MINERALOGY OF MAGMACLASTS AND INTERCLAST MATRICES OF KIMBERLEY-TYPE PYROCLASTIC KIMBERLITES FROM THE KAO, LETSENG-LA-TERAE, LETHLAKANE AND PREMIER KIMBERLITE PIPES IN SOUTHERN AFRICA

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A particular assemblage of magmaclasts (aka pelletal lapilli) and type of interclast matrix are characteristic features of Kimberley-type pyroclastic kimberlites (KPK; aka tuffisitic kimberlites). This specific textural variety of kimberlite forms the dominant infill of the diatreme zone of a certain type of kimberlite pipe (Class 1) which are common in southern Africa but also occur elsewhere in the world. Regardless of their widespread occurrence, little is actually known regarding their detailed petrography and mineralogy. This study presents textural and mineral compositional data for the magmaclasts and interclast matrices for KPK from the diatreme zone of the following southern African kimberlites: Letlhakane; Premier; Letseng-la-terae; and Kao. Samples from the latter include the Gritty (formerly K1) kimberlite from which "pelletal lapilli" were first described by Clement 1973). Back-scattered electron images show that magmaclasts and interclast matrices are petrographically very similar to each other, regardless of locality or age, and to previously reported examples from Wesselton (Mitchell et al. 2009); the type area of Kimberley-type pyroclastic kimberlite.

Typically magmaclasts consist of a kernel of pseudomorphed macrocrystal olivine and a microcrystalline groundmass of variable thickness composed predominantly of microcrystalline diopside, phlogopite, and apatite with lesser perovskite and spinel. Although relict fresh olivine is present in some magmaclasts, the macrocryst kernels are typically replaced by several compositionally distinct generations of serpentine and/or chlorite. This multi-generational replacement cannot be the result of secondary processes unrelated to magmaclast formation as phlogopite in the microcrystalline groundmass surrounding the olivine kernels is ***not*** altered to chlorite. The replacement must rather represent one or more phases of deuteric alteration prior to the formation of the magmaclast groundmass. The Kao Gritty kimberlite has textural characteristics of being transitional to hypabyssal kimberlite rather being a bona fide KPK.

The outer margins of KPK magmaclasts are diffuse and grade into the interclast areas being mantled and decorated by microcrystalline prismatic diopside and/or mica; with some magmaclasts exhibiting modal zoning of these minerals. Interclast matrices in all kimberlites studied are dominated by chlorite with lesser diopside microlites. The chlorite in the interclast matrix is associated with relict phlogopite and is undoubtedly derived by the alteration of this mineral. Importantly this episode of chloritization did not affect micas in the magmaclasts and must have occurred subsequent to magmaclast formation. The common diopside of the magmaclast groundmass and mantles is considered to be a primary crystallizing phase and cannot be a secondary mineral unrelated to the kimberlite magma as: (1) country rock basalt xenoliths adjacent to diopside-bearing magmaclasts lack diopside mantles;, and (2) diopside cannot form at low temperatures from externally derived unrelated aqueous fluids. None of the interclast textures are typical of secondary replacement as observed in other diatreme infills such as those of the so-called Class 3 kimberlites and melilitites. It is considered impossible that the similar character of Kimberley-type-type pyroclastic rocks, on either a local, regional or world-wide basis, is the result of secondary alteration by externally-derived unrelated fluids, as such fluids are extremely unlikely to have a common composition and style of replacement of any pre-existing consolidated rocks.

Representative optical and back-scattered electron images of the KPK investigated are given below to illustrate the character of the magmaclast and interclast assemblages.

KAO GRITTY KIMBERLITE

Figure 1

Figure 2

Figure 1. Large magmaclast with relict fresh macrocrystal olivine kernel together with smaller subhedral serpentinized and chloritized olivines set in an optically un-resolvable matrix.
Figure 2. Typical "pelletal lapilli: as described by Clement (1973) consisting of core of euhedral-to-subhedral olivine set in an optically un-resolvable groundmass.

Figure 3

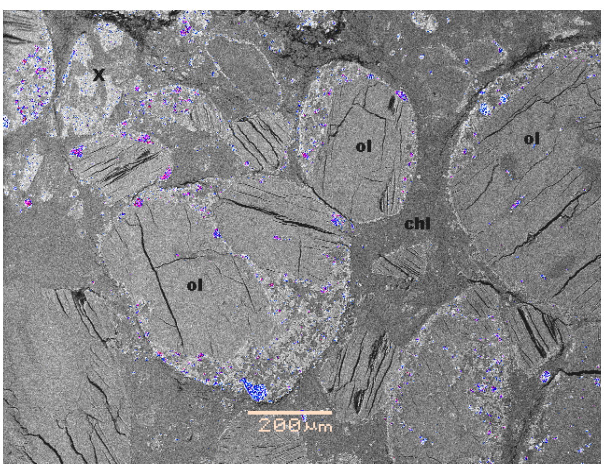


Figure 4

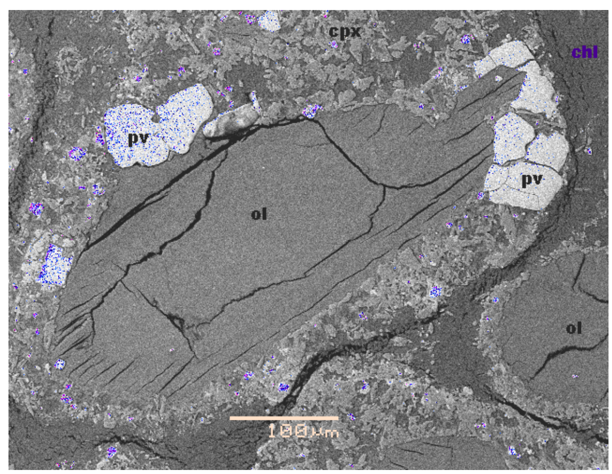
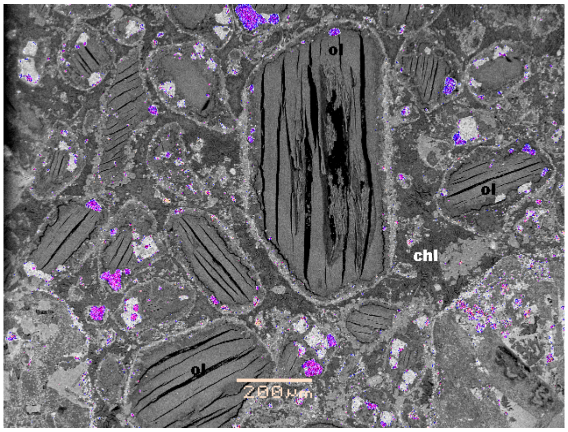


Figure 3. Typical magmaclasts with pseudomorphed olivine (ol) cores and mantle consisting mainly of diopside (grey), and phlogopite with apatite and perovskite. Also present is a clast of altered basalt which lacks any fringing diopside. Interclast matrix is composed principally of chlorite (chl)

Figure 4. Magmaclast with a core consisting of an intergrowth of perovskite (pv) and pseudomorphed olivine (ol). Mantle consists of diopside (cpx) and phlogpite (dark grey).

KAO QUARRY KIMBERLITE



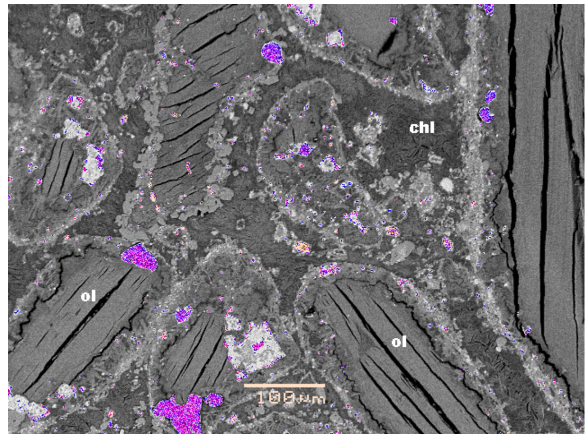


Figure 5 Figure 6

Figure 5. Pseudomorphed olivines (ol) mantled by aggregates composed dominantly of microcrystalline diopside with fresh phlogopite (see Fig 7). Also present are perovskite (purple) and hydroandradite plus titanite (white).

Figure 6. Detail of figure 6 showing mantles of microcrystalline diopside on pseudomorphed olivine. Also present are perovskite (purple) and hydroandradite plus titanite (white). The interclast matrix is composed dominantly of chlorite with relict phlogopite and minor diopside

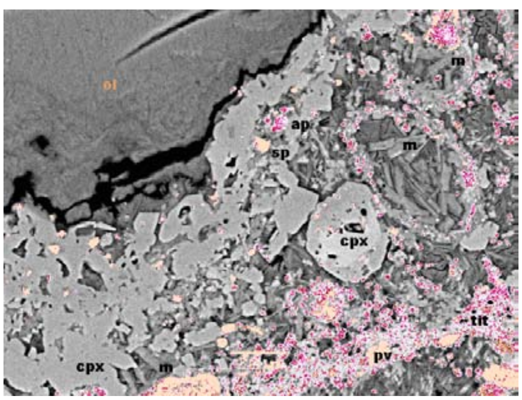


Figure 7. Detail of mantle surrounding a pseudomorphed olivine. Note the presence of abundant prismatic phlogopite (m) set in a chlorite matrix (dark grey). Also present are apatite (ap), spinel (sp), perovskite (pv) and titanite (tit; purple areas) .

It is not possible for the chlorite of the matrix to be introduced by secondary processes unrelated to the genesis of this KPK as the primary phlogopites would have be replaced by such a process.

LETSENG-LA-TERAE

Figure 8. Magmaclasts in Letseng KPK.
Note the different sizes and extent of development of the diopside-phlogopite mantles.The interclast-matrix is composed of chloritized phlogopite and aluminous chlorite.

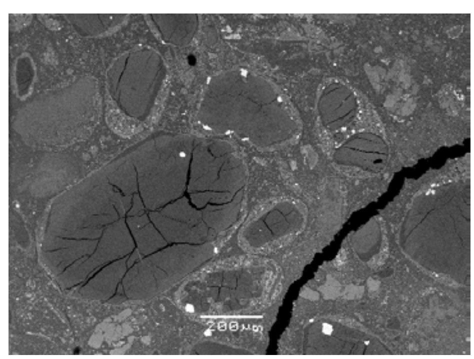


Figure 8

Figure 9. Interclast matrix in Letseng KPK.

Olivine macrocrysts are pseudomorphed by two generations of chlorite and mantled by microcrystalline diopside and fresh phlogopite. The mantles are gradational into interclast chlorite-3 and lesser amounts of microcrystalline diopside

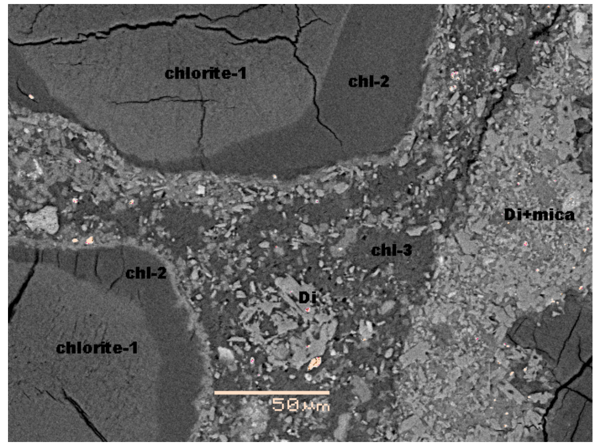


Figure 9

Figure 10. Cryptocrystalline mantle around olivine macrocryst in Letseng KPK.

Mantle composed of diopside (cpx), fresh phlogopite (m), and titanite (t) developed on a chloritized olivine macrocryst (CHL-1). Other minerals in the mantle are perovskite and magnetite (white). Interclast matrix is composed dominantly of chlorite (CHL-2).

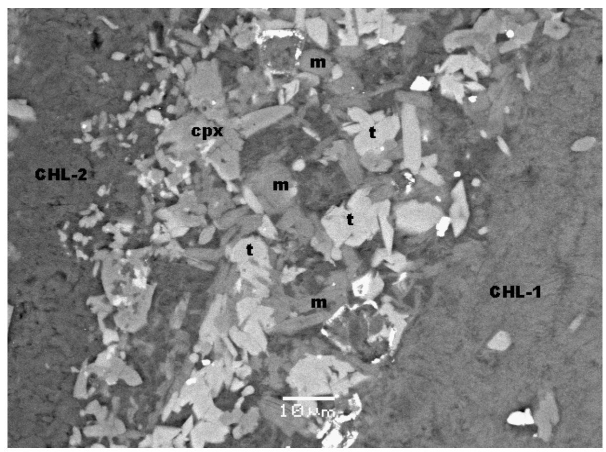


Figure 10

Figure 11. Interclast matrix, Letseng KPK.

Interclast matrix consists of diopside (cpx), fresh and partially chloritized phlogopite, with garnet, (g), set in a chlorite mesostasis (chl-2). The garnet is composed of a hydroandradite core (light grey) and a hydro-andradite-grossular rim.

Note the successive development of zones of cryprocrystalline diopside (cpx) and fresh phlogopite (m) on the chloritzed olvine macrocryst (chl-1). The cryptocrystalline mica has the same composition as the interclast phlogopite.

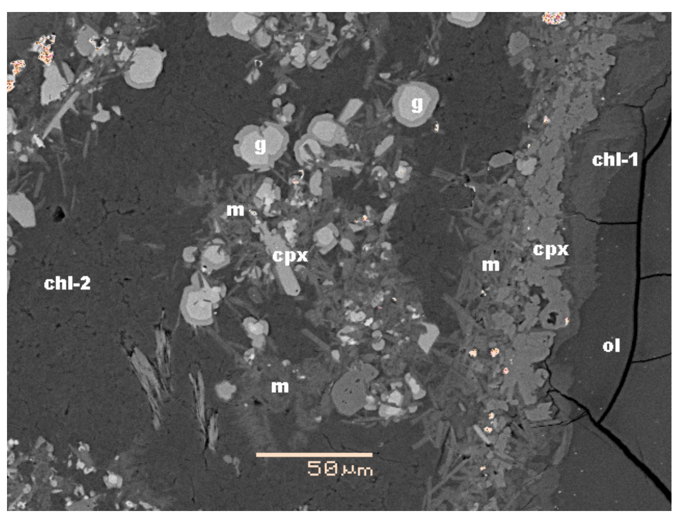


Figure 12. Interclast matrix, Letseng KPK.

Commonly, the interclast matrix in the Letseng K1-KPK contains abundant sprays of prismatic pectolite (p) . Its presence, together with hydro-andradite-grossular (g) suggests contamination of the magma forming the interclast matrix.. Note that fresh phlogopite is present within the interclast chlorite (chl-3) mesostasis.

Macrocrystal olivine forming the cores to the magmaclasts are pseudomorphed by two generations of chlorite (chl-1;chl-2) that are more aluminous than chlorite-3.

The macrocryst in the upper part of the figure contains abundant euhedral perovskite (pv) at the margin of the crystal

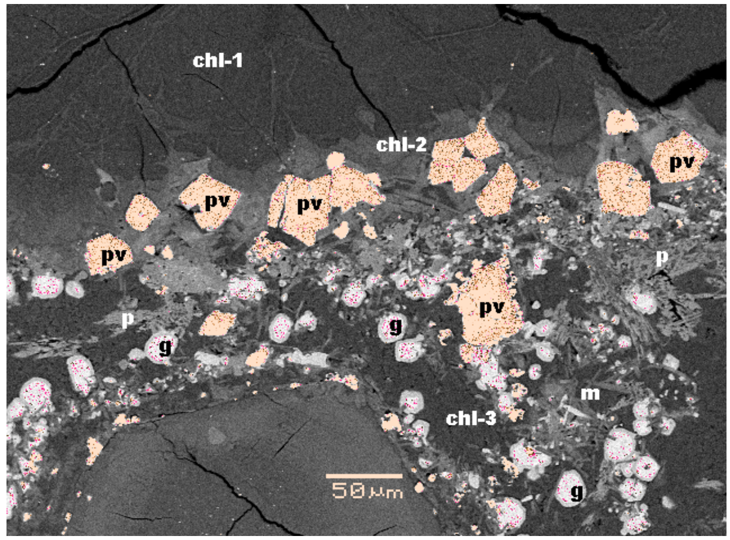


Figure 12

PREMIER GREY KIMBERLITE

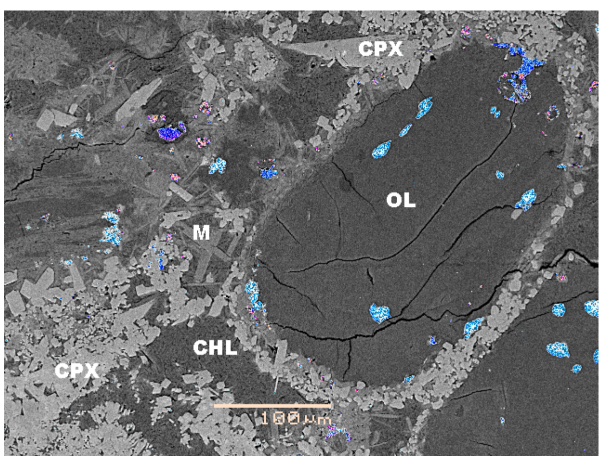


Figure 13

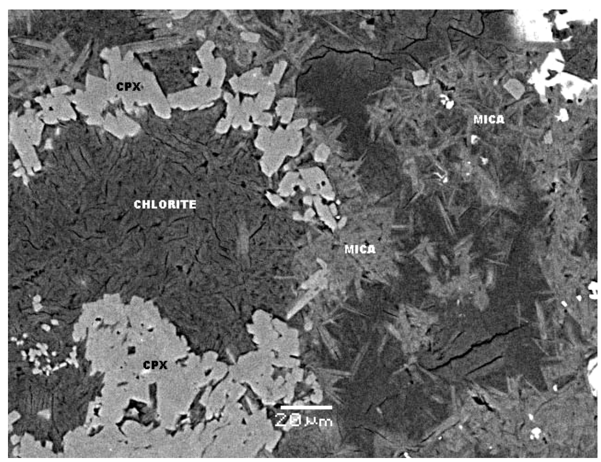


Figure 14

Figure 13. Diopside-rich (cpx) interclast matrix in Premier Grey KPK with late-forming fresh phlogopite. Also present is spinel (blue).

Figure 14. Interclast matrix in Premier grey KPK with diopside (cpx) and later -forming fresh phlogopite being transformed to K-bearing chlorite and ultimately to Al-chlorite. The relationships suggests that the interclast matrix was originally phlogopite-rich. None of these phases are considered to be secondary minerals replacing inter-clast ash or glass.

Clement, CR. 1973. Kimberlites from the Kao pipe, Lesotho. In: Nixon, PH (ed). *Lesotho Kimberlites*. Lesotho National Development Corp. Maseru, pp. 110-121/

Mitchell, RH., Skinner, EMW, Scott Smith, BH. 2009. Tuffisitic kimberlites from the Wesselton Mine, South Africa: Mineralogical Characteristics relevant to their formation. Lithos 112S, 452-464