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Regional and Temporal Variations in the Magmatism of the Diamond Province of southern West Greenland

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Ultramafic lamprophyre (UML) dykes of "kimberlitic" affinity in terms of mega- and macrocrysts and xenoliths occur in many parts of Greenland. The classic occurrence is in southern West Greenland (WG) in the Sisimiut, Sarfartoq and Maniitsoq regions (Fig. 1). The dykes are 550-600 Ma. old (Secher et al., this volume). Collectively these regions are referred to as the Diamond province in southern West Greenland.

Previously, the dykes from the Sisimiut and Sarfartoq regions were referred to as kimberlites (e.g., Larsen, 1991). However, Mitchell et al. (1999) concluded on the basis of the compositional variation in groundmass phases that the dykes were not *bona fide* kimberlites, but aillikites (or melnoites if melilite was to be found). This questioned the diamond potential in the West Greenland occurrences and prompted a major investigation.

Scope of the present investigations

The present investigation is part of a major survey program that tries to establish the foundation for evaluation of the diamond prospectivity on the basis of the distribution of: magma types (this investigation), nodule assemblages (Sand et al., this volume), mega- and macrocryst assemblages (Steenfelt et al., this volume), age of the mag-matism (Secher et al., this volume), and evaluation of the diamond potential on the basis of P and T conditions in of the lithospheric mantle (Sand et al., this volume).

Following the suggestions by Mitchell (1995) and Tappe et al. (2005) the variations in magma types in the WG dykes is based on the groundmass (gdm) paragenses and the variation in the composition of gdm ilmenite, spinel and phlogopite.

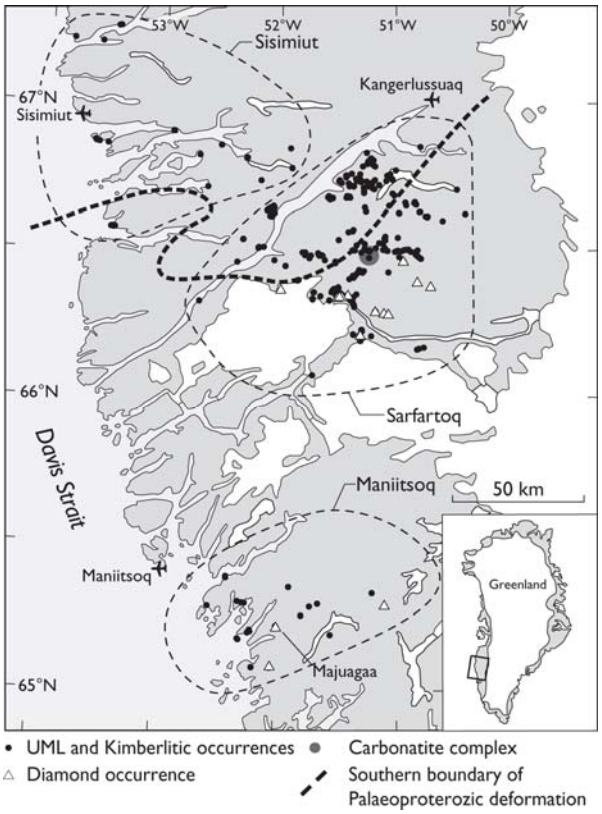

Fig. 1: The Diamond Province in southern West Greenland. Encompassing from N to S the Sisimiut, the Sarfartoq and the Maniitsoq regions.

Occurrences and analytical approach

Thirty-seven occurrences were selected for the investigation. The samples are representative for the dykes in: (1) the Archean craton (Maniitsoq), (2) in the border zone to the Palaeoproterozoic (Sarfartoq), and (3) in the Palaeoproterozoic terrains to the N (Sisimiut).

A large number of small (<100µm) grains and crystals were analysed by microprobe in one or more sample from the same dyke.

Groundmass parageneses

An initial sorting into petrographic (and compositional) types is based on the occurrence of gdm clinopyroxene, gdm chromite, the characteristics and proportion of gdm phlogopite, and euhedral gdm perovskite For practical reasons gdm grains and crystals are defined by a grain size <100 µm.

Hypabyssal kimberlites (Maniitsoq region) have no clinopyroxene, euhedral ilmenite, rare perovskite rims on spinel and rare pale translucent phlogopite with *no* tetraferriphlogopite rims. The melt in these dykes is kimberlitic, although carbonate rich (Nielsen & Sand, in press).

In general, the proportion of gdm phlogopite increases toward the Palaeoproterozoic border zone to the north and into the Palaeoproterozoic terrains. The phlogopite becomes increasingly brown and rimming by tetraferriphlogopite is abundant. Ilmenite disappears as a stable phase in the gdm and the proportion of carbonates is reduced, while clinopyroxene becomes a stable phase and chromite becomes abundant concurrently with an increase in the proportion of phlogopite and an increase in phlogopite-rich xenoliths (glimmerites). In phlogopite-rich samples the dominant Ti-phase (apart from spinel) is perovskite. The change from kimberlite in the Maniitsoq region to clinopyroxene-, and chromite-bearing, phlogopite- and perovskite-rich gdms of UML dykes in the Sisimuit region reflects a gradual change in the characteristics of the melts in the dykes.

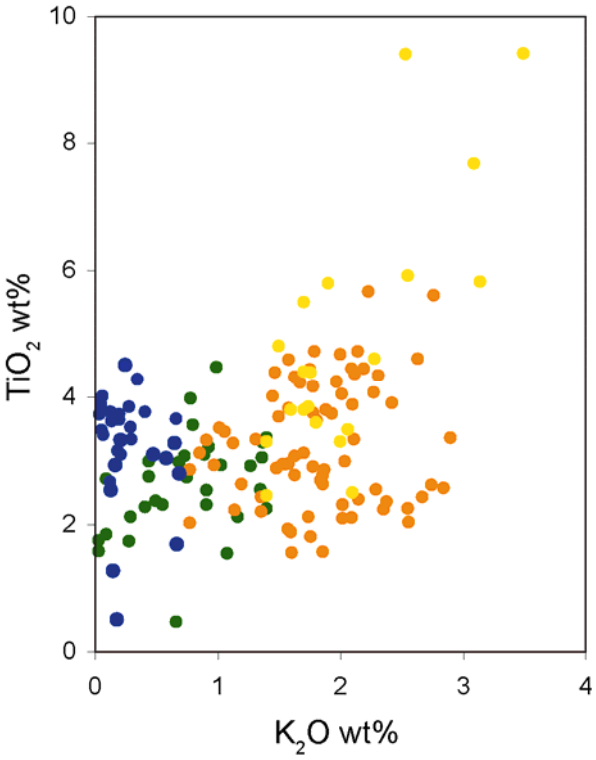

Fig. 2: Variation in kimberlites and ultramafic lamprophyres (aillikites) in K_2O vs. TiO_2 space (wt%) in Greenland and Canada. Maniitsoq kimberlites (blue); transitional UMLs Sarfartoq (green); Greenland UMLs (aillikites, orange); and Canadian UMLs (aillikites, etc; yellow; Tappe et al., 2004).

Empirically, gdms of the dykes are divided into three types: kimberlite, transitional UML (Trans-UML), and UML. The bulk rock compositions reflect the gradual change (e.g., increasing K_2O; Fig. 2) from kimberlite, over Trans-UML to UML. The time span for the magmatism is app. 550-600 Ma., but the kimberlites of the Maniitsoq region are 560+/-5 Ma. old and contemporaneous with the Sarfartoq carbonatite complex (Secher et al., this vol.)

Compositions of gdm phases

Ilmenite: Although the overlap is significant the general evolution is a systematic decrease in Mg-content from kimberlite to UML. The very high Mg-content (16-24 wt%) in ilmenite from kimberlite suggests ultimate preservation and risk of secondary growth of diamond. Ilmenite in Trans-UML (<16 wt%) are generally strongly resorbed and preserved due to an armour of euhedral spinel. The ilmenite is less Mg-rich and generally in the field of moderate diamond preservation. Ilmenite (<16wt% MgO) is rare and resorbed in UML gdm and generally assumed to be xenocrystic, as in Trans-UML.

Spinels of kimberlite are Mg- and Ti-rich magnetites (Fig. 2) of the so-called *magmatic trend* 1 (Mitchell, 1995). No chromites are recorded. In Trans-UML and in UML gdm spinel shows trends less Mg-rich and an abundance of chromite. The distinction between, on one hand, kimberlites of the Maniitsoq region and, on the other hand, Trans-UML and UML is very clear.

Phlogopite: The systematics in paragenesis and compositions of gdm ilmenite and spinel are paralleled by phlogopite. The minor phlogopite of Maniitsoq region kimberlite gdms are Al-rich and Fe- and Ti-poor, without tetraferiphlogopite rims (fig. 4). They show a characteristic Ba-enrichment. In Trans-UML to UML of the Sarfartoq and Sisimiut regions phlogopite cores become increasingly Fe and Ti rich and tetraferri-phlogopite rims are always developed. Ba contents remain low in rims, probably due to crystallisation of baryte.

General observations and conclusions

1: The dykes in the Maniitsoq region, located well inside the Archean craton are all typical hypabyssal kimberlites, even though they do not contain monticellite (Nielsen & Sand, in press).

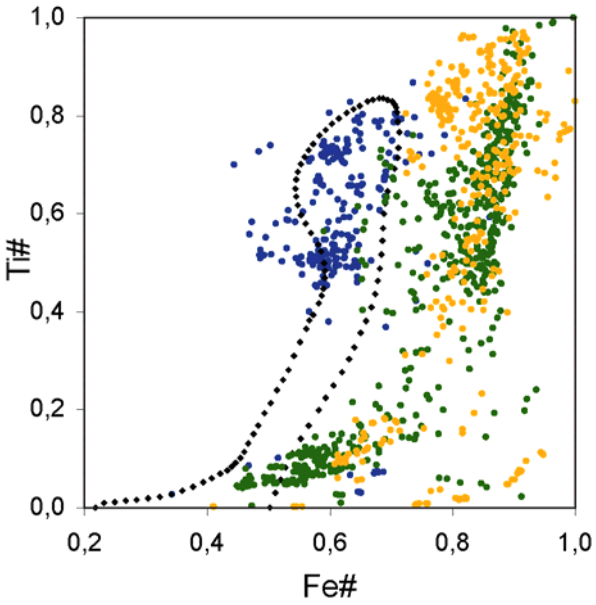

Fig. 3: Variation in the composition of groundmass spinel in kimberlites from the Maniitsoq region (blue), and transitional-UML and UML from the Sarfartoq region (green) and from the Sisimiut region (orange). Fe# = FeOt/(MgO + FeOt) (wt%); Ti# = Ti/(Ti + Al +Cr).

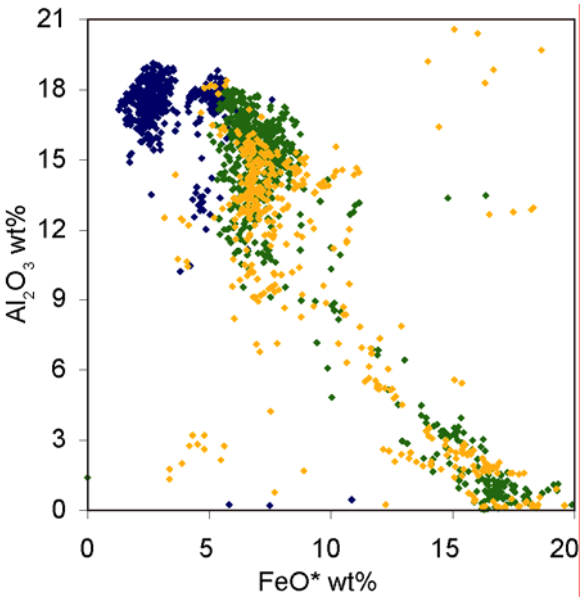

Fig. 4: Variation in the composition of groundmass phlogopite in: Maniitsoq kimberlites (blue), transitional UMLs ands UMLs from Sarfartoq (green) and Sisimiut (orange).

2: The dykes from the Sisimiut region well inside the Palaeoproterozoic terranes are all UMLs. The UMLs are similar to the Torngat and Aillik Bay dykes Tappe et al., 2004, 2006).
3. The dykes in the Sarfartoq region across the Archaean/Proterozoic border zone are Trans-UML and UML.
4: The range from kimberlite to UML is paralleled by the nodule assemblage. Phlogopite-rich nodules are apparently only found in Trans-UML and UML dykes.
5: A direct relationship appears to exist between type of gdm paragenesis and thus melt composition, and xenolith assemblage. This suggests a lithospheric mantle control over the composition of melts. The H_2O:CO_2 ratio and oxygen fugacity increase toward and into Palaoproterozoic lithosphere reflecting a gradual change in metasomatic environment from CO_2-rich in the Archean to more H_2O rich across the border zone and into the Palaeoproterozoic domains.

References

Larsen, L.M. (1991): Occurrences of kimberlite, lamproite and ultramafic lamprophyres in Greenland. Geol. Surv. Greenland, Open File Series 91/2, 36 pp.

Mitchell, R.H. (1995): Kimberlites, orangeites and related rocks. Plenum Press, New York, USA.

Mitchell, R.H., Scott-Smith, B.H. & Larsen, L.M. (1999): Mineralogy of ultramafic dikes from Sarfartôq, Sisimiut and Maniitsoq area, West Greenland. In: Proceedings of the VII[th] International Kimberlite Conference (J.J. Gurney, J.L Gurney, M.D. Pascoe, & S.H. Richardson eds.) 2, 574-583. Red Roof Design, Cape Town.

Nielsen, T.F.D. & Sand, KK (2008): The Majuagaa kimberlite dike, Maniitsoq region, West Greenland: constraint for an Mg-rich silicocarbonatite melt composition from groundmass mineralogy and bulk composition. Canadian Mineralogist

Sand, K.K., Waight, T., Nielsen, T.F.D. Pearson D.G., Makovicky, E., M. Hutchison, E.M. (2008): Four-phase geothermobarometry on mantle xenoliths from West Greenland: assessment of P/T-formulations and implications for diamond potential. Extended Abstract No. 9IKC-A-00146, 2008

Secher, K., Nielsen, T.F.D., Heaman, L.M., Jensen, S.M., Schjøth, F. (2008): Emplacement patterns of kimberlites and ultramafic lamprophyres in an alkaline province located 64º-67ºN in southern West Greenland – Evidence from 40 new robust age analyses. Extended Abstract No. 9IKC-A-00146, 2008.

Steenfelt. A., Jensen, S.M., Nielsen, T.F.D., Sand, K.K. (2008): Regional distribution patterns of minerals and chemical components in surface media reflecting and characterising occurrences of kimberlite, ultramafic lamprophyre and carbonatite in West Greenland. Extended Abstract No. 9IKC-A-00178, 2008

Tappe, S., Jenner, G.A., Foley, S.F., Heaman, L., Besserer, D., Kjarsgaard, B.A. & Ryan, B. (2004): Torngat ultramafic lamprophyres and their relation to the North Atlantic alkaline province. Lithos 76, 491-518.

Tappe, S., Jenner, G.A. & Kjarsgaard, B.A. (2005): Integrating ultramafic lamprophyres into the IUGS classification of igneous rocks: rational and implications. J. Petrol. 46, 1893-1900.

Tappe, S., Foley, S.F., Jenner, G.A., Heaman, L.M., Kjarsgaard, B.A., Romer, R.L. Stracke, A., Joyce, N. & Hoefs, J. (2006): Genesis of Ultramafic Lamprophyres and Carbonatites at Aillik Bay, Labrador: a Consequence of Incipient Lithospheric Thinning beneath the North Atlantic Craton. J. Petrol. 47, 1317-1343.