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Orbicular oxides in carbonatitic kimberlites

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ABSTRACT

A renewed interest in mineral spheres that exhibit oscillatory layering is assured with the spectacular discovery of hematite beads in Meridiani Planum, Mars. The Martian "blueberries" are variously interpreted as sedimentary concretions, impact spherules, or accretionary lapilli. We draw attention to a possible alternative that the spheres of oxides are of igneous origin in carbonate-rich upper mantle systems. Two spherical oxide assemblages from cabonatitic kimberlites in the central Namibia (formerly South West Africa) volcanic field show similarities and contrasts to orbicular structures in carbonatites from Uganda, South Africa, Germany, Finland, and Russia. Structures have rapakivi appearances that bear upon the controversial issue of a relation between kimberlites and carbonatites. The first example is from a carbonatitic kimberlite adjacent to the Mukorob kimberlite (*sesu stricto*). Oblate spheroidal nuggets (2 × 1.5 × 0.5 cm) have olivine (now serpentine + calcite) cores with concentrically layered bands of ilmenite + calcite, and pedestals of ilmenite ($Ilm_{55}Geik_{40}Hem_5$) with intergranular calcite; the spheres are matrix-supported in massive ferroan calcite + serpentine, with minor apatite (F = 1.5 wt%) and barite. The matrix contains xenocrystic Mg-Al chromite (55 wt% Cr_2O_3) mantled by ilmenite ($Ilm_{51}Geik_{43}Hem_6$) but the dominant groundmass oxide mineral is Mg-Al-Ti (MAT) magnetite. The second example is from the carbonatite facies of the Hatzium kimberlite, and is also in a dike. MAT-magnetite pellets (2–3 cm) have alternating wide (~1 mm), and thin (~0.25 mm) bands of magnetite nucleated on a complex mixture of calcite (FeO = 0.1 wt%) and serpentine (4 wt% FeO, 0.5–1 wt% Al_2O_3). The matrix assemblage of serpentine + calcite + MAT-magnetite has mineral compositions similar to the spheroids, but is distinguished by abundant Ba-phlogopite and lesser apatite (F = 2 wt%). Phlogopite is strongly zoned in patches and bands, is kink-banded and contains inclusions of MAT-magnetite + calcite. The assemblage is typical of phoscorites (also known as camaforites) in other carbonatites, but the ilmenite spheroids appear to be restricted to Mukorob. Our interpretation is that both types result from the nucleation of immiscible liquids (a high-density and high-viscosity ore-carbonate-silicate component in a low-viscosity phosphoric carbonatite melt) on olivine or olivine + magnetite, assisted by frothing and slow degassing on decompression and dike intrusion.

Keywords: oxide orbicules, kimberlite, liquid immiscibility, magnetite, Martian blueberries, carbonatite, ilmenite, Namibia