MINERALOGY OF ULTRAMAFIC DIKES FROM THE SARFARTOQ, SISIMIUT AND MANIITSOQ AREAS, WEST GREENLAND: KIMBERLITES OR MELNOITES?

Mitchell, Roger H.[1], Scott Smith, Barbara H.[2], & Larsen, Lotte M.[3]

1. Department of Geology, Lakehead University, 955 Oliver Rd., Thunder Bay, Ontario, Canada P7B 5E1
2. Scott-Smith Petrology, 2555 Edgemount Blvd., North Vancouver, British Columbia, Canada V7R 2M9
3. Geological Survey of Denmark and Greenland (GEUS), Thoravej 8, DK-2400, Copenhagen, Denmark

Ultramafic dikes and sheets occur in several areas of West Greenland (Larsen & Rex 1992). The regions of Sisimiut (Holsteinsborg), Sarfartoq and Maniitsoq-Sukkertoppen contain three distinct groups of 600Ma old ultramafic dikes. The contemporaneous Sarfartoq carbonatite complex lacks ultramafic rocks but is the focus of a cone sheet of some of the Sarfartoq ultramafic dikes. All of the rocks described in this work have been previously been classified as kimberlites, in part because they have gross petrographic similarities to some archetypal kimberlites and host upper mantle-derived garnet lherzolite xenoliths (Larsen & Ronsbo 1993, Scott 1981). Diamonds have been reported both historically and recently from these areas of ultramafic dikes. Currently, central and south-west West Greenland are the focus of intensive diamond exploration. This study includes some of the newly discovered dikes and boulders from the Maniitsoq area which have recently been shown to contain diamonds and subcalcic Cr-pyrope (G10 garnet).

Classification of these rocks on a purely petrographic basis is difficult. On the one hand they have some similarities with kimberlite i.e. the presence of two generations of olivine plus groundmass spinel, phlogopite and perovskite, whereas on the other, on a modal basis, they might also be described using lamprophyre terminology as aillikite or alnoite. Some examples, poor in mica, could even be termed olivine spinel carbonatite. Consequently, the rocks may be regarded as falling in the region of petrographic convergence between the extreme variants of melnoite and kimberlite recognized by Scott (1995). From an economic viewpoint correct classification is critical as identification as melnoite would normally result in the province being given low exploration priority with respect to its diamond potential. Terminological problems may be resolved by resorting to mineralogical-genetic classifications of the type advocated by Mitchell (1995). This type of classification attempts to determine the magma type from which rocks are formed and permits discrimination between petrographically similar, but genetically distinct, rocks which might on a purely petrographic basis be inappropriately named.

The dike rocks exhibit an extremely wide variation in their xenolith/xenocryst content and modal mineralogy, resulting in part from the pronounced flow differentiation of their undoubtedly very low viscosity carbonate-rich parental magmas. Despite the modal variation, all of the rocks are mineralogically similar and composed essentially of primary olivine, spinel, phlogopite and carbonate. The principal petrographic differences are seen in the accessory and oxide mineralogy. Each group is of slightly different petrographic character, e.g. the Sarfartoq rocks are characterised by the presence of perovskite whereas this mineral appears to be absent in the Maniitsoq suite. Despite these differences, in terms of their overall mineralogy (see below) all of the rocks must be considered as being cogenetic.

All of the dikes contain macrocrysts of rounded fresh-to-partially serpentinized magnesian olivine. These are associated with microxenoliths of lherzolite and dunite and are in part undoubtedly derived by fragmentation of these rocks. Crystals lacking strain cannot be unambiguously classified. Some macrocrysts containing inclusions of Mg-ilmenite may be cognate. Others contain small droplets of Fe-Ni sulphides and may have inclusions of chromite. Macrocrysts may be unzoned, normally (e.g. mg# = 90.8 - 84.5) or reversely- (mg# = 77.9 - 83.7) zoned. Total range in mg# is 91.8 - 77.8; commonest is 90-84. In general these olivines are richer in Fe than those kimberlite. A mixed population of normal and reversed zoned crystals is unlike that found in kimberlite. Phenocrysts of euhedral-to-subhedral olivine are common and in some examples are the only primary silicate phase.

Microphenocrystal phlogopite occurs as anhedral-to-rectangular plates. Many crystals have thin red rims of tetraferriphlogopite. The cores of the crystals are pale yellow and very weakly pleochroic and show no optical zonation. All are Cr-poor (<0.05 wt.% Cr_2O_3) with low BaO contents (0.1 -1.1 wt.%). TiO_2 ranges from 1-3.5 wt %, Al_2O_3 from 11.5 - 17.0 wt.%, and FeO from 6.5 - 8.5 wt.% FeO_T. NiO is <0.1 wt.%. The evolutionary trend is from high Al and Ti to low Al, lower Ti and higher Fe. Tetraferriphlogopite rims are low in TiO_2 (<1.0 wt.%) and Al_2O_3 (<2.5 wt.%) and have very high FeO_T (15.0 -18.5 wt.%) at high MgO contents. Ba and Cr contents are low (<0.3 wt.%). The overall composition i.e. alumina enrichment, and evolutionary trends are unlike groundmass micas in kimberlite and members of the phlogopite-kinoshitalite series are absent.

Ilmenite is found as: anhedral inclusions in olivine macrocrysts; mantled macro/microcrysts; and euhedral groundmass laths. Inclusions in macrocrysts have a limited compositional range 10-12 wt.% MgO 2.7-5.0 wt.% Cr_2O_3, and <1 wt.% Al_2O_3, MnO, and Nb_2O_5, and are similar to spinel-mantled ilmenite in the same rock. All rocks are characterised by irregular macrocrysts and microcrysts of Mg-ilmenite mantled by zoned Cr-poor Mg-Ti-magnetite. The latter are compositionally identical to discrete primary groundmass spinels. Individual samples contain Mg-ilmenite of distinct compositional ranges. Large macrocrysts may have MgO-poor (10-12 wt.%) cores and are zoned towards MgO-rich margins (19-23 wt.%). Their is no correlation of Mg with Cr content and the most magnesian ilmenites may be poor (<1.0 wt.%) or rich (3-5 wt.%) in Cr_2O_3. The crystals may have rutile, PbS and ThO_2 inclusions but not spinel. Macrocrysts are interpreted to be high pressure cognate phases. Primary euhedral ilmenite in the groundmass contains 1-20 wt.% MgO and may be enriched in Mn and Nb relative to spinel-mantled ilmenite. In some instances quench-like aggregates of very fine grained cryptocrystalline prisms of Mg-free ilmenite occur in dolomite.

Spinel forms mantles on ilmenite and occurs as discrete euhedral-to-subhedral crystals in the groundmass. Atoll-textured spinels only very rarely present. The spinels are typically Cr-poor relative to kimberlite spinels and primarily members of the $MgAl_2O_4$ - Fe_2TiO_4 - Fe_3O_4 series. Many crystals contain anhedral-to-rounded discrete inclusions of Cr-poor $(Mg,Fe)Al_2O_4$ or subhedral cores of Al-rich chromite. Many crystals have outer mantles of Ti-magnetite or magnetite. Individual spinel crystals may be weakly-to-strongly zoned and particular dikes differ in the extent of zoning. The evolutionary trend follows that of trend 2 of Mitchell (1995) and is thus unlike that of spinels found in kimberlite.

Some rocks contain primary Cr-poor diopside. At Sisimiut these contain 1-4 wt.% TiO_2 and 1-6 wt.% Al_2O_3. At Sarfartoq they contain 1-2 wt.% TiO_2 and 1-2.5 wt.% Al_2O_3. The compositions suggest that they, in common with mica and spinel, crystallised from a relatively aluminous magma. Perovskite occurs as subhedral-to-rounded crystals and as a part of reaction assemblages around ilmenite macrocrysts. All are relatively pure $CaTiO_3$ perovskite. Not all dikes contain perovskite and in some instances perovskite has been replaced by an intimate intergrowth of Mg-free ilmenite, anatase and kassite. Apatite forms subhedral, commonly resorbed prisms, and irregular groundmass plates; most has crystallised subsequent to spinel and contemporaneously with groundmass carbonates. The apatite is poor in Sr and REE.

The mesostasis of the dikes is composed primarily of calcite plus dolomite in an emulsion or irregular intergrowth texture. Some dikes contain patches of serpentine. Other minerals present are: (Ca,Ti)-Zr-oxide (zirconolite?), (Ca,Ti)-Nb-oxide, ZrO_2 (baddeleyite), TiO_2 (rutile and/or anatase), kassite, thorite, strontiobarite, barite, celestite, strontianite, Sr(REE)-carbonate (ancylite?) galena, chalcopyrite, pyrite, Ni-pyrite, and djerfisherite.

The West Greenland ultramafic dikes differ markedly in their mineralogy from archetypal kimberlites in that they contain primary high Al-mica, Al-diopside, compositional trend 2 spinels (Mitchell 1995), and are enriched in late stage Sr-Ba minerals. They lack members of the phlogopite-kinoshitalite series and primary mica reacts in some instances with magma to form tetraferriphlogopite. Perovskite is low in abundance compared with *bona fide* kimberlites. It is concluded on the basis of this mineralogical-genetic classification that these rocks are NOT kimberlites, and that their mineralogical characteristics suggest derivation from an aluminous ultrabasic carbonated magma. It is suggested this magma is of melilitite composition as such magmas elsewhere evolve to produce similar ultramafic lamprophyres and form rocks containing mantle-derived ultramafic xenoliths. Against this hypothesis is the observation that melilitites and related rocks have not yet been found in this region. However, this may merely reflect a sampling bias as carbonate-rich rocks are resistant to weathering. Silicate rocks may have been deeply-weathered and not observed in reconnaissance work.

On the basis of the above it is concluded that the Sisimiut, Sarfartoq and Maniitsoq fields are not kimberlites but form a part of a previously unrecognized 200 x 100km province of alkaline magmatism in West Greenland. The dikes may be termed melnoites or ultramafic lamprophyres (*sensu lato)*, and as such may represent a carbonate-rich extreme variety of the melilitite clan. The presence of subcalcic Cr-pyrope and diamond in Maniitsoq dikes but apparently not in the Sisimiut or Sarfartoq rocks cannot as yet be explained. Although all dikes must have passed through the Archean cratonic crust at depth, only the Maniitsoq magmas appear to sampled and disaggregated, a diamond-bearing horizon. This province is now recognized as one of the few *bona fide* provinces of diamond-bearing melnoites or ultramafic lamprophyres; consequently it may contain economic melnoite!

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SEVENTH INTERNATIONAL KIMBERLITE CONFERENCE

Cape Town, April 1998

EXTENDED ABSTRACTS

All extended abstracts in this volume were submitted by the authors in camera ready form. There has been no editing of the extended abstracts and they have not been subject to review. The Organising Committee of the 7th International Kimberlite Conference takes no responsibility for authors' errors and omissions.

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