deposits comprising crater rim and more distal deposits would have formed at the time of emplacement of volcanic pipes but are rarely preserved. Extra-crater deposits are associated with but do not form part of volcanic pipes. Most known kimberlite sheets are intrusions (see intrusive sheet). Intrusive sheets may occur as feeder systems to both volcanic pipes and intrusive plugs or occur separately and unrelated to pipes. Non-intrusive kimberlite sheets could include lava sheets and tabular volcaniclastic deposits, but documented examples are not common.



Recommendation: Appropriate use of this term. General descriptors of body shape can be added (see kimberlite body morphology). Stage 4 of the Scheme of Scott Smith *et al.* (2013) for the description, classification and interpretation of kimberlites and related rocks involves an assessment of the spatial relationship to, and morphology of, the kimberlite body from which the rocks under investigation derive. Examples are shown below. This requires larger-scale observations and is typically based on drilling and/or mapping information. Importantly, subdivisions of kimberlite bodies (e.g. pipe zones) should not be used to describe the type of infill or process of formation. See also volcanic pipe, kimberlite pipe, intrusive plug, sheet.

Further clarification: The table below provides a diagrammatic guide to kimberlite body and pipe zone terminology (Figure 5 of Scott Smith *et al.* 2013).

Stage 4
PROGRESSIVE INTERPRETATION
Intrusive / Volcanic Spatial Context
e.g. intra-crater ICK sheet; non-volcanic HK plug; sub-volcanic root zone-fill
e.g. intra-crater ECK; extra-crater ECK
e.g. pipe-fill KPK; subsurface diatreme-fill KPK; crater-fill KPK
e.g. vent-proximal FPK, intra-crater FPK; crater rim FPK; distal extra-crater FPK
e.g. pipe-fill RVK; intra-crater *kimberlitic* sediments; distal extra-crater RVK
e.g. pipe-proximal EVK; epiclastic volcanic *kimberlitic* sediment



kimberlite body morphology

Shape of a kimberlite body. Kimberlite bodies are subdivided based on their overall morphology into two main categories: (i) pipes and (ii) sheets. Other morphology descriptors can be applied to an entire kimberlite body, e.g. steep-sided pipe, irregular pipe, bifurcated sheet, or to parts of a body, such as the different volcanic pipe zones, e.g. elongate inclined diatreme zone, asymmetric flared crater zone, lobate irregular root zone (see pipe zone).
Recommendation: Appropriate use of the term. See kimberlite body, sheet, kimberlite pipe, pipe zone. Description of kimberlite body morphology should be distinct from description of its infill.

kimberlite breccia

A term widely used historically to describe a kimberlite containing abundant rock inclusions, irrespective of their nature and origin. The rock inclusions in kimberlite are predominantly xenoliths but also include autoliths.
Recommendation: Appropriate use of this term in the most general sense (see breccia) until more information is available. Any use of the term, however, requires definition because of a lack of consistency in its general definition and usage. The previous and widely used definition of kimberlite breccia as any type of kimberlite containing > 15 modal % xenoliths > 4 mm in size (with additional descriptors such as xenolithic and autolithic) should be discontinued. It is instead recommended that the abundance of xenoliths (and autoliths) in a kimberlite be described using broad abundance descriptors, e.g. xenolith-poor kimberlite, xenolith-rich kimberlite (see xenolith; abundance descriptors for xenoliths (and autoliths)). See also size descriptors for xenoliths (and autoliths). These descriptors are applied irrespective of the texture of the host kimberlite or the nature of the xenoliths. When sufficient evidence is available, additional modifiers with respect to rock type can be added, e.g. limestone xenolith-rich volcaniclastic kimberlite, mantle xenolith-bearing coherent kimberlite, granitoid microxenolith-rich hypabyssal kimberlite. The term breccia is applicable to kimberlites in other specific instances including country rock breccia or alloclastic breccia.
Further clarification: The term kimberlite breccia was used by Dawson (1967) for kimberlite containing 20-60 modal % fragments of various rock types (autoliths, xenoliths or heterolithic mixtures of the two types) set in a matrix of massive kimberlite. Dawson (1971 a,b,c; 1980) subdivided hypabyssal-facies kimberlite into massive and breccia depending on the proportion of xenoliths. It was suggested that the term breccia be used if > 20 modal % by volume of xenoliths are present. In the textural-genetic classification of Clement and Skinner (1985), the term breccia is applied to any textural variety of kimberlite if > 15 modal % xenoliths > 4 mm in size are present. The term breccia (*sensu lato* and *sensu stricto*) as defined by Clement and Skinner (1985) has been widely used for kimberlites. The kimberlites to which this term has been previously applied are most commonly those containing an accumulation of xenoliths. There is no consistent use of the terms breccia, kimberlite breccia, volcanic breccia or pyroclastic breccia. In kimberlites, xenoliths and autoliths are not necessarily pyroclasts and the host rock may not even be volcanic. Thus the terms volcanic breccia and pyroclastic breccia are in many cases not applicable.

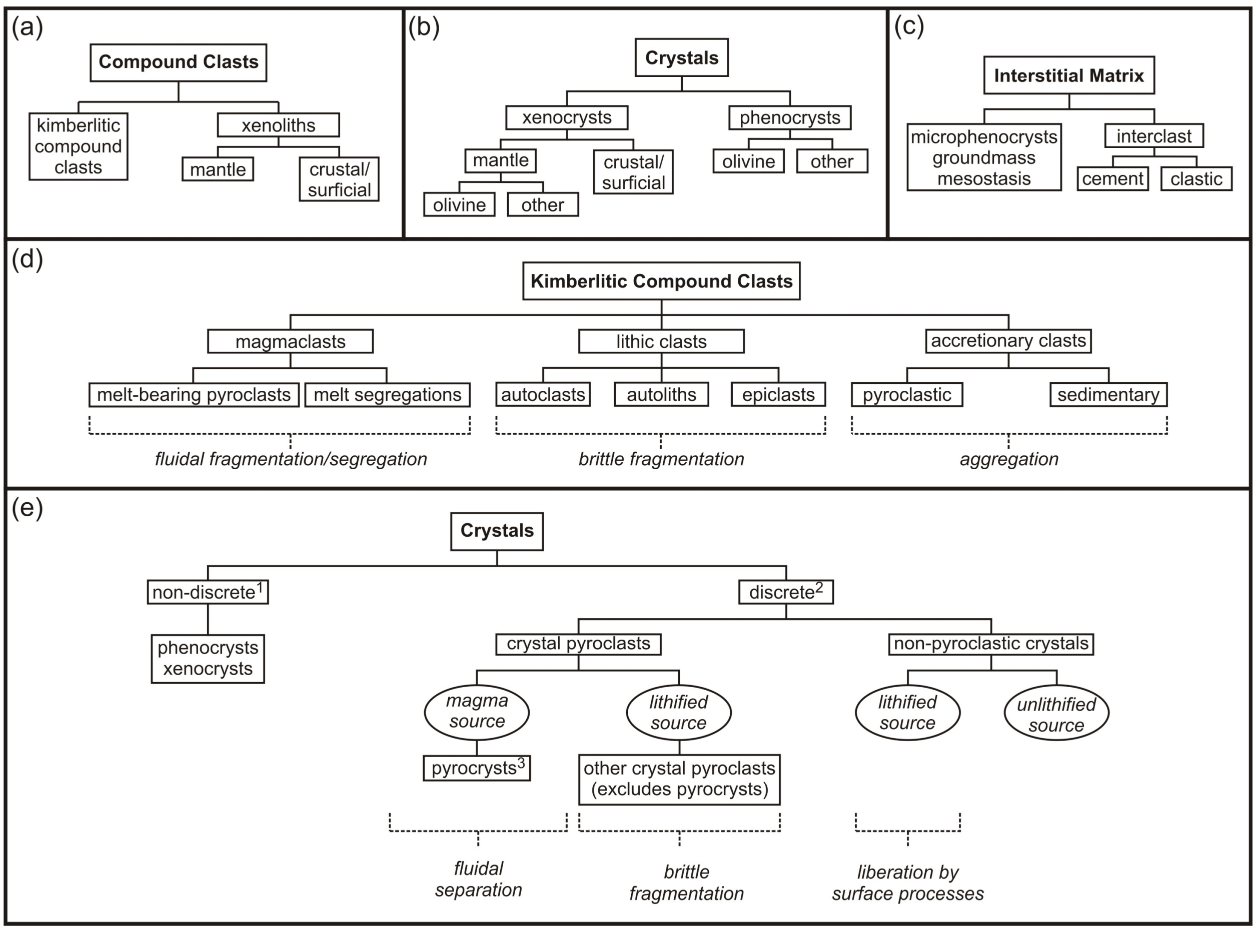
kimberlite clan

The term used to describe all rocks derived by diverse petrogenetic processes from kimberlite parental magmas originating from asthenospheric mantle. Kimberlites are mineralogically and geochemically distinct from lamproites and orangeites.
Recommendation: Appropriate use of this term. See kimberlite. Also see orangeite for recommendation to replace this term with lamproite (var. Kaapvaal).

kimberlite component

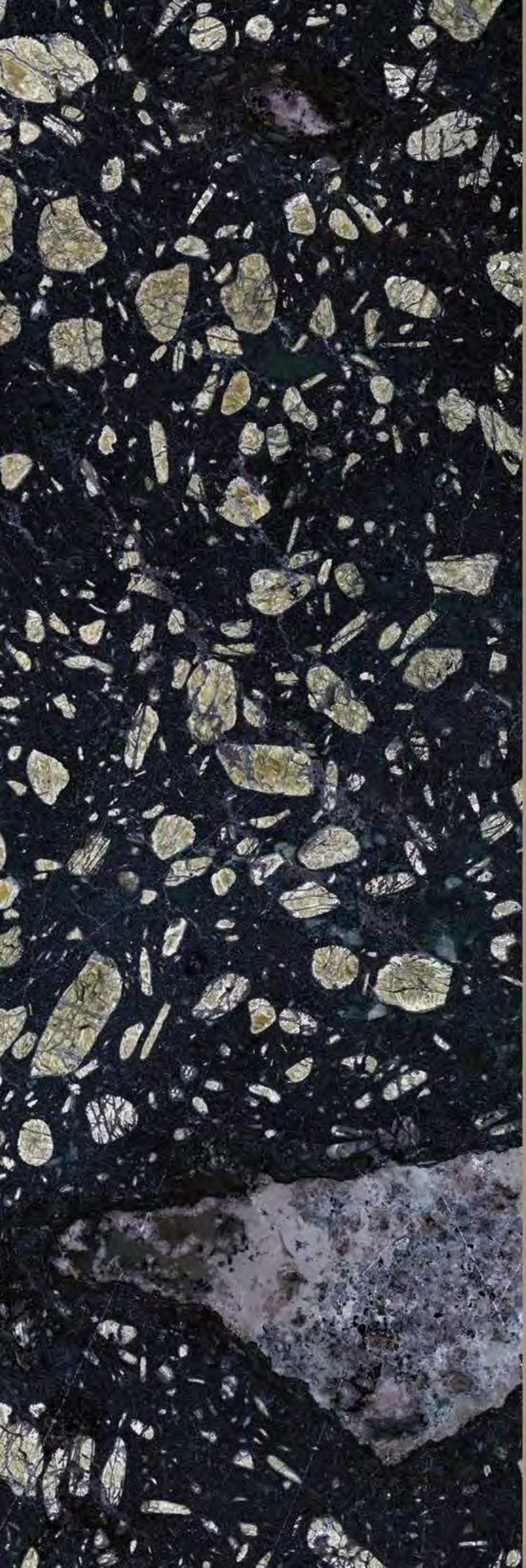
Kimberlites are composed of various components, which for practical descriptive purposes can be divided into three main classes (listed in order of decreasing size): (i) Compound Clasts; (ii) Crystals; and (iii) Interstitial Matrix, as illustrated below (Figure 3 of Scott Smith *et al.* 2013). The three classes are listed in order of general decreasing component size but the subdivision focusses on the internal relationships of the components. In this context, the descriptive component class (ii) encompasses single crystals larger in size than the surrounding interstitial matrix and excludes crystals forming the interstitial matrix (see crystals). Thus, descriptive component class crystals are more easily identified and are commonly

observable with the unaided eye (or binocular microscope) in contrast to the surrounding interstitial matrix. Each kimberlite component class can be further subdivided based on composition and/or origin.
Recommendation: Appropriate use of this term as defined above. Determining the components of a kimberlite (or related rock) is one of the four main parts of Rock Description, Stage 1 in the Scheme of Scott Smith *et al.* (2013) for the description, classification and interpretation of kimberlites and related rocks, the others being Alteration, Structure and Texture. Components is considered the most critical part of any rock description and subsequent interpretation.
Further clarification: The conceptual framework for the description of kimberlite components and their relationship to each other is presented below (after Scott Smith *et al.* 2008 and modified by Scott Smith *et al.* 2013). The three main component classes are listed in order of decreasing component size with further subdivision based on composition and origin. Components from all three classes occur in most textural-genetic types of kimberlite (Stage 3 in the Scheme of Scott Smith *et al.* 2013), and some are common in, or diagnostic of, certain textural-genetic types. For example: (i) groundmass, mesostasis and melt segregations typify coherent kimberlites; (ii) melt-bearing pyroclasts, pyrocrysts and interclast cement are typical of pyroclastic kimberlites; (iii) sedimentary accretionary clasts and clastic interclast matrix are typical of resedimented volcaniclastic kimberlites.



Notes: (1) occur within solidification products of original host melt (includes crystals in magmaclasts); (2) kimberlitic and non-kimberlitic crystals separated from a host melt, a lithified source or derived from an unlithified source; (3) crystals separated from their original host kimberlite melt during pyroclastic processes before deposition and/or solidification (note: in Figure 3(e) of Scott Smith *et al.* 2013 the word 'fluidal' is erroneously missing).

kimberlite component class - compound clasts - *see kimberlite component and compound clast*



A Glossary of Kimberlite and Related Terms

Part 2

PRACTICAL GUIDE

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Part 2 – PRACTICAL GUIDE

Introduction

This Glossary of Kimberlite and Related Terms and the practical, systematic framework or kimberlite nomenclature Scheme presented by Scott Smith et al. (2013; see Table 1, Figure 1) together represent a handbook for the investigation of kimberlites (and related rocks). The goal of these documents is to provide a standard for both the diamond industry and academia which should result in (i) more consistent description, classification, interpretation and understanding of the complex and unusual rocks encountered during diamond exploration and mining; and (ii) improved communication of that information especially during diamond resource development.

The Glossary in Part 1 provides detailed information for 343 terms applicable to kimberlites. A more convenient Glossary Subset (158 terms) is provided in this Part 2. The Glossary Subset includes only recommended terms that are commonly used during the investigation of kimberlites. Excluded from the subset are the following: terms no longer recommended, terms not commonly relevant to kimberlites, terms associated with related rocks and the figures. The key figures from the Glossary are, however, presented in this Part 2 as Figures 2 to 4. In the Glossary Subset each term includes the definition with any associated tables and, where appropriate, an additional practical note (the full Recommendation and Further clarification in the Glossary are excluded).

A number of previously used terms, especially certain historical kimberlite-specific terms, are problematic in their application to kimberlites and related rocks. In many cases it is recommended to discontinue their use. A summary of these terms is provided in Table 2 with guidelines for alternatives.

Unfortunately, by necessity, some of the recommended terms in the Glossary are cumbersome. To facilitate their more convenient and consistent use, abbreviations for selected commonly used kimberlite and related terms are provided in Table 3. During the investigation of kimberlites (e.g. mapping, logging, petrography) the systematic application of these abbreviations is recommended because it leads to (i) more consistent and accurate communication especially of cumbersome terms (e.g. FPK for Fort à la Corne-type pyroclastic kimberlite) and (ii) improved convenience and reproducibility in recording observations and interpretations whether by hand or digitally (e.g. v-x-poor vf-vc ol-rich HK, see Figure 1(a)).

Some of the terms in the Glossary are either focussed on kimberlites and not in general use or have kimberlite-specific definitions to cater for the unique properties of kimberlite magmas and the particular demands of diamond exploration and mining. These terms are italicised in Table 4.

Application of the Nomenclature Scheme

Kimberlite investigations follow the practical five stage systematic framework, or nomenclature Scheme, of Scott Smith et al. (2013) shown in Table 1 and Figure 1. The five different stages represent progressive levels of investigation and interpretation. The primary aim of the Scheme is to assist with the development of the three-dimensional geological models required for the evaluation, diamond resource estimation and mining of kimberlite bodies (see domain, geological model, geological unit, internal geology of a kimberlite body, magma batch, phase of kimberlite in Glossary Subset). This Scheme, however, is also valid, practical and applicable to academic studies of kimberlites. The focus of the Scheme is kimberlites, the most common type of primary diamond deposit. The same concepts, but commonly not the details, of the Scheme are applicable to related rocks such as lamproites which represent the second type of primary diamond deposit.

Investigations are based on representative rock bodies, lithological units and samples. Typically, the Scheme is applied progressively (Table 1, Figure 1), with an overall broadening of the scale of observation (i.e. incorporation of smaller and larger scale observations), increased sample density, greater integration of other data and higher levels of interpretation as investigations proceed from Stages 1 to 5. Stages 1 to 3 are typically applied to a sample or unit but Stages 4 and 5 commonly rely on much larger scale information and context. Stage 1 is the descriptive stage whereas Stages 2 to 5, when possible, involve classification and interpretation based on increasing degrees of genetic inference.

It is very important that each stage of the Scheme is applied only when sufficient evidence is available. 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 investigator with these rock types, and the degree of detail in the investigation. Understanding the different and varying degrees of confidence in the conclusions is vital, particularly in the economic application of the results. The degree of confidence reflects: (i) the accuracy of the recognition of primary features and constituents in Stage 1; and (ii) the validity of the interpretation of that evidence in Stages 2 to 5. Stage 1 is considered to be the most critical part of the Scheme because it provides the evidence, or foundation, for the interpretations undertaken in Stages 2 to 5. Units or phases of kimberlite, the basis of internal geological models, can be established using Stage 1 and without much of the further investigation or interpretation in Stages 2 to 5. Further valid interpretations significantly improve the degree of confidence in the geological models as well as in the predictions of diamond distributions.

Effective investigations usually comprise two main parts: (i) onsite megapetrography such as mapping or logging together with macropetrography of unprepared or cut samples using a binocular microscope; (ii) laboratory-based micropetrography including macroscopic examination of polished slabs using a binocular microscope and microscopic examinations of specially prepared (wedged, super thin) thin sections using a petrographic microscope. Different phases of investigation result from increasing sample density, preparation of representative petrography samples and integration of supporting data from related investigations.

Brief guidelines for the application of each stage of the Scheme are provided in the legend to Table 1; example rock names for each Stage are given in the table. Terms from the Glossary relevant to each stage are listed in Table 4. Examples of the progressive application of the five stages of the Scheme are illustrated in Figure 1. Key diagrammatic guides for Stages 1 and 4 are provided in Figures 2 to 4. Tables 3 and 4 provide abbreviations and terms relevant to each Stage. Some experience with the components and features in kimberlites is required and the progressive levels of interpretation necessitate increasing levels of experience. Further discussion on the application of each Stage is given below.

Stage 1 – Rock Description documents the major or pertinent primary characteristics of a kimberlite (alteration, structure, texture, components) based mainly on observations with only limited genetic interpretation. Tables which can assist with rock descriptions are included in the Glossary Subset (see abundance descriptors for crystals and magmaclasts, abundance descriptors for olivine macrocrysts, abundance descriptors for xenoliths and autoliths, kimberlite alteration, olivine crystal, size descriptors for crystals and magmaclasts, size descriptors for xenoliths (and autoliths), structure, texture). Some description and understanding of alteration is necessary to establish the degree of confidence in the description, classification and interpretation of the original nature of the rock, and in turn the confidence level of the geological model.

For descriptive purposes, the components are ascribed to three classes as illustrated in Figure 2: (a) compound clasts, (b) crystals and (c) interstitial matrix (crystals are those observable with the unaided eye or under the binocular microscope). Olivine is the dominant and essential crystal type in kimberlites forming ~50 modal % of a typical hypabyssal kimberlite and is the most critical component in the interpretation of the geology and economic potential of kimberlites (see olivine crystal and Figure 3(c)).

Xenoliths are also important and are subdivided according to their origin: mantle (e.g. peridotite, eclogite) and crustal/surficial. The total and relative abundance, distribution, character and degree of alteration or metamorphism of xenoliths can be extremely useful in distinguishing different phases of kimberlite. Crustal xenoliths are most common and their incorporation into, and 'dilution' of, kimberlite is a key aspect of the economic assessment of primary diamond deposits. Importantly, the xenolith size and abundance of a relatively small sample may be different from that of the larger scale intersection or unit from which it derives; the selection of petrographic samples to examine the nature of the host kimberlite typically avoids xenoliths.

Stage 2 – Petrogenetic Classification is the determination of the Parental Magma Type (e.g. kimberlite) and Mineralogical Classification (e.g. monticellite kimberlite). This classification requires identification of primary typomorphic minerals for which microscope-based petrography is usually necessary to reach an acceptable degree of confidence.

Stage 3 – Textural-Genetic Classification is the second subdivision of a Parental Magma Type, the other being the Mineralogical Classification discussed in Stage 2. Stage 3a is the broad textural-genetic classification into Coherent Kimberlite and Volcaniclastic Kimberlite and Stage 3b involves further subdivision. Microscope-based petrography is usually necessary to reach an acceptable degree of confidence.

Stage 4 – Intrusive / Volcanic Context incorporates an assessment of the morphology of the kimberlite body from which the rocks under investigation derive. When sufficient evidence is available, kimberlite body shapes can be described using the terms provided in Figure 4. This requires larger-scale observations and is typically based on drilling and/or mapping information. Importantly, subdivisions of kimberlite bodies (e.g. pipe zones) should not be used to describe the type of infill or process of formation.

Stage 5 – Genetic / Process Interpretation involves more detailed genetic interpretation with more specific classification based on the mode of formation. The interpretation of the rock formation process integrates information obtained in Stages 1 to 4 and, in most cases, relies on increased sample density and level of investigation. Interpretations are based on well-established intrusive and volcanic processes and products described in various standard texts, many of which also apply to kimberlite bodies. The unusual characteristics of kimberlite magmas, however, result in certain apparently unique kimberlite-specific processes and rock types. Also, most kimberlite studies focus on subsurface rocks which can be expected to involve processes and products that are not well known. In many cases, the interpretations made in Stage 5 are subjective, considered to be lower confidence than those made in previous stages or can reveal more than one potentially valid scenario. However, such interpretations can be important in the prediction of diamond distribution and hence for improving confidence in diamond resource estimates.

Rock Names usefully summarise the conclusions of the investigation. The names can evolve as the investigation proceeds and vary according to the aim of the investigation. Examples of rock naming are presented in Table 1 and in Figure 1.

Reference

Scott Smith BH, Nowicki TE, Russell JK, Webb KJ, Mitchell RH, Hetman CM, Harder M, Skinner EMW, Robey JV (2013) Kimberlite terminology and classification. Proceedings of the 10th International Kimberlite Conference, Spec. Issue J. Geol. Soc. India, 2:1-17

Table 1 Nomenclature Scheme

Evolving and flexible rock names are only applied to a sample when the evidence allows (See Figure 1). The Rock Name Descriptors shown in green can vary according to the stage or purpose of the investigation or the rock name. Dashed and dotted lines indicate potential for gradations between rock types. Table 4 provides a list of terms relevant to each part of each Stage.

Stage 1 - Rock Description

This stage documents the pertinent characteristics of a kimberlite – see kimberlite rock description, petrography, megascopic, macroscopic and microscopic.

Alteration – see alteration, kimberlite alteration; where relevant, the descriptive rock names can be modified by adding alteration terms.

Structure – see structure.

Texture – see texture.

Components – see Figure 2 and kimberlite component. Involves the accurate identification of the original components especially those relevant in the prediction of diamond distribution, in particular olivine (see olivine crystal), other mantle-derived xenocrysts and all types of xenoliths. Abundance and size descriptors are summarised in Figure 3 (see abundance descriptors for crystals and magmaclasts, abundance descriptors for xenoliths (and autoliths), size descriptors for crystals and magmaclasts, size descriptors for xenoliths (and autoliths) and provided in detail in Part 3.

Descriptive Rock Name – summarises the observations from above, typically emphasising the objectives of the investigation.

Stage 2 - Petrogenetic Classification

This stage involves identification of the parental magma type and the further subdivision into mineralogical types. If the parental magma is a related rock, the term kimberlite can be replaced by another parental magma type such as lamproite.

Parental Magma Type – see essential mineral, typomorphic mineral, petrogenetic classification, petrological clan, parental magma, mineralogical-genetic classification.

Mineralogical Classification - see mineralogical classification.

Petrogenetic Rock Name – combines the terms from above.

Stage 3 - Textural-Genetic Classification

This stage involves assigning broad textural-genetic classes in two stages (see textural genetic classification). Stage 3a is the broad textural-genetic classification into coherent kimberlite and volcaniclastic kimberlite with Stage 3b involving further subdivision.

Stage 3a – see coherent, volcaniclastic kimberlite.

Stage 3b – see intrusive, extrusive, pyroclastic kimberlite, resedimented volcaniclastic kimberlite, epiclastic kimberlite.

Textural-Genetic Rock Name - summarises the terms from above and, if useful, a series of descriptive prefixes can be added from Stages 1 and/or 2. If more appropriate, standard volcanological and sedimentological rock names can be used.

Stage 4 - Intrusive / Volcanic Spatial Context

This stage involves application of terms from Figure 4 to indicate the spatial relationship to, and morphology of, the kimberlite body from which the rocks under investigation derive (see kimberlite body, kimberlite body morphology).

Contextual Rock Name - terms are added to the rock name.

Stage 5 - Genetic / Process Interpretation

This stage usually relies on increased sample density and level of investigation and integrating the information obtained in Stages 1 to 4.

Genetic Rock Name - results are combined into a genetic rock name.

<table>
<tr><th>Stage 1</th><th>Stage 2</th><th>Stage 3a</th><th colspan="2">Stage 3b</th><th>Stage 4</th><th>Stage 5</th></tr>
<tr><th colspan="7">PROGRESSIVE INTERPRETATION</th></tr>
<tr><th>Rock Description</th><th>Petrogenetic Classification</th><th colspan="3">Textural-Genetic Classification</th><th>Intrusive / Volcanic Spatial Context</th><th>Genetic / Process Interpretation</th></tr>
<tr>
<td rowspan="6">Alteration:
intensity; distribution; mineralogy; imposed textures; preservation; timing; xenolith reaction

Structure:
e.g. massive; inhomogeneous; layered; flow zoned; laminated; cross-bedded; jointed

Texture:
component distribution; shape; size distribution (e.g. well sorted; inequigranular); packing; support (e.g. clast or matrix supported)

Components:
compound clasts (e.g. xenoliths, magmaclasts, autoliths, accretionary clasts); crystals (e.g. olivine macrocrysts, crustal xenocrysts); interstitial matrix</td>
<td rowspan="6">Parental Magma Type:
e.g. kimberlite; lamproite; melnoite; alnoite; olivine melilitite

Mineralogical Classification:
e.g. monticellite; phlogopite; carbonate</td>
<td rowspan="2">Coherent:
[descriptors] coherent kimberlite (CK)</td>
<td colspan="2">Intrusive:
[descriptors] intrusive coherent kimberlite (ICK) or hypabyssal kimberlite (HK)</td>
<td>e.g. intra-crater ICK sheet; non-volcanic HK plug; sub-volcanic root zone-fill</td>
<td>e.g. composite flow-differentiated hypabyssal sheet; intrusive plug</td>
</tr>
<tr>
<td colspan="2">Extrusive:
[descriptors] extrusive coherent kimberlite (ECK)</td>
<td>e.g. intra-crater ECK; extra-crater ECK</td>
<td>e.g. fountain-fed clastogenic lava lake; effusive lava flow</td>
</tr>
<tr>
<td rowspan="4">Volcaniclastic:
[descriptors] volcaniclastic kimberlite (VK)</td>
<td rowspan="2">Pyroclastic:
[descriptors] pyroclastic kimberlite (PK) or [descriptors] kimberlitic [standard pyroclastic rock name]</td>
<td>Kimberley-type:
[descriptors] Kimberley-type pyroclastic kimberlite (KPK)</td>
<td>e.g. pipe-fill KPK; subsurface diatreme-fill KPK; crater-fill KPK</td>
<td>e.g. fluidised; column collapse</td>
</tr>
<tr>
<td>Fort à la Corne-type:
[descriptors] Fort à la Corne-type pyroclastic kimberlite (FPK)</td>
<td>e.g. vent-proximal FPK, intra-crater FPK; crater rim FPK; distal extra-crater FPK</td>
<td>e.g. spatter; fallout; base surge; pyroclastic flow</td>
</tr>
<tr>
<td colspan="2">Resedimented Volcaniclastic:
[descriptors] resedimented volcaniclastic kimberlite (RVK) or [descriptors] resedimented kimberlitic [standard sedimentary rock name]</td>
<td>e.g. pipe-fill RVK; intra-crater kimberlitic sediments; distal extra-crater RVK</td>
<td>e.g. grain flow; debris flow; mass flow; lacustrine; reworked crater rim; alluvial fan; turbidite</td>
</tr>
<tr>
<td colspan="2">Epiclastic Volcanic:
[descriptors] epiclastic volcanic kimberlite (EVK) or [descriptors] epiclastic kimberlitic [standard sedimentary rock name]</td>
<td>e.g. pipe-proximal EVK; epiclastic volcanic kimberlitic sediment</td>
<td>e.g. lithified crater rim scarp slope mass wasting</td>
</tr>
<tr>
<td>Example names: uniform, xenolith-poor, medium-grained, olivine macrocryst-rich rock; massive, xenolith-rich, fine to medium-grained, olivine-poor rock; cross-bedded microcrystic rock</td>
<td>Example names: olivine macrocryst-rich carbonate phlogopite monticellite kimberlite; 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 colspan="2">Example names: macrocryst-poor ICK; uniform macrocrystic HK; flow banded crystal-poor ECK; thickly bedded PK; massive unsorted very macroxenolith-rich KPK; graded xenolith-poor olivine pyrocryst-rich FPK; cross-bedded very fine-grained crystal-dominated RVK; well sorted resedimented kimberlitic sandstone; poorly sorted EVK; bedded kimberlitic lapilli tuff</td>
<td>Example names: steep discordant HK sheet; diatreme-fill massive xenolith-rich KPK; crater-fill mega-graded olivine pyrocryst-dominated FPK</td>
<td>Example names: graded, olivine pyrocryst-rich FPK fallout deposit; kimberlitic lacustrine mudstone; clast supported, very xenolith-rich RVK mass flow deposit</td>
</tr>
</table>

Table 2 Recommendations for Problematic Terms

accretionary lapillus	avoid use; preferred term is *accretionary clast* and for size apply *size descriptors for crystals and magmaclasts* (see also Figure 3)
basaltic kimberlite	discontinue; replace with *kimberlite*
blue ground	discontinue; in most instances can be replaced with *fresh* or *unweathered kimberlite*
crater-facies kimberlite	discontinue; replace with separate terms describing, when known, the *pipe zone* and the material that occupies it (e.g. crater-fill pyroclastic kimberlite)
crystal-tuffisitic kimberlite	discontinue; replace with *pyrocryst-rich Kimberley-type pyroclastic kimberlite*
crystallinoclastic kimberlite	discontinue; replace with *pyrocryst-rich Kimberley-type pyroclastic kimberlite*
diatreme-facies kimberlite	discontinue; replace with separate terms describing, when known, the *pipe zone* and the material that occupies it (e.g. diatreme-fill Kimberley-type pyroclastic kimberlite)
floating reef	discontinue; replace with *large megaxenolith* (see *size descriptors for xenoliths (and autoliths)*)
fragmental kimberlite	avoid use; preferred terms are *xenolith*-poor to *xenolith*-rich to describe the abundance of country rock fragments (xenoliths; see *size descriptors for xenoliths (and autoliths)*) and *volcaniclastic* or *pyroclastic* to indicate formation by volcanic fragmentation processes; *magmaclastic* can be used as an interim term to describe kimberlites composed of *magmaclasts*
globular	use only as a descriptor of shape but best avoided; preferred shape descriptor terms are spherical and subspherical
globular segregation	use only in a descriptive sense but best avoided; preferred terms are spherical or subspherical *melt segregation* or *segregation of melt-in-fluid*
globular segregationary kimberlite	use only in a descriptive sense but best avoided; preferably describe a rock as composed of spherical *segregations of melt-in-fluid* or as a spherical *melt segregation*-rich kimberlite
Group 1 kimberlite	discontinue; replace with *kimberlite*
Group 2 kimberlite	discontinue; replace with *lamproite (var. Kaapvaal)* as recommended in Part 1
hardebank	discontinue
hypabyssal-facies kimberlite	discontinue; the term *hypabyssal kimberlite* suffices (or describe as *intrusive coherent kimberlite* until a hypabyssal environment is established)
kimberlite breccia	discontinue use as a descriptor of xenolith content; replace with *abundance descriptors for xenoliths (and autoliths)* and *size descriptors for xenoliths (and autoliths)*
kimberlite microbreccia	discontinue use as a descriptor of xenolith content; replace with *abundance descriptors for xenoliths (and autoliths)* and *size descriptors for xenoliths (and autoliths)*

lapilli	use only as a descriptor for pyroclasts with a certain particle size; the sizes of *pyroclast*s (including *melt-bearing pyroclast*s, *pyrocryst*s and *xenolith*s) can be more usefully described with *size descriptors for crystals and magmaclasts* (see also Figure 3) and *size descriptors for xenoliths (and autoliths)*
maar	use only if there is evidence indicating formation of a volcanic crater by phreatomagmatic processes; where this is not the case, the terms *volcanic crater* or *crater zone* (which imply no particular process of formation) should be used
magmatic kimberlite	discontinue; replace with *coherent kimberlite*
micaceous kimberlite	discontinue; replace with *lamproite (var. Kaapvaal)* as recommended in Part 1; a mica-rich kimberlite is described as phlogopite kimberlite
orangeite	discontinue; replace with *lamproite (var. Kaapvaal)* as recommended in Part 1
orangeite clan	discontinue; use *lamproite clan* as recommended in Part 1
pelletal lapilli	discontinue; use *melt-bearing pyroclast*s irrespective of the type of pyroclastic kimberlite and apply appropriate descriptors such as *size descriptors for crystals and magmaclasts* (see also Figure 3) and shape (e.g. spherical or subspherical)
pyroclastic breccia	avoid use as a descriptor of xenolith content; describe as pyroclastic rock and apply *abundance descriptors for xenoliths (and autoliths)* and *size descriptors for xenoliths (and autoliths)*
pyroclastic-facies	avoid use; the term *pyroclastic* suffices
tuff	use only as a descriptor of pyroclastic rocks dominated by ash-sized particles but best avoided; more useful to describe as *pyroclastic kimberlite* with *size descriptors for crystals and magmaclasts* (see also Figure 3)
tuffaceous	avoid use
tuffisite	best avoided in most instances; use only as specifically defined
tuffisitic kimberlite	discontinue; replace with *Kimberley-type pyroclastic kimberlite*
volcanic block	preferably describe as a pyroclast and apply *size descriptors for crystals and magmaclasts* (see also Figure 3) and *size descriptors for xenoliths (and autoliths*)
volcanic bomb	preferably describe as a pyroclast and apply *size descriptors for crystals and magmaclasts* (see also Figure 3) and *size descriptors for xenoliths (and autoliths)*
Wesselton-type pyroclastic kimberlite	discontinue; replace with *Kimberley-type pyroclastic kimberlite*
Wesselton-type volcaniclastic kimberlite	discontinue; replace with *Kimberley-type pyroclastic kimberlite*
yellow ground	discontinue; in most instances can be replaced with *weathered kimberlite*

Table 3 Abbreviations for Kimberlite Terms

Mineral abbreviations are from IUGS Subcommission on the Systematics of Metamorphic Rocks (Siivola and Schmid 2007; www.bgs.ac.uk/scmr/docs/papers/paper_12.pdf).

STAGE 1 - Kimberlite Components

abundance descriptors	see Figure 3	
autolith	autx	
clast	cl	
compound clast	ccl	
country rock xenolith	crx	
of basement	crxb	
of country rock breccia	crxcrb	
of granitoid basement	crxg	
of sediment	crxs	
‘cryst	ct	
crystal (see also olivine crystal)	ctl	
crystal pyroclast	ctlpy	
epiclast	epicl	
interclast matrix	icm	
interstitial matrix	ism	
kimberlite indicator mineral	kim	
kimberlitic compound clast	kccl	
macrocryst (see also olivine macrocryst)	mact	
macrophenocryst	maph	(ct is implicit)
macroxenocryst	maxct	
magmaclast	mc	
magmatic segregation	seg	
of melt in melt	seg-mim	
of melt in fluid	seg-mif	
of fluid in melt	seg-fim	
melt-bearing pyroclast	mbpy	(cl is implicit)
megacryst	mect	
microcryst (see also olivine microcryst)	mict	
microphenocryst	miph	(ct is implicit)
microxenocryst	mixct	
olivine crystal	ol	(ctl is implicit)
olivine microcryst	olmi	(ct is implicit)
olivine microphenocryst	olmiph	(ct is implicit)
olivine microxenocryst	olmix	(ct is implicit)
olivine macrocryst	olma	(ct is implicit)
olivine macrophenocryst	olmaph	(ct is implicit)
olivine macroxenocryst	olmax	(ct is implicit)
olivine phenocryst	olph	(ct is implicit)
olivine microphenocryst	olmiph	(ct is implicit)
olivine macrophenocryst	olmaph	(ct is implicit)
olivine pyrocryst	olpy	(ct is implicit)
olivine xenocryst	olx	(ct is implicit)
phenocryst	ph	(ct is implicit)
pyroclast	pycl	
pyrocryst	pyct	

size descriptors for crystals and magmaclasts	see Figure 3b	
ultra fine [crystal]	uf	
super fine [crystal]	sf	
very very fine [crystal]	vvf	
very fine [crystal]	vf	(e.g. vf-ol)
fine [crystal]	f	(e.g. f-ol)
medium [crystal]	m	(e.g. m-ol)
coarse [crystal]	c	(e.g. c-ol)
very coarse [crystal]	vc	(e.g. vc-ol)
ultra coarse [crystal]	uc	(e.g. uc-ol)
xenocryst	xct	
xenolith	x	(cl is implicit)
microxenolith	mix	
macroxenolith	max	
megaxenolith	mex	

STAGE 1 and 2 - Minerals

amphibole	am
apatite	ap
biotite	bt
calcite	cal
carbonate	cb
chlorite	chl
chromite	chr
clinopyroxene	cpx
diopside	di
dolomite	dol
feldspar	fsp
feldspathoid	foid
garnet	grt
ilmenite	ilm
leucite	lct
mica	mca
melilite	mel
monticellite	mnt
nepheline	ne
olivine	ol
orthopyroxene	opx
perovskite	prv
phlogopite	phl
plagioclase	pl
pyrope	prp
pyroxene	px
quartz	qtz
spinel	spl
serpentine	srp

STAGE 2 - Parental Magma Type

kimberlite	K

STAGE 3 - Textural-Genetic Classification

brecciated country rock	BCR
coherent kimberlite	CK
intrusive coherent kimberlite	ICK
country rock	CR
country rock breccia	CRB
epiclastic kimberlite	EK
epiclastic volcanic kimberlite	EVK
extrusive coherent kimberlite	ECK
Fort à la Corne-type pyroclastic kimberlite	FPK
hypabyssal kimberlite	HK
Kimberley-type pyroclastic kimberlite	KPK
magmaclastic kimberlite	mcK
pyroclastic kimberlite	PK
resedimented volcaniclastic kimberlite	RVK
resedimented Fort à la Corne-type pyroclastic kimberlite	RFPK
resedimented Kimberley-type pyroclastic kimberlite	RKPK
volcaniclastic	V
volcaniclastic kimberlite	VK

Figure 1 Application of the Nomenclature Scheme

Four rock samples illustrate the application of the nomenclature Scheme shown in Table 1 focussing on the components that are economically relevant in the prediction of diamond distributions (i.e. olivine and xenoliths; figure from Scott Smith et al. 2013). The figures show the macroscopic constituents traced in polished slabs (from Scott Smith and Smith 2009). These rocks display minimal alteration resulting from weathering; the textures are well preserved and the original mineralogy is evident. Different component types are represented by different colours:

- **green** = olivine crystals or their pseudomorphs (31, 11, 21 and 6 modal % in (a), (b), (c) and (d), respectively);
- **white** (a, c) = solidified former melt (crystalline groundmass in (a); cryptocrystalline/glassy groundmass in (c));
- **orange** = solidified thin melt selvages on all constituents in (b);
- **red** = country rock xenoliths and xenocrysts (0, 30, 0 and <1 modal % in (a), (b), (c) and (d), respectively);
- **brown** (b), **purple** (c) and **grey** (d) = different types of interclast matrix.

Rock names are only applied to a sample when the evidence allows. The naming format is flexible. Here the staged approach to the terminology reflects an overall increasing level of investigation. The observations were made on the illustrated polished slabs and augmented with drillcore and thin section examination.

In ***Stage 1*** observations are summarised in a descriptive rock name. Xenoliths are listed first because they are typically larger and more easily discerned. The descriptors can be retained, modified or abbreviated as appropriate to subsequent stages of the investigation.

In ***Stage 2*** the petrogenetic rock name (red text) replaces “rock” from Stage 1, combining the petrogenetic classification and, when possible, the mineralogical classification.

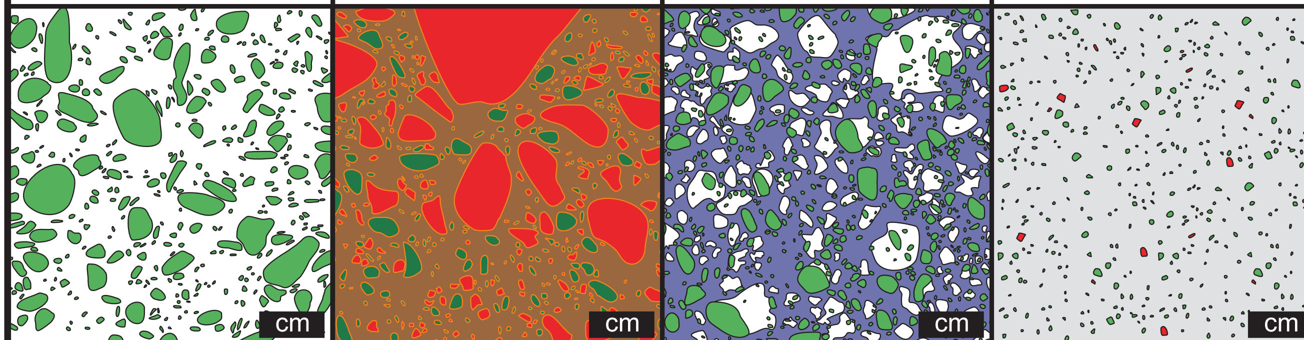
In ***Stage 3a*** initial broad textural subdivisions are added (black text).

In ***Stage 3b*** more detailed observations and interpretations result in the following changes: replacement of the term magmaclast by melt-bearing pyroclast in sample (c); and the more specific textural-genetic rock name (black text) for all samples. The descriptor terms are retained but abbreviated (from Table 3) to make the rock name much more manageable.

In ***Stage 4*** terms describing the spatial context of the rock (black italicised text; from Figure 4) are applied to the abbreviated textural-genetic rock name from Stage 3 (black and red upper case letters, from Tables 1 and 3).

In ***Stage 5*** data from previous Stages are integrated to propose a high-level genetic interpretation (black italicised text).

In ***Summary*** the pertinent information and interpretations for each sample are combined.



		(a) Snap Lake Mine, NWT	(b) Tuzo, Gahcho Kué 47.4m, NWT	(c) Fort à la Corne 175 160.9m, SK	(d) Fort à la Corne 140 140.2m, SK
Stage 1	**Rock Description**	very xenolith-poor very fine to very coarse olivine-rich uniform rock	micro to small macroxenolith-rich very fine to coarse olivine-poor massive rock	very xenolith-poor very fine to coarse olivine-rich fine to ultra coarse magmaclast-rich massive rock	very xenolith-poor super fine to fine olivine-rich graded rock
Stage 2	**Petrogenetic Classification**	very xenolith-poor very fine to very coarse olivine-rich monticellite kimberlite	micro to small macroxenolith-rich very fine to coarse olivine-poor kimberlite	very xenolith-poor very fine to coarse olivine-rich fine to ultra coarse magmaclast-rich monticellite kimberlite	very xenolith-poor super fine to fine olivine-rich kimberlite
Stage 3a	**Textural-Genetic Classification**	very xenolith-poor very fine to very coarse olivine-rich coherent monticellite kimberlite	micro to small macroxenolith-rich very fine to coarse olivine-poor volcaniclastic kimberlite	very xenolith-poor very fine to coarse olivine-rich fine to ultra coarse magmaclast-rich volcaniclastic monticellite kimberlite	very xenolith-poor super fine to fine olivine-rich volcaniclastic kimberlite
Stage 3b		v-x-poor vf-vc ol-rich intrusive coherent monticellite kimberlite	mix-smax-rich vf-c ol-poor Kimberley-type pyroclastic kimberlite	v-x-poor vf-c ol-rich f-uc melt-bearing pyroclast-rich Fort à la Corne-type pyroclastic monticellite kimberlite	v-x-poor sf-f ol-pyrocryst-rich Fort à la Corne-type pyroclastic kimberlite
Stage 4	**Intrusive / Volcanic Spatial Context**	v-x-poor vf-vc ol-rich ICK *inclined intrusive sheet*	mix-smax-rich vf-c ol-poor KPK *diatreme-fill*	v-x-poor vf-c ol-rich f-uc melt-bearing pyroclast-rich FPK *vent-proximal crater-fill*	v-x-poor sf-f ol-pyrocryst-rich FPK *crater-fill*
Stage 5	**Genetic / Process Interpretation**	v-x-poor vf-vc ol-rich HK *uniform hypabyssal sheet*	mix-smax-rich vf-c ol-poor KPK *massive fluidised deposit*	v-x-poor vf-c ol-rich f-uc melt-bearing pyroclast-rich FPK *massive spatter deposit*	v-x-poor sf-f ol-pyrocryst-rich FPK *graded fallout deposit*
	Summary	**uniform olivine macrocrystic HK inclined sheet**	**massive olivine macrocryst-poor KPKx diatreme-fill**	**massive olivine macrocrystic FPK crater-fill**	**graded olivine microcrystic FPK crater-fill**

GLOSSARY SUBSET – Table of Contents

Main Recommended Terms Relevant to Kimberlites

abundance descriptors for crystals and magmaclasts

Abundance descriptors for crystals and magmaclasts in kimberlites are presented in the table below. For magmaclasts, substitute [magmaclast] for [crystal] (similarly for accretionary clasts). The abundance of crystals and magmaclasts can be determined by simple visual estimate or more accurately by modal analysis (point counting) or image analysis. Abundance descriptors for xenoliths and other lithic compound clasts are the same as those in the table below but are presented separately for clarity, see abundance descriptors for xenoliths (and autoliths).

Percentage range	Descriptor
0	[crystal]-free
> 0 – 5	very [crystal]-poor
> 5 – 15	[crystal]-poor
> 15 – 50	[crystal]-rich
> 50 – 75	very [crystal]-rich
> 75	[crystal]-dominated

Note: These are non-genetic kimberlite-specific abundance descriptors for crystals and magmaclasts which are applied regardless of their nature and origin, the texture of the rock in which they occur (i.e. coherent or volcaniclastic) and their context within it. The term "bearing" is useful to indicate the presence of a component without any specific abundance connotation. See Figures 3(a) and 4 for a diagrammatic guide to the abundance descriptors and Table 2.

abundance descriptors for olivine macrocrysts

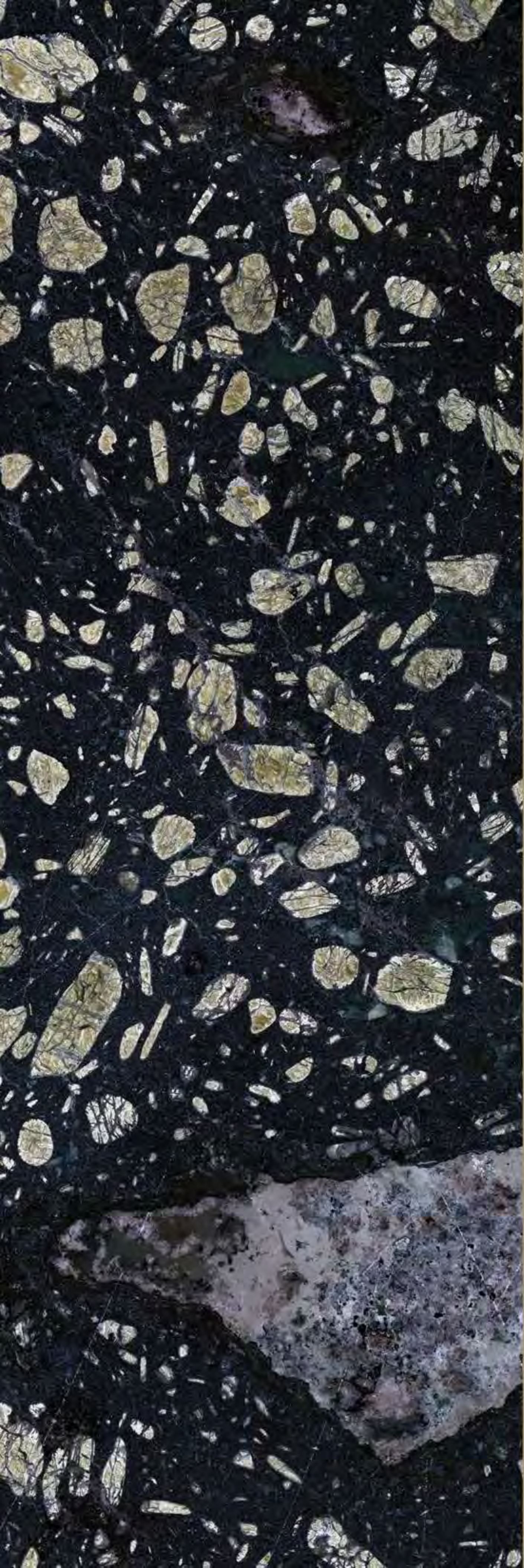
Abundance descriptors for olivine macrocrysts in kimberlites are presented in the table below. As for abundance descriptors for crystals (see abundance descriptors for crystals and magmaclasts), substituting [olivine macrocryst] for the generic term [crystal]. The abundance of olivine macrocrysts can be determined by simple visual estimate or more accurately by modal analysis (point counting) or image analysis.

Percentage range	Descriptor
0	olivine macrocryst-free
> 0 – 5	very olivine macrocryst-poor
> 5 – 15	olivine macrocryst-poor
> 15 – 50	olivine macrocryst-rich
> 50 – 75	very olivine macrocryst-rich
> 75	olivine macrocryst-dominated

Note: See Figure 3(a) and 4 for a diagrammatic guide to the abundance descriptors and Table 2. The term olivine macrocrystic can be used to describe kimberlite with > 15 modal % of olivine macrocrysts. No qualifier to the term macrocrystic usually implies that olivine is the dominant macrocryst mineral.

abundance descriptors for xenoliths (and autoliths)

Abundance descriptors for xenoliths (and autoliths) in kimberlites are presented in the table below. Xenolith abundance can be determined by simple visual estimate or more accurately by modal analysis (line scans, point counting) or image analysis. For autoliths, substitute the term autolith for xenolith (and similarly for other lithic compound clasts such as epiclasts). Abundance descriptors for crystals and magmaclasts are the same but are presented separately for clarity (see abundance descriptors for crystals and magmaclasts).



A Glossary of Kimberlite and Related Terms

Part 3

ABUNDANCE AND SIZE DESCRIPTORS

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Part 3 - ABUNDANCE AND SIZE DESCRIPTORS

Introduction

Part 3 of the Glossary provides guides to assist with the visual application of kimberlite-specific abundance and size descriptors for Components in the Rock Description (Stage 1 of Table 1 in Part 2). The descriptors are kimberlite-specific to make them relevant to the economics of diamond deposits and are applied irrespective of the nature and origin of the rock, in particular the classification of the host rock as either volcaniclastic or coherent. The abundance and size descriptors can be applied using visual estimates undertaken by comparing components in rocks to the guides presented here. Different descriptors are applied to two groups which together comprise the main components in kimberlites (and related rocks):

(i) crystals, magmaclasts, accretionary clasts and interstitial matrix
(ii) xenoliths, autoliths and epiclasts.

The abundance classes and descriptors are the same for both groups but are presented separately for clarity. The size classes and descriptors are different for the two groups.

The descriptor guides include self-explanatory summaries, definitions and diagrammatic illustrations as follows:

- Summary Guides
  - Table Compilation (Pages 2-3, see also inside back cover)
  - Diagrammatic Compilation (Pages 4-6, see also outside back cover)
- Detailed Guides
  - Definitions for abundance and size descriptors (Pages 7-13)
  - Diagrammatic guides for abundance estimates (Pages 14-43; see also Page 54)
  - Diagrammatic guides for size estimates (Pages 44-47)
  - Size Descriptors for crystals and magmaclasts (Pages 48-53)

The components are represented in the diagrams by black or white circles which mimic the characteristic round shape of olivine macrocrysts and many magmaclasts, the most important components in kimberlites. Magmaclasts include melt segregations and melt-bearing pyroclasts.

The diagrams in pages 14-53 are to scale and include components ranging from 0.5 mm to 16 mm. The minimum illustrated size of 0.5 mm is the smallest that can be depicted and the smallest that can be discerned by the naked eye. This is also the size cut-off between very fine (vf) and very very fine (vvf) crystals and magmaclasts, the latter usually occurring within interstitial matrix. For crystals, the illustrated size range includes the coarsest class of microcrysts (0.5 – 1.0 mm) and all classes of macrocrysts (> 1 mm). It is implicit in the use of any size terms > 1 mm (f upwards) for crystals that they are macrocrysts. The maximum depicted size of 16 mm is the upper limit of very coarse crystals (vc) and magmaclasts. A few coarser components are included in pages 48-51 to illustrate ultracoarse crystals and magmaclasts. If relevant, the same diagrams can be used in the application of descriptors to xenoliths (and autoliths), especially microxenoliths (< 16 mm), although they display a wider range of shapes from round to angular.

In the diagrams the specified abundance is the modal % or proportion of components within each box figure. Most diagrams are presented as two versions: (i) black on white; and (ii) white on black. This is to cater for potential differences in precision during the visual estimation of abundance of dark and light components. It is commonly observed that the abundance of dark components is overestimated and that of light components is underestimated. Other important factors affecting visual estimations include the contrast between components and interstitial matrix as well as component size.

A diagram representing ~25 modal % for components ≥ 1 mm (Pages 5-(c)(ii), 6, 9) is a schematic illustration of the abundance and size of olivine macrocrysts in a typical hypabyssal kimberlite. Olivine macrocrysts (> 1 mm) with a wide range of sizes are the dominant and characteristic crystal component. This diagram is included in this Glossary to emphasise the nature of a typical pre-eruption kimberlite magma best illustrated by typical hypabyssal kimberlite. Importantly, this is used as a benchmark to assess the economic potential of a kimberlite (or related rock) and, when diamonds are present, to assess the potential degree of modification to the distribution of diamonds during the emplacement of such magmas (see Pages

4-5(c)). These observations provide key lines of evidence for understanding mantle, ascent and near-surface magmatic and volcanic emplacement processes. The average mode for olivine macrocryst abundance (~25 modal %) in hypabyssal kimberlites lies in the middle of the abundance category "olivine macrocryst-rich" thereby avoiding the use of different abundance descriptors for rocks having similar olivine contents.

It is important to note that visual estimates have limited reliability. Investigators can improve their visual estimates by reviewing all the diagrammatic guides presented within Part 3. When size and abundance assessments are important to a project, quantitative investigations can be undertaken. More accurate estimates can be determined by modal analysis (point counting, line scans) or image analysis (preferably on traced components). Dennison (1966) noted that a modal analysis comprising 16 points has the precision of a visual estimate whereas meaningful modal analyses commonly comprise 300-1000 points. Investigators can improve their visual estimates by point counting a selection of unknowns for which visual estimates have been made to calibrate their visual estimations.

Abundance and Size Descriptors

Summary Guides

Definitions

Diagrammatic Guides

Summary Guides - Table Compilation

These desriptors can be applied irrespective of the textural-genetic classification of the rock in which they occur.

(a) Abundance and Size Descriptors for Crystals and Magmaclasts

- for magmaclasts substitute [magmaclast] for [crystal]
- for a mineral such as olivine substitute [olivine] for [crystal]
- for olivine macrocrysts substitute [olivine macrocryst] for [crystal]
- for accretionary clasts substitute [accretionary clast] for [crystal]

(i) Abundance Descriptors

(ii) Size Descriptors

(b) Abundance and Size Descriptors for Xenoliths (and Autoliths)

- for autolith substitute [autolith] for [xenolith]
- for epiclast substitute [epiclast] for [xenolith]

(iii) Abundance Descriptors

(iv) Size Descriptors

(a) Abundance and Size Descriptors for Crystals and Magmaclasts

(i)

Percentage range	Descriptor
0	[crystal]-free
> 0 – 5	very [crystal]-poor
> 5 – 15	[crystal]-poor
> 15 – 50	[crystal]-rich
> 50 – 75	very [crystal]-rich
> 75	[crystal]-dominated

(ii)

Size range (mm)	Descriptor	Abbreviation
< 0.125	ultra fine	uf
> 0.125 – 0.25	super fine	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	ultra coarse	uc

(b) Abundance and Size Descriptors for Xenoliths (and Autoliths)

(iii)

Percentage range	Descriptor	Abbreviation
0	xenolith-free	x-free
> 0 – 5	very xenolith-poor	v-x-poor
> 5 – 15	xenolith-poor	x-poor
> 15 – 50	xenolith-rich	x-rich (or Kx)
> 50 – 75	very xenolith-rich	v-x-rich (or Kxx)
> 75	xenolith-dominated	x-dominated (or Kxxx)

(iv)

Size range	Modifier	Descriptor	Abbreviation
< 16 mm	-	microxenolith	mix
> 16 – 64 mm	small	macroxenolith	smax
> 64 – 256 mm	medium		mmax
> 256 – 1024 mm	large		lmax
> 1.0 – 4.1 m	small	megaxenolith	smex
> 4.1 – 16.4 m	medium		mmex
>16.4 m	large		lmex

Summary Guides - Diagrammatic Compilation

These desriptors can be applied irrespective of the textural-genetic classification of the rock in which they occur. These diagrams are not to scale.

(a) Abundance Descriptors for Crystals and Magmaclasts (and Xenoliths)

The abundance classes and descriptors are the same for all components including crystals, magmaclasts and xenoliths. Abundance classes for [crystals] are shown inside the white bars. Each box figure illustrates the cut-offs between the abundance classes using a range of component sizes.

- for magmaclasts substitute [magmaclast] for [crystal]
- for a mineral such as olivine substitute [olivine] for [crystal]
- for olivine macrocrysts substitute [olivine macrocryst] for [crystal]
- for accretionary clasts substitute [accretionary clast] for [crystal]
- for xenoliths substitute [xenolith] for [crystal]

(b) Size Descriptors for Crystals and Magmaclasts

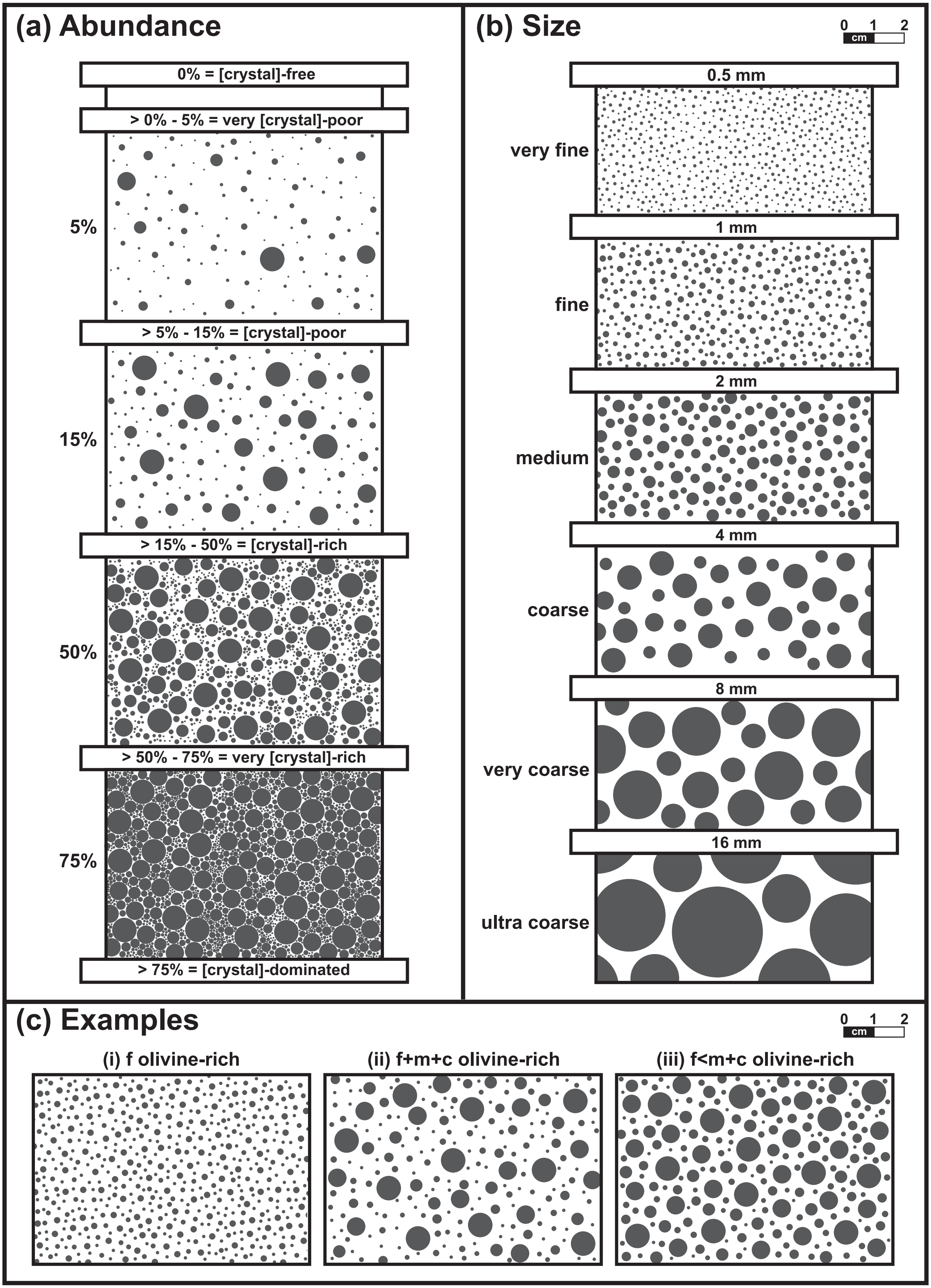
The size classes and descriptors are the same for crystals, magmaclasts and accretionary clasts; when relevant apply substitutions listed above. The size classes for xenoliths are different; for xenoliths, autoliths and epiclasts (see Table Compilation (iv) above). The cut-offs between the [crystal] size classes are shown inside the white bars. Each box figure illustrates the [crystal] size classes from very fine (vf) to ultra coarse (uc) using a range of sizes within each class (from Table Compilation (ii) above). The finer size classes of very very fine (vvf) to ultrafine (uf) are not illustrated. For reference, the abundances of crystals within each of these box figures are: very fine = 11%; fine = 18%; medium = 32%; coarse = 31%; very coarse = 54% ultra coarse = 69%.

(c) Schematic Example Rocks

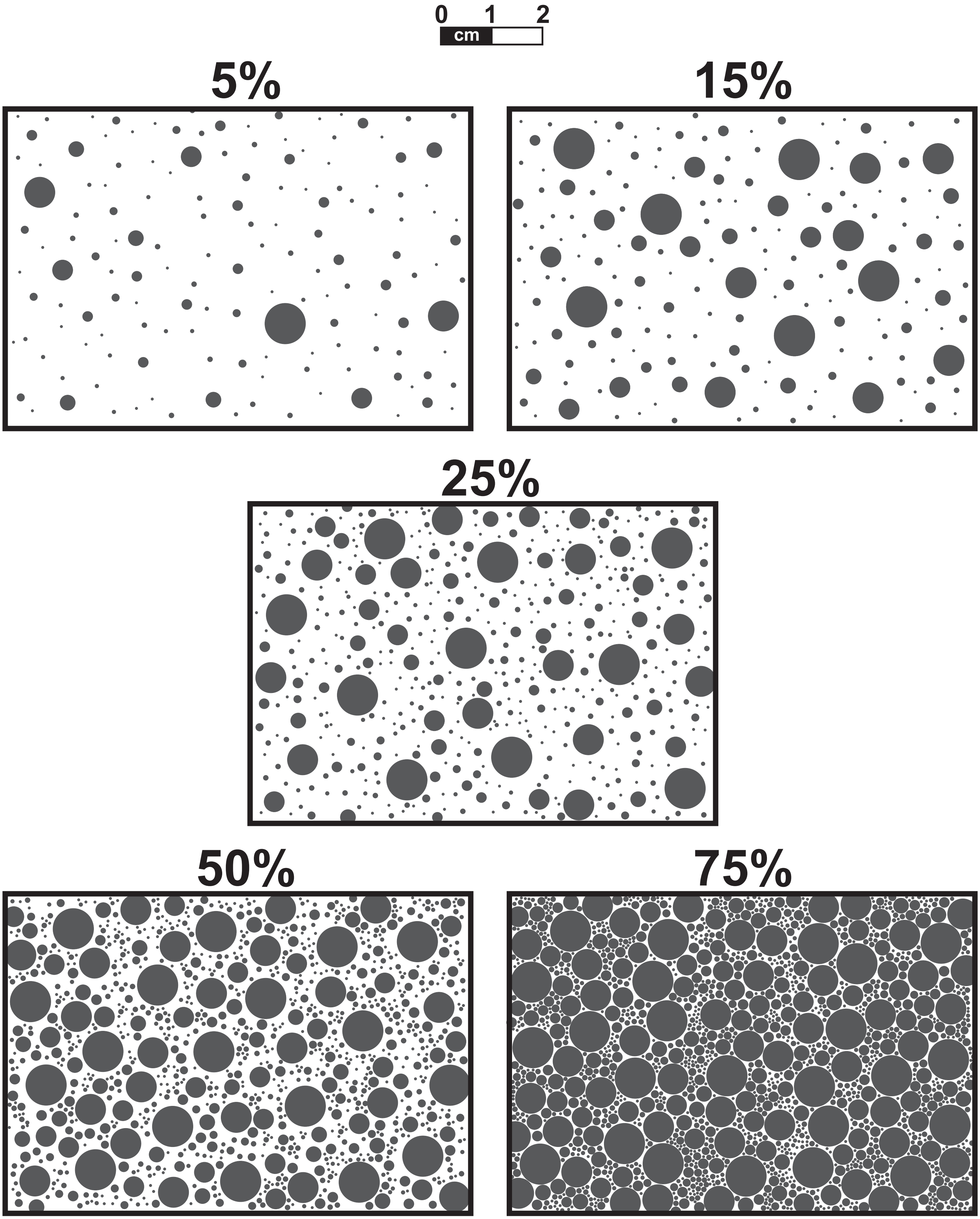
In this diagram three schematic example rocks are illustrated using box figures (i) to (iii) in which the black circles represent olivine crystals ≥ 1 mm in size and the title is the abbreviated olivine size and abundance descriptor (from Table Compilation (i) and (ii) above). The abundances of the depicted olivines are: (i) 18%; (ii) 25%; (iii) 39% and thus all the samples can be described as olivine macrocryst-rich or macrocrystic; it is implicit in the use of any size terms > 1 mm for olivine that they are macrocrysts. Example (ii) is a diagrammatic representation of a typical olivine macrocryst-rich hypabyssal kimberlite (as Page 6). Examples (i) and (iii) could be different emplacement products of such a magma which have undergone flow differentiation within a hypabyssal sheet, sorting during deposition from a pyroclastic eruption column or sorting during resedimentation. The very brief rock descriptors usefully summarise the differences in macroscopically observable olivine crystal content between these samples and can be used to predict diamond distributions within, and between, phases of kimberlite. The degree of economic interest increases from (i) to (ii) to (iii), reflected in the increased abundance and size of the olivine macrocrysts, assuming that they are predominantly mantle-derived.

(d) 25% Abundance of Mixed Grain Sizes ≥ 1 mm (Page 6)

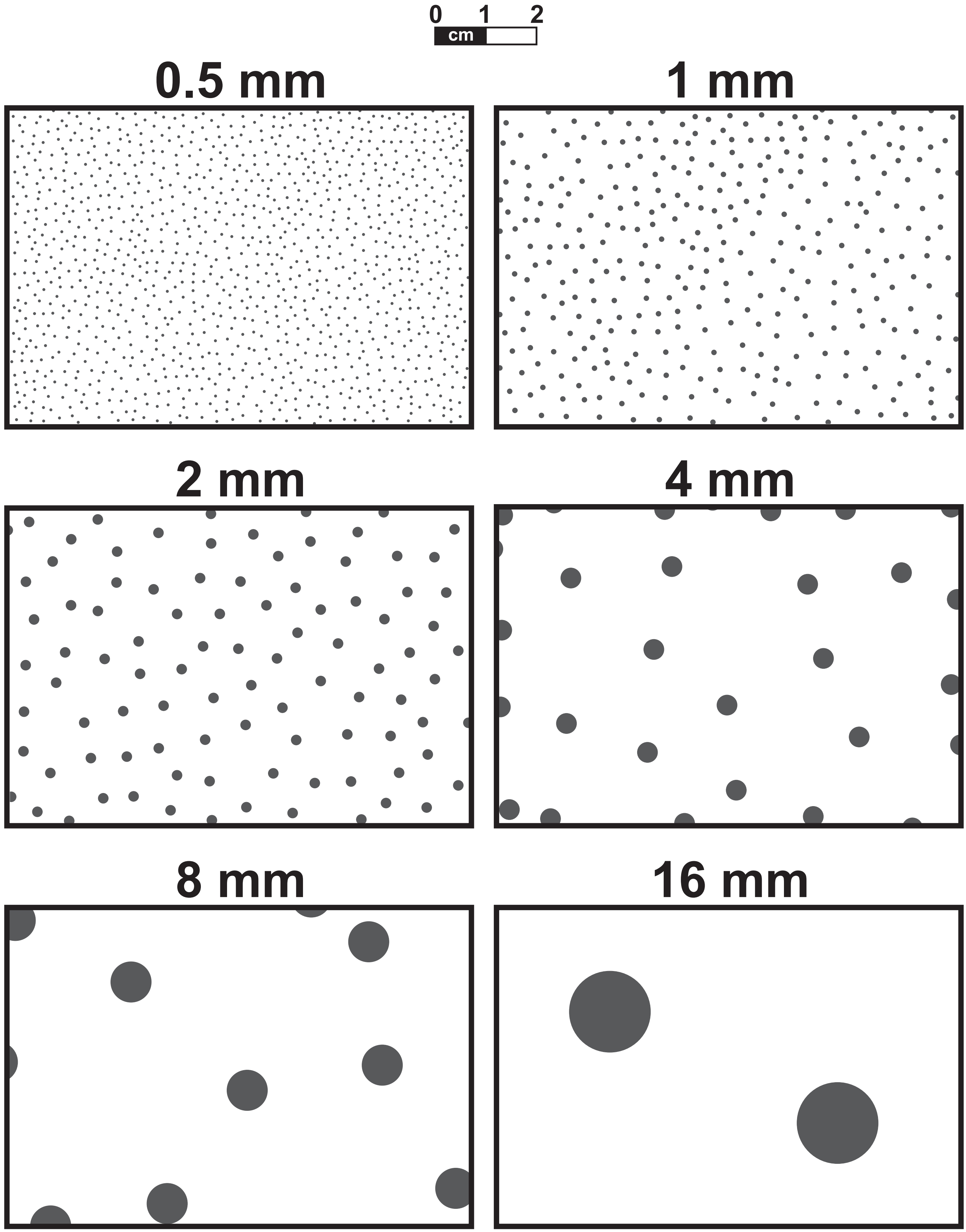
This diagram is a schematic illustration of the abundance and size of olivine macrocrysts in a typical hypabyssal kimberlite: ~25 modal % with a wide size range ≥ 1 mm (see also Page 4-5(c)(ii) above; Page, 9). Olivine macrocrysts range up to and can exceed 20 mm in size. Crystals in the upper end of the size range are typically not common (and may or may not belong to the megacryst suite). This diagram is used as a benchmark to assess economic potential of a kimberlite (or related rock) and, when diamonds are present, to assess the potential degree of modification to the distribution of diamonds during the emplacement of such magmas.


(a) Abundance
0% = [crystal]-free
> 0% - 5% = very [crystal]-poor
5%
> 5% - 15% = [crystal]-poor
15%
> 15% - 50% = [crystal]-rich
50%
> 50% - 75% = very [crystal]-rich
75%
> 75% = [crystal]-dominated
(b) Size
0 1 2
cm
0.5 mm
very fine
1 mm
fine
2 mm
medium
4 mm
coarse
8 mm
very coarse
16 mm
ultra coarse
(c) Examples
0 1 2
cm
(i) f olivine-rich
(ii) f+m+c olivine-rich
(iii) f<m+c olivine-rich

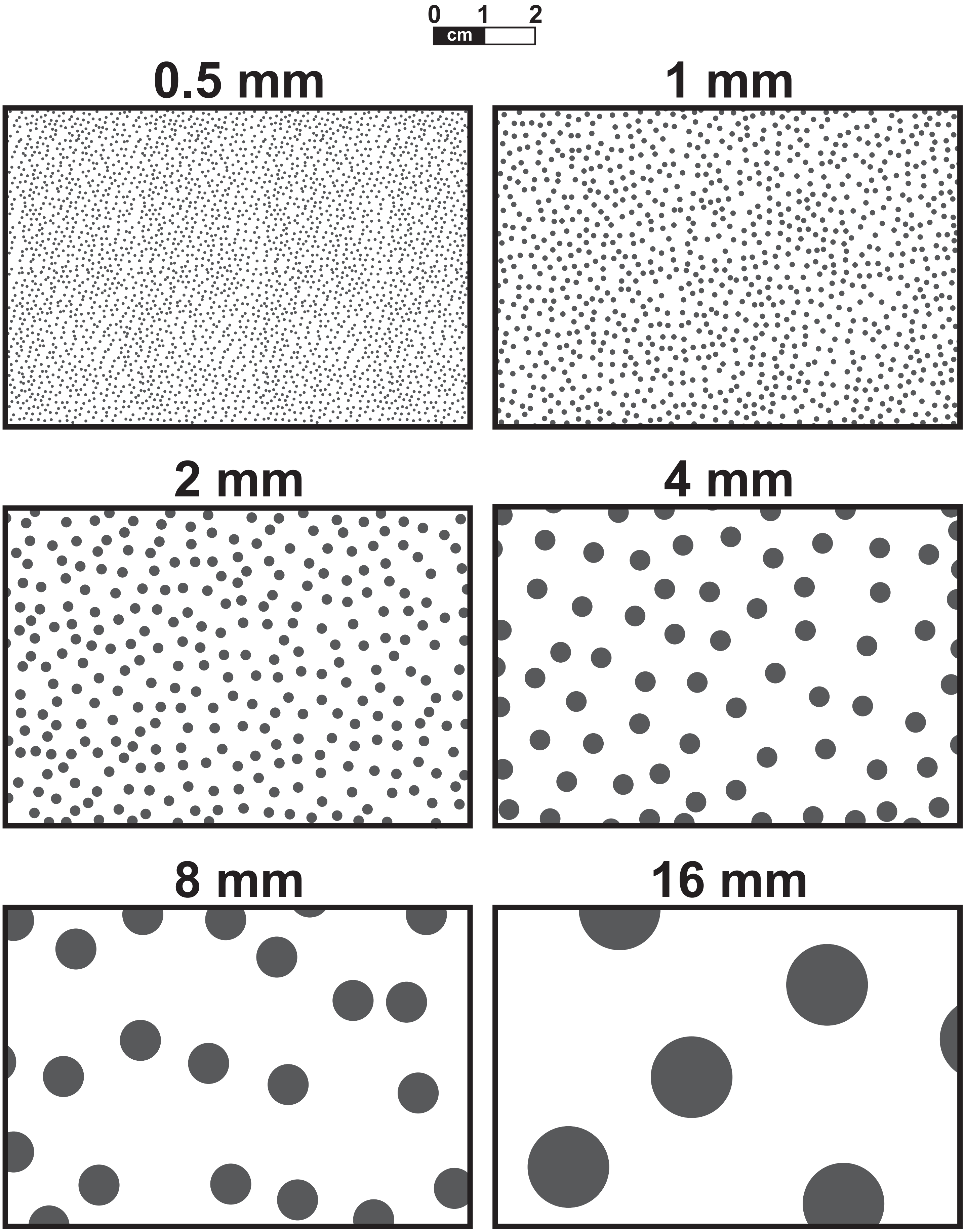
Abundances of Mixed Grain Sizes



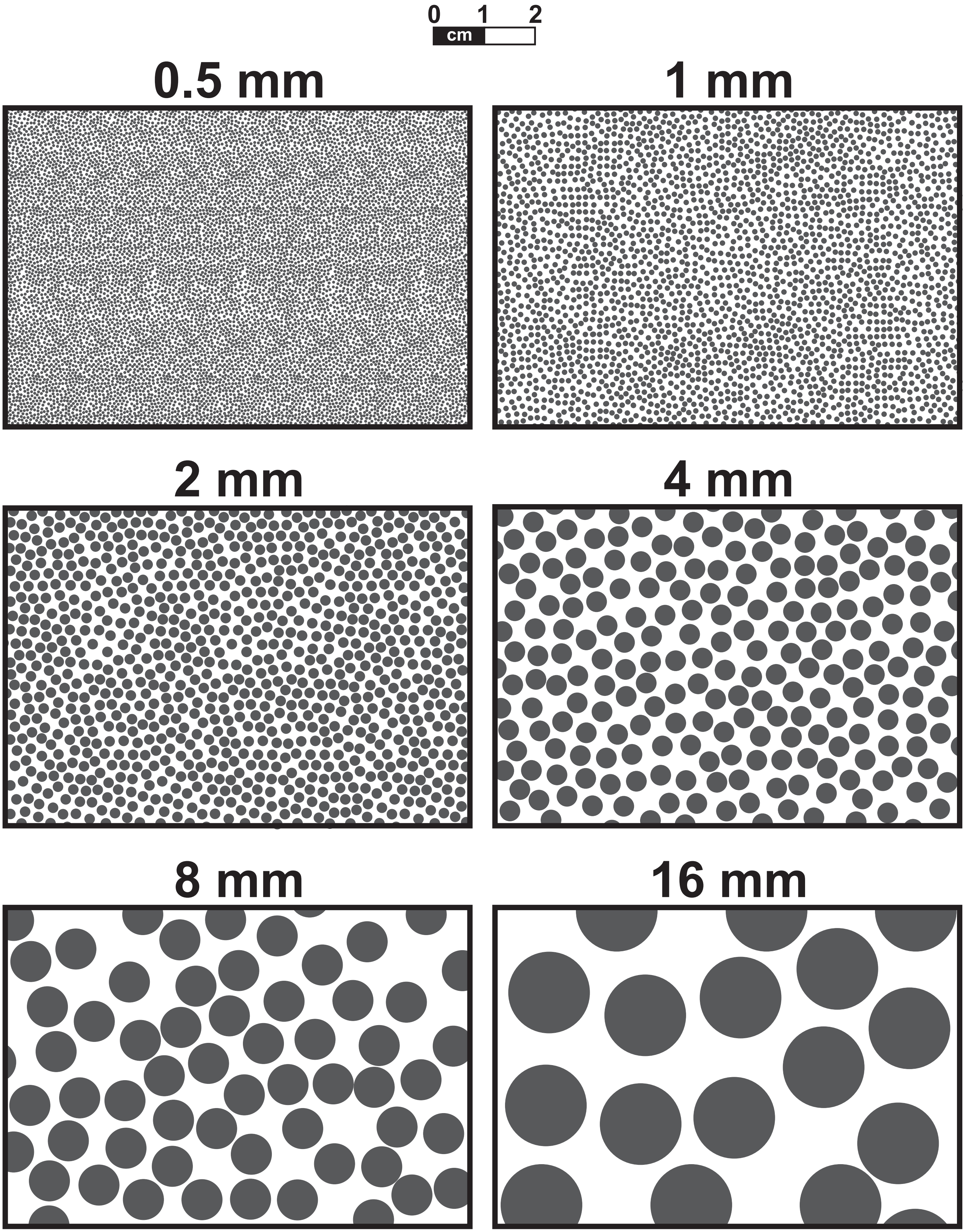
5% Abundances



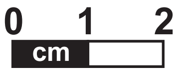
15% Abundances



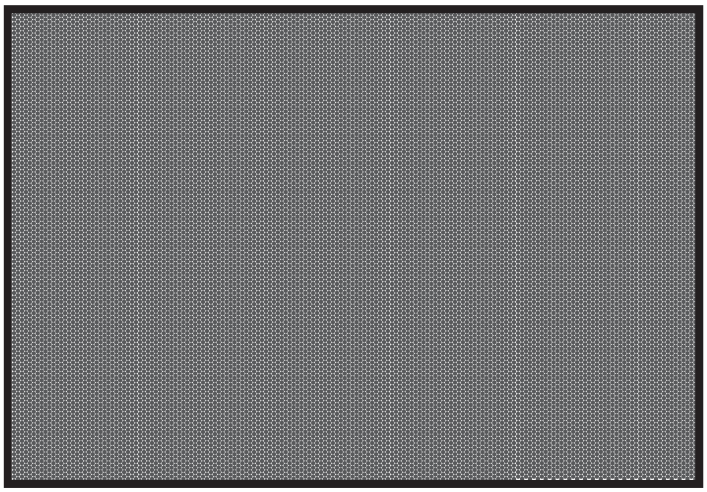
50% Abundances



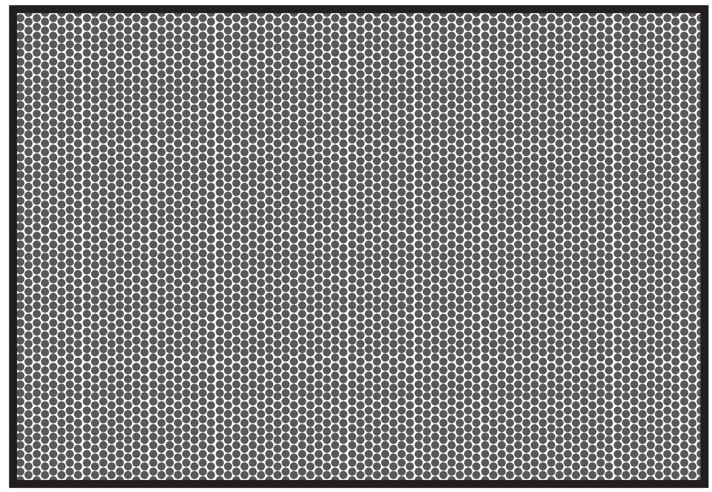
75% Abundances



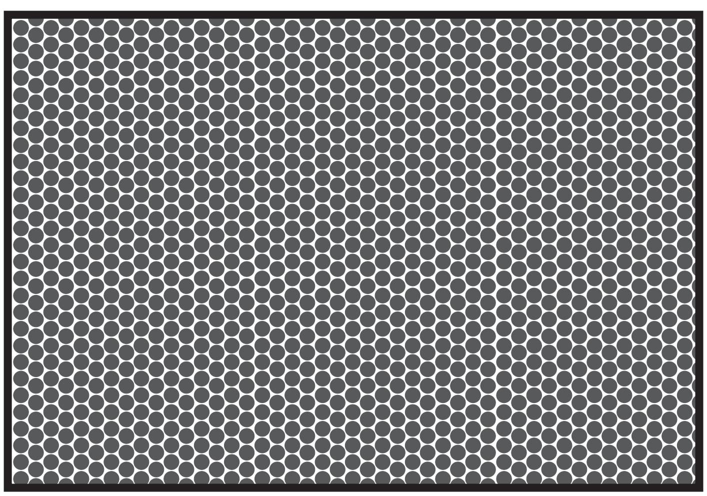
0.5 mm



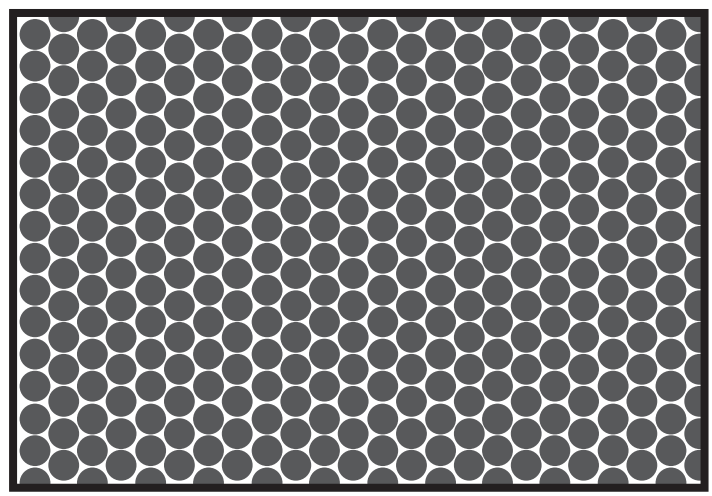
1 mm



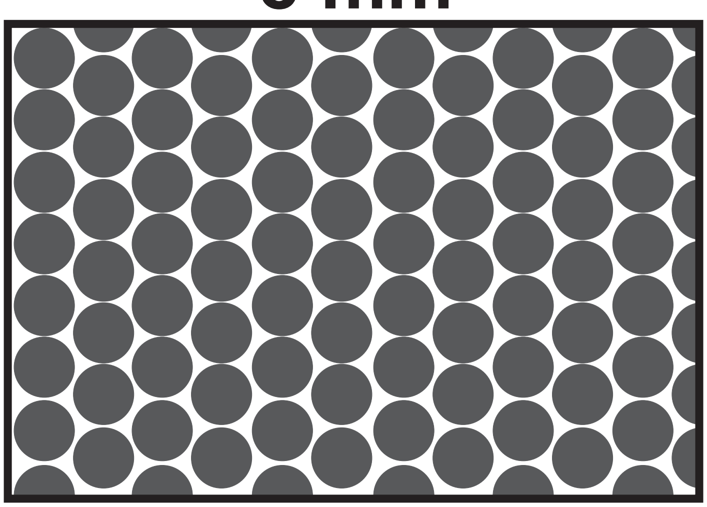
2 mm



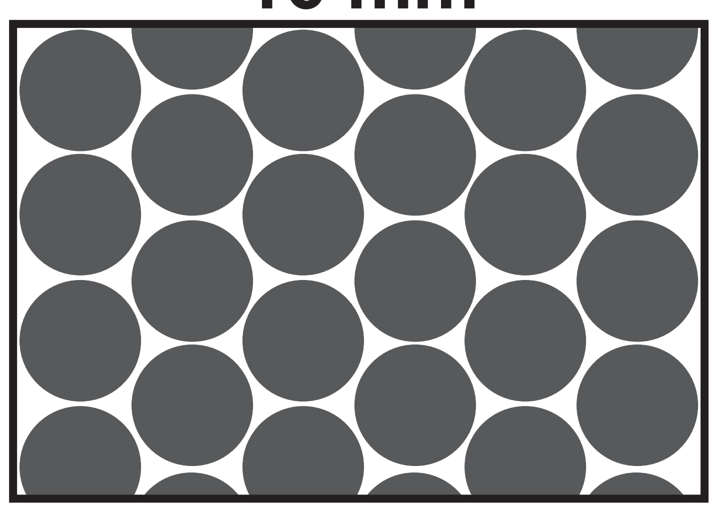
4 mm



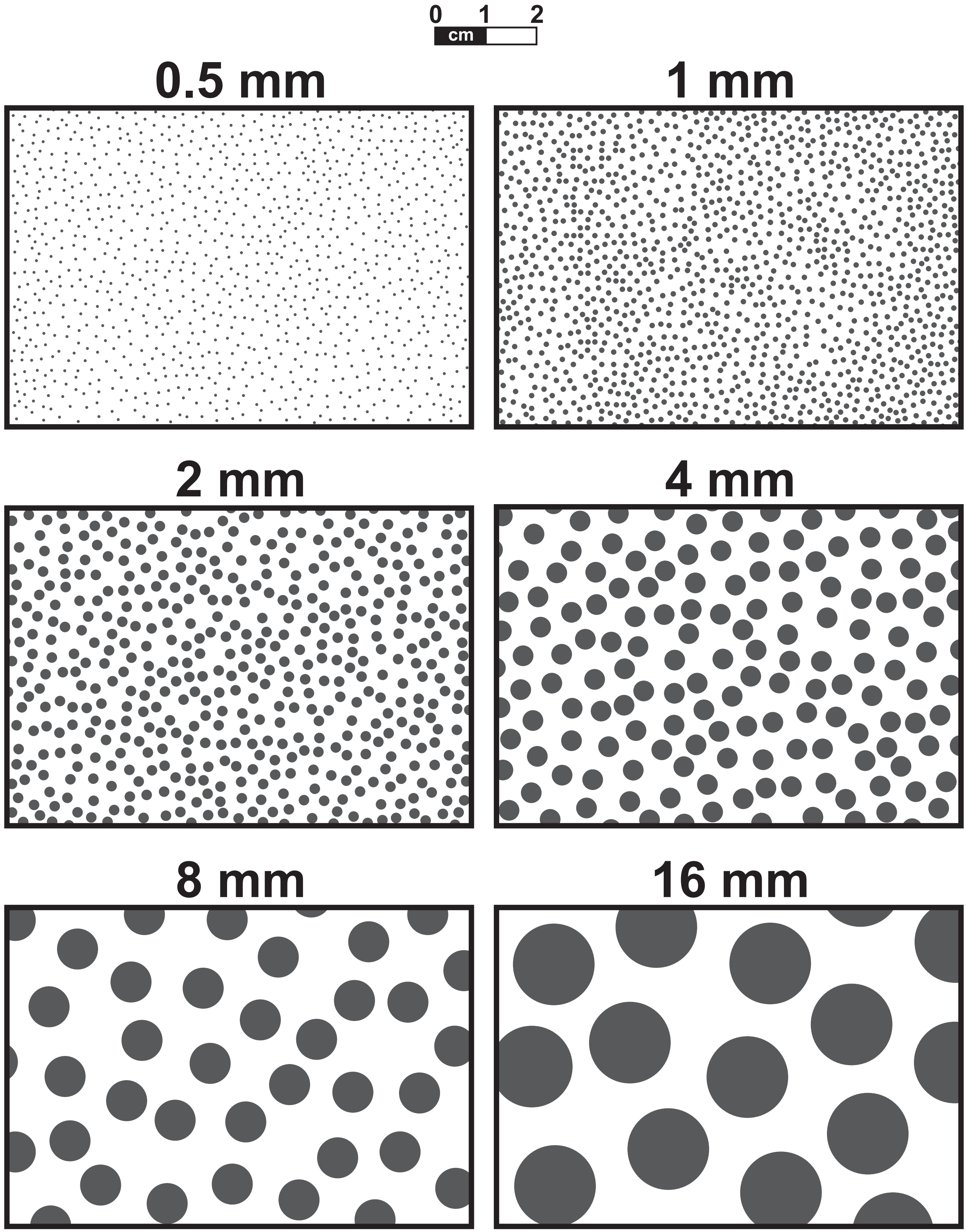
8 mm



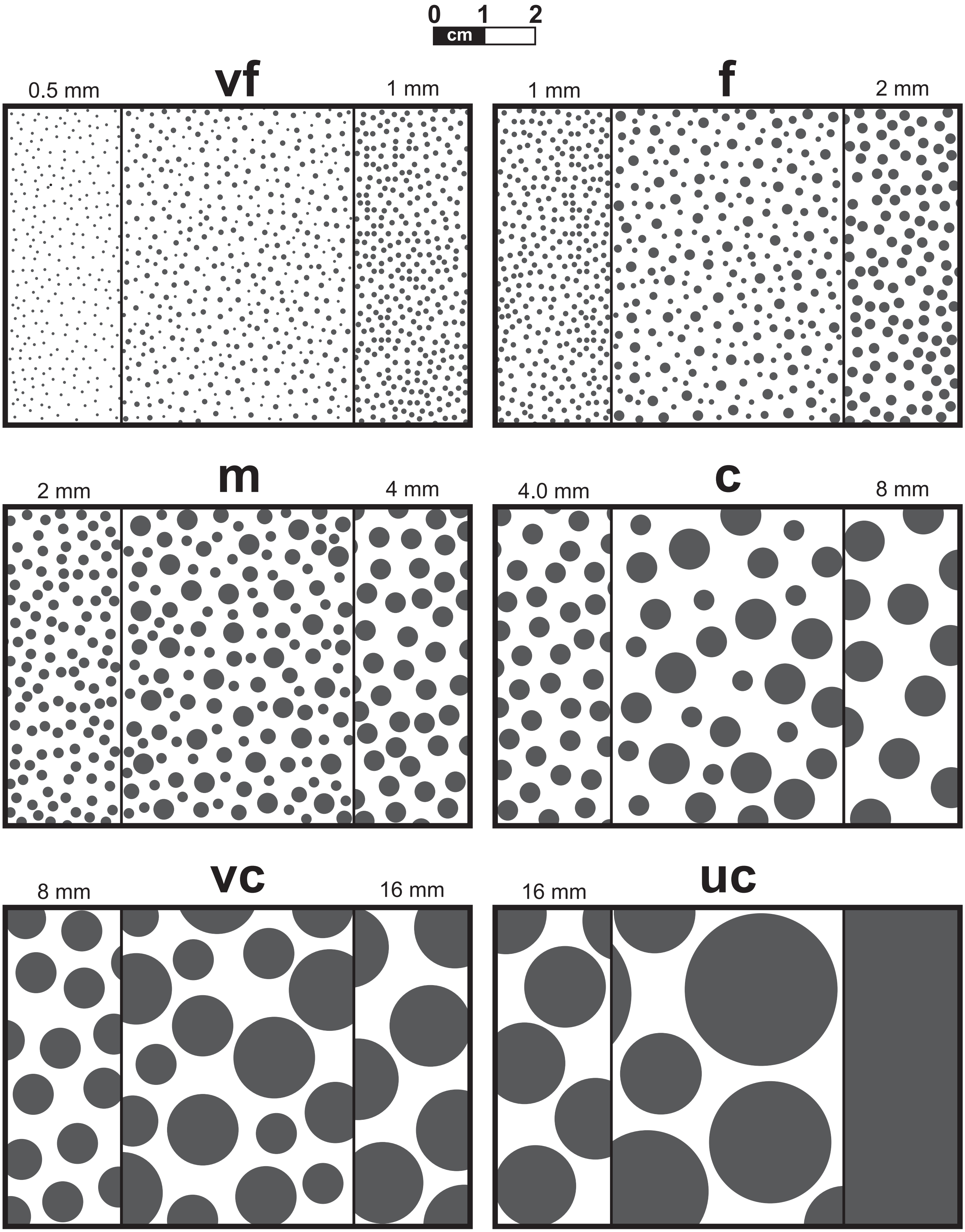
16 mm



Sizes of Crystals and Magmaclasts



Size Descriptors for Crystals and Magmaclasts



Size Descriptors for Crystals and Magmaclasts