# MINERAL CHEMISTRY OF THE PREMIER MINE KIMBERLITE

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The detailed crystallization history of kimberlite magmas still remains poorly understood compared to our knowledge of the xenoliths carried by these magmas. In the present study we have performed detailed microprobe analyses of oxide and silicate minerals occurring as phenocrysts, xenocrysts and matrix phases in a fresh kimberlite from the Premier Mine, South Africa.

The oxide minerals represent a complex yet systematic series of mineral assemblages. Picroilmenite (6-16% MgO) is the most distinctive kimberlite oxide mineral occurring as both inversely zoned and unzoned crystals. Typically, the inversely zoned crystals have MgO, $TiO_2$, MnO and CaO enriched rims with $Fe_2O_3$-rich cores, while $Cr_2O_3$, $Al_2O_3$ and FeO remain relatively constant from core to rim. However, in many instance, both FeO and $Fe_2O_3$ increase from rim to core with FeO/$Fe_2O_3$ remaining relatively constant. The larger picroilmenite grains may be chemically unzoned or erratically zoned with granoblastic textures. The picroilmenites are always mantled by perovskite and Ti, Mg, Cr, Al magnetites.

Textural evidence indicates that during the evolution of kimberlitic magmas picroilmenite undergoes a peritectic-like reaction with the liquid to produce these mantles of perovskite and Ti, Mg, Cr, Al magnetite. The perovskites comprising these mantles are slightly zoned with Cr-rich and Al-poor regions adjacent to picroilmenite and Cr-poor and Al-rich rims adjacent to the groundmass.

The presence of rutile in many mineralogical associations demonstrates its importance in the evolution of kimberlitic magmas. These rutile grains have $\sim$ 1% $Cr_2O_3$, $\sim$ 1% $Fe_2O_3$, $\sim$ 1% MgO, and 0.5% $Al_2O_3$. Rutile is common as lensoidal intergrowths within both the perovskites mantling picroilmenite and the picroilmenite itself. Often it appears that rutile has resulted by exsolution from picroilmenite. The occurrence of armalcolite associated with rutile and picroilmenite in South African kimberlites (DuToitspan) has been reported by Haggerty (1975). In some instances that we have examined, rutile and picroilmenite intergrowths may have resulted from the breakdwon of armalcolite. Rarely, rutile is found as a distinct crystal mantled by perovskite plus Ti, Mg, Cr magnetites. The other common occurrence of rutile is as inclusions within phlogopite crystals. Due to their encapsulation by phlogopite, these rutiles have not developed later crystallizing perovskite and Ti, Mg, Cr, Al magnetite reaction mantles.

Although some rutile grains may have been produced by exsolution from picroilmenite or decomposition of armalcolite into picroilmenite plus rutile, the rutiles associated with phlogopite crystals cannot be attributed to these processes. They are not associated with picroilmenite and must be crystallized directly from the kimberlitic magma.

Red chromium spinels are occasionally found in the groundmass or as inclusions within xenocrysts. Their chemical similarity to chromites from peridotite nodules as well as their mode of occurrence suggests a xenocrystic origin during ascent of the kimberlitic magma. When not enveloped by xenocrysts, the chromites are mantled by perovskite and Ti, Mg, Cr, Al magnetites.

The presence of opx, cpx, garnet, olivine and phlogopite megacrysts within the kimberlite matrix enables a comparison of xenocrystic and phenocrystic phases to be made. Diopside, opx and pyrope garnets are common in megacrysts but are not found as phenocrysts or groundmass minerals. However, both olivine and phlogopite are abundant as megacrysts and as groundmass minerals. It is possible to distinguish groundmass and phenocrystic phlogopites from xenocrystic phlogopites by higher $Cr_2O_3$, $Al_2O_3$, and lower FeO in the latter. It is also possible to distinguish two generations of olivines by microprobe analyses. Olivine megacrysts and xenocrysts ($Fo_{94-92}$) are distinct from the groundmass olivines which are more iron rich ($Fo_{90-88}$); the more fayalite rich rims of olivines have all been partially serpentinized. The groundmass is composed of serpentine, sulfide microphenocrysts, carbonate, perovskite and Ti, Mg, Cr, Al magnetite

During the early evolution of a kimberlitic magma at high pressure, minerals such as opx, cpx, olivine,garnet, phlogopite, and Mg-carbonates must be liquidus phases. Of these minerals, only olivine and phlogopite have extended crystallization intervals, continuing to crystallize at low pressure. Other minerals such as perovskite and Ti, Mg, Cr, Al magnetites are formed only during the groundmass crystallization of a kimberlitic magma; vast physiochemical changes must occur as evidenced by the changes in mineralogical associations.

Haggerty, S.E. (1975) The Chemistry and Genesis of Opaque Minerals in Kimberlite. Phys. Chem. Earth 9, 295-307.

| | PICROILMENITE | | RUTILE | PEROVSKITE | Ti,Mg,Cr,Al MAGNETITE | PHLOGOPITE | | OLIVINE | | CHROMITE |
|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | .11 | .09 | .02 | .02 | .09 | 42.24 | 43.02 | 39.93 | 40.31 | .06 |
| $TiO_2$ | 52.64 | 47.17 | 96.26 | 56.76 | 10.91 | .22 | .59 | .00 | .00 | .67 |
| $Al_2O_3$ | .54 | .57 | .40 | .47 | 1.73 | 9.41 | 12.17 | .21 | .14 | 10.88 |
| $Cr_2O_3$ | 2.68 | 2.24 | 1.33 | .01 | 7.16 | .02 | .62 | .01 | .00 | 57.16 |
| $Fe_2O_3$ | 7.41 | 16.25 | .48 | 1.07 | 43.15 | | | | | 4.90 |
| FeO | 22.66 | 22.45 | | | 27.79 | 8.36* | 2.82* | 11.83* | 8.40* | 13.25 |
| MnO | .48 | .39 | .01 | .04 | .54 | .04 | .00 | .09 | .08 | .21 |
| NiO | -- | -- | -- | -- | -- | .07 | .19 | -- | -- | -- |
| MgO | 13.43 | 11.04 | .61 | .00 | 8.94 | 23.76 | 25.74 | 47.93 | 50.42 | 13.14 |
| ZnO | .00 | .01 | .00 | .00 | .27 | .07 | .00 | -- | -- | -- |
| CaO | .32 | .00 | .21 | 39.96 | -- | .02 | .05 | .02 | .00 | .62 |
| $Na_2O$ | -- | -- | -- | -- | -- | .04 | .43 | -- | -- | -- |
| $K_2O$ | -- | -- | -- | -- | -- | 10.41 | 9.58 | -- | -- | -- |
| $P_2O_5$ | -- | -- | -- | -- | -- | .00 | .00 | -- | -- | -- |
| TOTAL | 100.27 | 100.21 | 99.32 | 98.33 | 100.58 | 94.66 | 95.21 | 100.02 | 99.35 | 100.89 |
| | Rim | Core | | | | Pheno | Xeno | Pheno | Xeno | |