C Kimberlites: how? why?

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MINERALOGICAL AND TEXTURAL-GENETIC CLASSIFICATION OF KIMBERLITES IN NORTHERN COLORADO AND SOUTHERN WYOMING, U.S.A.

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Accurate comparisons between kimberlites from different world-wide localities commonly are difficult to establish from the literature because no unified scheme of classification has been utilized. Mineralogical and textural-genetic classifications recently were developed by Skinner and Clement (1979) and Clement and Skinner (1979) in an effort to correct previous deficiencies in nomenclature. These classifications have been combined into a descriptive terminology scheme that is being applied to North American kimberlites (McCallum, 1981). Most Colorado-Wyoming kimberlites are phlogopite, calcite, serpentine, varieties, but opaque mineral, diopside, or perovskite rich types are abundant at some localities. Carbonatized kimberlite is common and silicified phases occur locally. All varieties are classified as diatreme and hypabyssal facies, any crater facies having been removed by erosion. Diatreme facies consist of tuffisitic kimberlite and tuffisitic kimberlite breccia with microlitic, and crystallinoclastic and segregationary textures. Autolithic types are abundant in some pipes and commonly reflect substantial compositional differences from host phases. Hypabyssal facies include both aphanitic and microporphyritic kimberlite and kimberlite breccia. Segregationary textures are common, and a pronounced flow layering is present locally. Wall rock breccia containing minor amounts of kimberlitic components occurs adjacent to several pipes and is characteristic of the hypabyssal or "root zone" facies. Names of specific kimberlite phases are established primarily on texture, and dominant matrix minerals are included as modifiers (e.g. tuffisitic calcite kimberlite breccia). (Study supported, in part, by Earth Sciences Section of NSF, Contract EAR-7810775)

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KIMBERLITE TEXTURES I

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The occurrence of hypabyssal- and diatreme-facies kimberlites in kimberlite pipes has long been recognized. In this contribution, the first of two companion papers, the range of textures exhibited by hypabyssal-facies kimberlites is described and the origins of the different textures are evaluated.

Particular attention is paid to the genesis of a variety of segregationary textures. The irregular to globular segregations in these rocks are commonly composed of the volatile-rich, late-crystallizing components of the kimberlites but relatively high temperature anhydrous minerals also occasionally occur in segregations. Volatile-rich segregations are ascribed to a variety of causes; some are interpreted as segregation vesicles (gas cavities filled by residual liquids) and others are regarded as direct segregations of melt. Most are, however, ascribed to condensation of gas-rich exsolved volatiles following varying degrees of vesiculation under conditions where the escape of the exsolved fractions was inhibited. The possibility that some segregations may relate to carbonate-silicate or silicate liquid immiscibility is examined.

The textures of rocks which are intermediate in character between hypabyssal- and diatreme-facies kimberlites are also described and their modes of origin assessed.

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KIMBERLITE TEXTURES II

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In this contribution, the second of two companion papers, the range of textures exhibited by diatreme-facies kimberlites is described and their petrogenesis is discussed.

Emphasis is placed on the pelletal textures which are characteristic of many tuffisitic kimberlite breccias. These textures reflect the occurrence of abundant pelletal lapilli which display a variety of internal and morphological features. Variations in the character of lapilli are evaluated in terms of an evolutionary scheme which incorporates an assessment of the degrees to which lapilli are formed prior to, or during, vapour-solid fluidization events which were triggered by explosive breakthrough to surface. Modifications of the lapilli by deuteric alteration or

post-fluidization crystallization, under stagnant conditions, are described. The formation of segregationary and uniform textures by post-fluidization crystallization of vapour condensates are also considered.

Some attention is paid to the effects of fluidization (and contemporaneous contamination of residual fluids during fluidization) on the mineralogy of diatreme-facies kimberlites.

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A NEW LOOK AT PRAIRIE CREEK, ARKANSAS

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Previous studies of the Prairie Creek occurrence have identified three main rock types namely; "volcanic breccias", "tuffs and fine-grained breccias" and hypabyssal kimberlite or peridotite. We take a new look at these rocks in the light of a suggestion by R.H. Mitchell (pers. comm.) that the body is not a true kimberlite but rather a lamproite.

Our investigation confirms the presence of three distinct rock groups which include both hypabyssal and crater-facies types. The so-called "volcanic breccia" and "tuffs" are both considered to be predominantly of pyroclastic origin. The "volcanic breccias" are subdivided into two sub-groups. One, composed of igneous lapilli set in a serpentinous base, is interpreted as a primary tuff. The other is thought to be a reworked tuff. The latter group is similar in many respects to the so-called "tuffs". These contain abundant comminuted and xenolithic material in addition to igneous lapilli. Certain features of these rocks are atypical of kimberlites.

The hypabyssal rocks contain two generations of relatively abundant olivine (Fo_{88-93}) in a fine-grained matrix composed of phlogopite, clinopyroxene, amphibole, perovskite, spinel and serpentine. Some phlogopite and serpentine crystallised from a glass. Although many petrographic features of these rocks are similar to those of kimberlites, the form of the euhedral olivine, presence of abundant glass and occurrence of potassic richterite are uncharacteristic of kimberlite but typical of lamproitic rocks. Both the groundmass phlogopite (4-5 wt.% TiO_2) and the bulk rock have compositions intermediate between lamproite and kimberlite.

It is concluded that the Prairie Creek intrusion is transitional between kimberlite and lamproite.

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POSSIBLE PRE-KIMBERLITE SERPENTINIZATION IN ULTRABASIC XENOLITHS FROM BULTFONTEIN AND JAGERSFONTEIN MINES, SOUTH AFRICA

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Textural analyses of garnet peridotites showing various degrees of deformation revealed an early generation of pre- and synkinematic serpentine that appears to predate kimberlite emplacement. In sheared nodules, serpentine fibers between recrystallized olivine and in fractured porphyroclasts and layers of orthopyroxene are consistently parallel with the planar fabric. Numerous porphyroclastic nodules have sets of serpentine-filled fractures perpendicular to the mineral elongation. In some porphyroclastic nodules random networks of serpentine-filled fractures are deformed near orthopyroxene and garnet porphyroclasts. Sections of xenolith-kimberlite contacts show that deformation-related fibrous serpentine veins may have been reopened and filled by a late generation of nonfibrous serpentine.

Time relationships between early serpentinization and K-metasomatism at Bultfontein are difficult to establish, though rare textures suggest that richterite may have overgrown olivine with serpentine-filled fractures. As some of the K-metasomatism is also synkimmatic, it is possible that the two are related. Recognition of a pre-kimberlite serpentinization overprint on anhydrous assemblages of diverse P-T conditions at Jagersfontein casts doubt on the interpretation that the two rock types were incorporated into the kimberlite at different depths. It raises the possibility that rocks originally equilibrated at different P and T became tectonically juxtaposed prior or during serpentinization preceding incorporation into the kimberlite.

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THE KOIDU KIMBERLITE COMPLEX, Sierra Leone.

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Three Kimberlite pipes, multiple dikes, and a small ring-dike complex of kimberlite occur in the Yengema-Koidu area. Dikes are both older and younger than the kimberlite pipes and a variety of textural, petrological, and mineralogical types characterize the complex. Discrete ilmenite nodules show evidence of coupled exsolution (ilm_{ss} from $geik_{ss}$) and subsolidus reduction (sp_{ss} from ilm_{ss}) associated with Cpy + Po+Pn. These ilmenites have 3-6 wt% MgO and 0.2-1.4 wt% Cr_2O_3. Redox reactions producing Mn-rich ilmenites (up to 16% MnO) and spinels (up to 1.2 wt% MnO are intimately associated with calcite. Ilmenites in Ilm-pyroxene intergrowths contain 10-12 wt% MgO and 0.8-1.5 wt% Cr_2O_3, and are associated with Jd pyroxene, sulfides, and trapped magmatic inclusions. Both diamond-bearing and non-diamond bearing eclogites are present, and metallic Fe has been identified in one eclogite. Discrete chlorite nodules (up to 5cm in size) and primary groundmass chlorite are highly oxidized (8-20 wt% [illegible]$_2O_3$, low in Al_2O_3 (9-10 wt%), and high in MgO (2[illegible]-28 wt%) Phylogopites low in Cr_2O_3 (0.05 wt%), TiO_2 (0.20 wt%) and high in FeO (7-8 wt%) have reversed pleochroism, and are mantled by normal pleochroic phlogopites high in Cr_2O_3 (1.5 wt%), TiO_2 (2-3 wt%), and low in FeO (4-5 wt%). Core phlogopites are preferentially replaced by chlorite. Bulk chemistry of dike and pipe kimberlites are markedly different in the ranges of composition: the former are tightly clustered (e.g. MgO= 2[illegible]-32 wt% CaO= 3-8 wt%, Al_2O_3= 2-4 wt%) whereas the latter are heterogeneous (e.g. MgO= 16-30 wt%, CaO= 2-18 wt%, Al_2O_3= 2-9 wt%). Volatile variations (CO_2 and H_2O) suggest that the earliest kimberlite magma (i.e. autolith) was H_2O enriched, that the later kimberlite was CO_2 enriched (i.e. autolith encasement) and that the host kimberlite (i.e. youngest) was intermediate. Preliminary paleomagnetic studies record paleovector directions