DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2007/77

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Mineral resource assessment of the Archaean Craton (66° to 63°30'N) SW Greenland Contribution no. 4

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Contents

Abstract

The report describes the 2006 discovery and investigation of kimberlite-like ultramafic lamprophyre (UML) rocks during GEUS surveys on a 10 km^2 large nunatak in the Inland Ice, about 140 km south-east of Nuuk. A large number of erratic boulders were discovered in a side moraine along the northern edge of the nunatak. The source of the boulders is unknown, as no in situ UMLs have yet been observed, neither on the nunatak nor within the ice-free land area to the west. Nunatak 1390 is located in the Tasiusarsuaq terrane within the Inland Ice east of the region Alangorlia, and is dominated by a metamorphic volcanic succession, north-east-striking and dipping steeply to the north-west. The Tasiusarsuaq terrane is characterised by mafic rocks (amphibolite), tonalitic gneiss and granodiorite yielding ages of 2.92- 2.86 Ga. No signs of in-situ occurrences of UMLs are known. Investigations of compositions of groundmass phases in the samples from Nunatak 1390 suggest that the rocks could not have been kimberlitic in nature. Additionally, pressure and temperature estimated on mantle peridotite xenoliths yield conditions of last equilibration above the field of diamond stability. Finally, a caustic fusion diamond test failed to recover any diamonds. The diamond potential of these rocks is suggested to be low.

Introduction

A new and exciting discovery of UML was made in 2006 during the GEUS investigation of supracrustal rocks on a 10 km^2 large nunatak in the Inland Ice, about 140 km south-east of Nuuk. Here, a large number of boulders and floats were discovered in a side moraine along the northern edge of the nunatak (Figure 1). The floats occur over a distance of 600 m and are up to ~1 cubic metre in size. They contain many xenoliths of crustal and mantle origin. The source of the boulders is unknown, as no in situ UMLs have yet been seen, neither on the nunatak nor within the ice-free land area to the west of the nunatak. This combined with the discovery of the Jurassic Tikiusaaq carbonatite complex with related UMLs (Steenfelt et al. 2006) 50 km to the north-west of the Nunatak 1390, did that the region was suggested to have a potential for new kimberlitic occurrences.

The area was re-visited during the fieldwork in 2007, where similar rock-types were found on nunataks S and SW of Nunatak 1390. No observations were made of in-situ occurrences (Sand 2007).

UMLs with kimberlitic megacrysts and mantle nodules have been known for decades from the northern part of the Archaean block and the adjacent Proterozoic terrains in southern West Greenland (Larsen 1991; Larsen & Rex 1992). Some of the dykes are proved to be diamondiferous (Jensen et al. 2004a & b). The Neoproterozoic dykes in southern West Greenland were during the exploration period from 2000–2005 collectively designated 'kimberlitic' (Larsen & Rex 1992; Jensen et al. 2004a & b). In Mitchell et al. (1999) it was concluded that the rocks were best referred to as a "carbonatite- ultramafic lamprophyre" suite (aillikites or melnoites). In 2005 it was, however, realised that the ~560 Ma event in the Maniitsoq region resulted in the emplacement of calcite-kimberlites (Nielsen & Jensen 2005; Nielsen et al. 2006).

Figure 1. *Large UML boulder on the moraine along the northern edge of Nunatak 1390.*

Geology of Nunatak 1390

Nunatak 1390 is located in the Tasiusarsuaq terrane within the Inland Ice to the east of the region Alangorlia. The nunatak is dominated by a metamorphic volcanic succession, north-east-striking and dipping steeply to the north-west. The Tasiusarsuaq terrane is characterised by mafic rocks (amphibolite), tonalitic gneiss and granodiorite yielding ages of 2.92-2.86 Ga (Stendal & Scherstén 2007). The metamorphic grade ranges from green-schist to granulite facies.

A lower mafic pillow sequence shows large deformed pillow structures (50-100 cm across) and pillow breccias with calc-silicate alteration in the matrix between the pillows and in the centre of some pillows. The pillowed sequence is cut by a slightly deformed E-W-trending swarm of mafic dykes (1-5 m thick) of fine- to medium-grained gabbroic or noritic rocks. An upper pillow sequence contains very well-preserved primary structures in pillows, lava flows and ash layers. The upper mafic pillow sequence is overlain by a unit of acid volcanic and pyroclastic rocks, including ignimbrites. Fine-grained, light-coloured porphyritic dykes cut the volcanic rocks and are interpreted as feeder dykes to the acid rocks. An island arc environment is suggested (Stendal & Scherstén 2007).

A prominent hydrothermal zone up to 50 m wide, strongly silicified and epidotised, follows a fault lineament. The hydrothermal zone is overlain by a thick sequence (700-800 m) of finely laminated tuff layers. Granite intrusions in the tuffs increase in abundance upwards and pass upwards into porphyritic granite with tuff xenoliths (Stendal & Scherstén 2007).

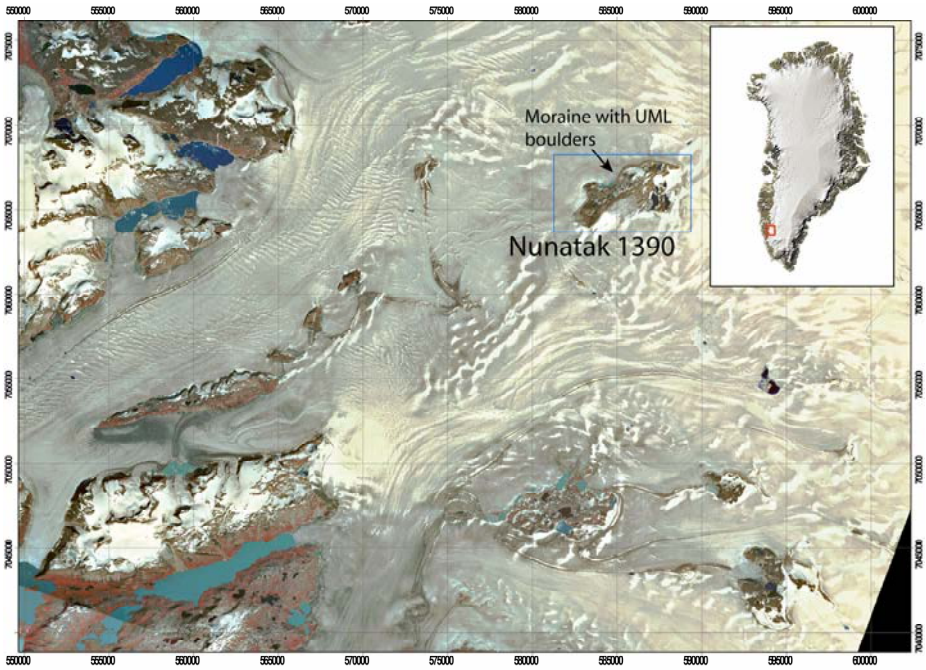

Figure 2. *The geographical context of Nunatak 1390. Colour composite of ASTER bands 3(R), 2(G), 1(B) (Tukiainen, in progress)*

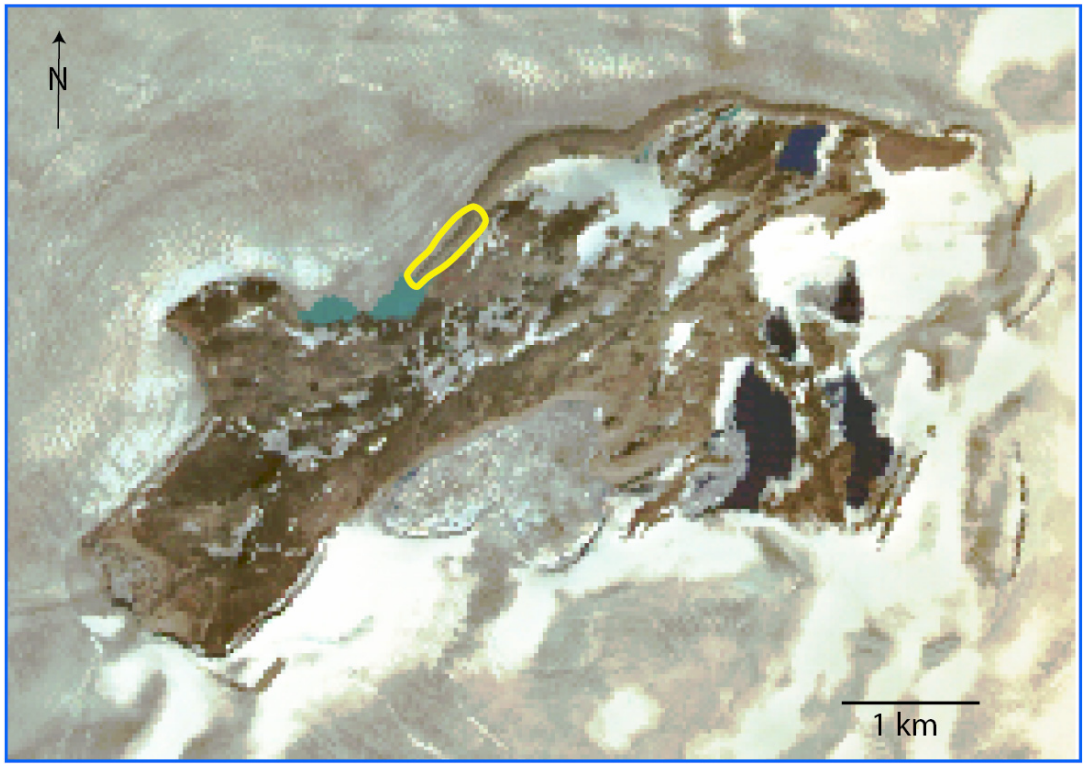

Figure 3. *Nunatak 1390. Yellow area outlines the area with heavy concentration of the UML boulders. Index map, see Figure 2.*

Field description of the UML rocks at Nunatak 1390

At Nunatak 1390 kimberlitie-like ultramafic lamprophyres are found on a moraine in the north-western part of the nunatak. The moraine is interpreted to be a lateral moraine deposited by shear planes (Svend Funder pers. comm. October 2007). The moraine is ca. three kilometres long and approx. 60 m wide around the area where the Nunatak 1390 UMLs are found. The majority of the finds are confined to a 600 m stretch of the south-western end of the moraine. The UML boulders are of up to 1m^3 in size. Rare occurrences of these rocks (in cm-dm size) are found along the north-eastern extension of the moraine. Along the moraine other UML-types are also found (classification in progress), but no in-situ occurrences of UMLs have been found on the nunatak. Due to the concentration of these kimberlite-like ultramafic boulders it is believed that the kimberlites have been transported by the ice for a relatively short distance (< 1 km). This is supported by the general observation in southern West Greenland that the kimberlitic boulders generally are within near vicinity of the in-situ occurrence.

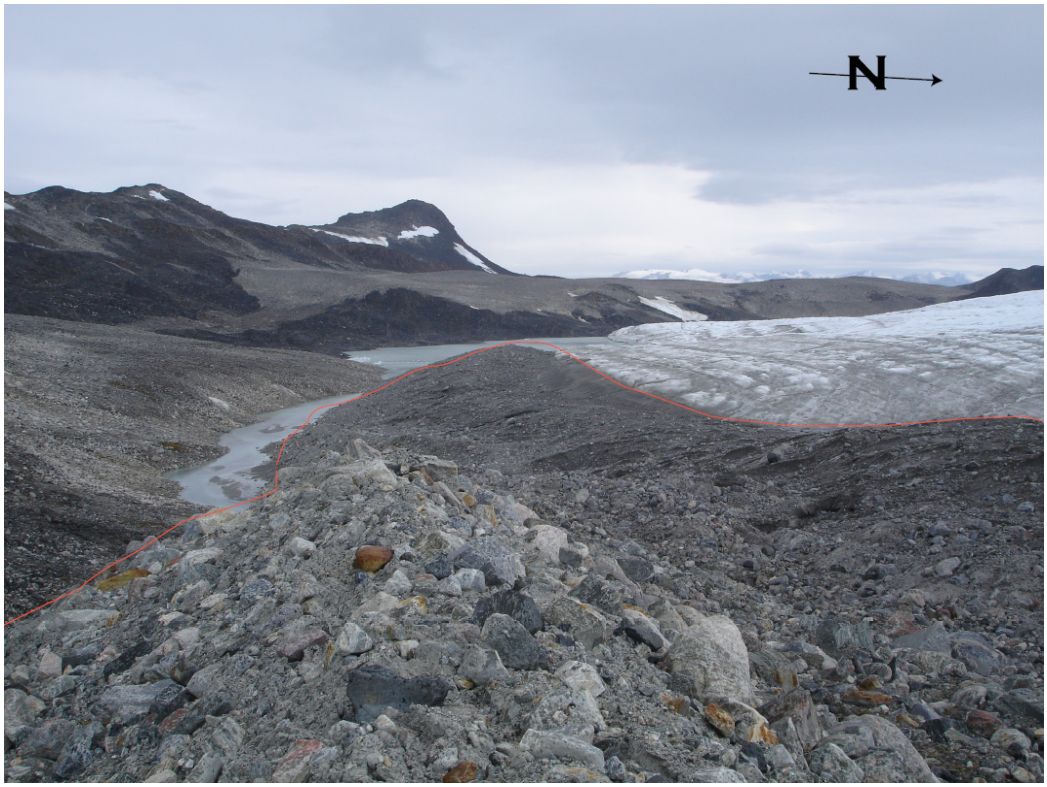

Figure 4. *The moraine on Nunatak 1390 where the UML boulders were found (outlined in red). Boulders in the foreground are up to 0.5 m.*

Figure 5. *Kimberlitic UMLs collected on the moraine for bulk sampling. Note hammer for scale.*

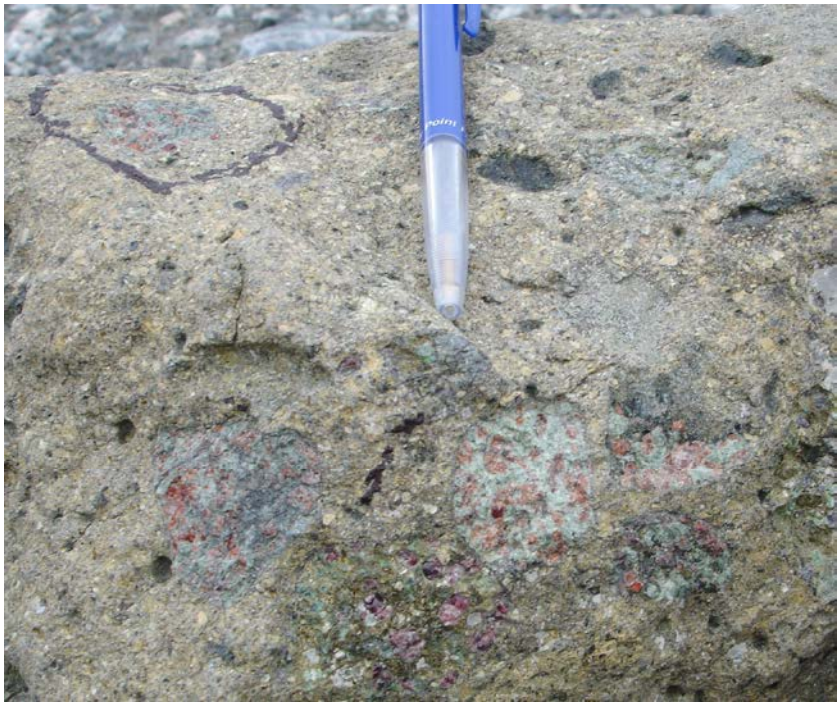

Figure 6. *Kimberlitic UML with garnet rich mantle xenoliths.*

Figure 7. *Kimberlitic UML with angular crustal xenoliths surrounded by an alteration halo. The green colour is due to chloritisation.*

Classification of kimberlitic rocks

Nunatak 1390 ‘kimberlitic’ rocks are light coloured, medium grained, massive, olivine-rich rocks with a large proportion of basement inclusions and garnet- and clinopyroxene-rich peridotitic and eclogitic xenoliths of mantle origin. Compared to all other known kimberlite and UML occurrences in West Greenland (Nielsen et al. 2006) Nunatak 1390 samples are distinct in being characterised by high contents of chlorite. No similar occurrence is known in the ‘West Greenland kimberlite province’.

The classification of kimberlites, ultramafic lamprophyres and related rocks from West Greenland is based on the groundmass paragenesis and the chemistry of the groundmass minerals in accordance with Mitchell (1986, 1995) and Tappe et al. (2005). The investigation of the samples collected on Nunatak 1390 is divided in three separate investigations: (1) the initial classification of magma type is based on reconnaissance investigation of the groundmass paragenesis and the compositions of the groundmass phases, (2) estimates of the equilibration pressure and temperature in peridotitic xenoliths on the basis of mineral equilibria, and (3) detailed investigation of the chemistry and pressures and temperatures of equilibration for eclogitic xenolith (to be reported else-where).

Description

Nunatak 1390 samples are massive and rather homogeneous with small grains of olivine in a grey groundmass with xenoliths of both crustal and mantle origin. In thin section the rock consists of up to 1 mm large, altered and un-altered fragments of olivine. No euhedral olivine grains are observed and subhedral grains appear to be fragments of larger grains. Phenocrysts are not identified. The olivine grains form a compositionally very homogeneous population with 93 atomic % forsterite (Table 1). The homogeneity of the population and the anhedral appearance suggests that they are all fragments of xenocrystic material, i.e. fragments from disintegrated mantle nodules.

SiO_2	TiO_2	$Al2O_3$	Cr_2O_3	FeO	MnO	NiO	MgO	CaO	Na_2O	K2O	Total	Fo%
41.68	0.00	0.01	0.04	6.94	0.11	0.41	52.58	0.03	0.00	0.00	101.84	93.10
41.56	0.00	0.00	0.01	7.23	0.08	0.45	52.54	0.00	0.01	0.00	101.89	92.83
41.18	0.00	0.00	0.00	7.15	0.00	0.41	52.48	0.00	0.00	0.00	101.22	92.90
41.69	0.01	0.00	0.01	6.68	0.10	0.37	52.38	0.00	0.00	0.00	101.37	93.32
41.32	0.00	0.01	0.00	6.84	0.10	0.44	52.35	0.01	0.00	0.00	101.09	93.17
41.35	0.00	0.02	0.02	6.75	0.09	0.41	52.30	0.00	0.00	0.02	100.95	93.25
41.38	0.00	0.00	0.02	6.81	0.11	0.37	52.25	0.01	0.00	0.00	100.98	93.18
41.05	0.02	0.01	0.00	7.11	0.06	0.46	52.24	0.00	0.00	0.01	100.96	92.90
41.62	0.00	0.00	0.00	7.07	0.04	0.40	52.20	0.02	0.00	0.01	101.38	92.94
41.21	0.01	0.00	0.00	7.11	0.06	0.36	52.19	0.00	0.02	0.00	100.96	92.90
41.43	0.00	0.00	0.00	6.90	0.17	0.38	52.18	0.00	0.00	0.00	101.06	93.09
41.58	0.00	0.00	0.00	6.70	0.16	0.32	52.14	0.04	0.00	0.00	101.03	93.27
41.43	0.02	0.02	0.00	7.51	0.08	0.46	52.08	0.01	0.00	0.00	101.61	92.51
41.17	0.03	0.00	0.02	7.03	0.10	0.33	52.07	0.02	0.02	0.01	100.87	92.96
41.17	0.00	0.00	0.01	7.22	0.19	0.38	51.94	0.01	0.00	0.02	100.93	92.76
41.49	0.01	0.00	0.00	6.73	0.10	0.38	51.50	0.00	0.00	0.00	100.25	93.17

Table 1. *Random analyses of anhedral olivine grains in groundmass of sample GGU 492572*

Sheet silicates up to 0.5 mm occur throughout the samples. The larger grains may retain zones of brown-yellow pleocroitic phlogopite, but most and all of the small grains are replaced by chlorite. All sheet silicate grains, except one observed fragment of a possible megacryst, are anhedral and resorbed.

Olivine and larger sheet silicates float in a groundmass dominated by carbonates (no distinction between calcite and dolomite) dotted with euhedral to subhedral Fe-Ti oxides. As shown below (Figure 12) most of these oxides are chromite and chrome-rich spinels with minor magnetite. Besides carbonates the groundmass contains serpentine and in relation to alteration zones also chlorite.

Xenocrystic material include garnet with kelyphitic rims, resorbed clinopyroxene and irregular and heavily altered masses of Fe-Ti-oxides, and resorbed orthopyroxene.

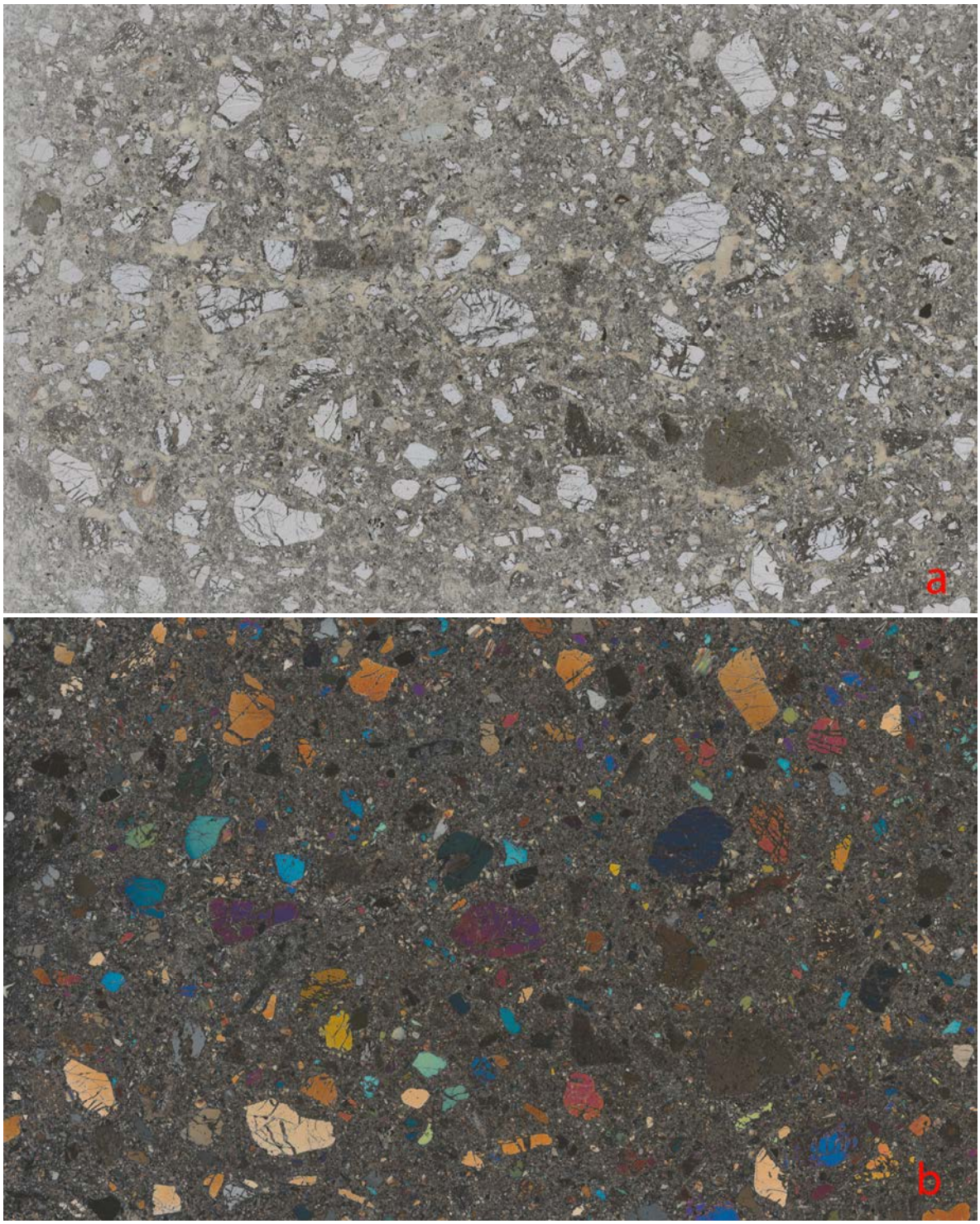

Figure 8. *Thin section of Nunatak 1390. Sample GGU 492572. Field of view is 31x21 mm. The corroded olivine grains sit in a matrix of fine-grained carbonate, spinel, ilmenites, phlogopite and olivine, where the latter two have alteration products of chlorite and serpentine, respectively. a) plane polarised light. b) crossed nicols.*

Classification based on paragenesis

Mineral chemistry

The three groundmass minerals used in the classification of the magmatism are: ilmenite, spinel and phlogopite. All three minerals are present, but phlogopite is commonly replaced by chlorite, ilmenite is not very common and hematite-rich, and spinel is in general chrome-rich. These characteristics set Nunatak 1390 samples apart from all other occurrences in the southern West Greenland.

Phlogopite and chlorite

It is difficult to distinguish between phenocrysts, microphenocrysts and groundmass grains of phlogopite due the common replacement, resorbsion and corrosion of the sheet silicate. Preserved phlogopite is comparatively poor in Al_2O_3 and TiO_2-poor, and has moderate FeO contents (Figures 9 and 10, Table 2). None of the observed compositions fall within the field of recognised kimberlitic groundmass phlogopites. As expected the BaO content – where recorded – is low (below 0.05 wt%), except for one analysis with ca. 3 wt% BaO. Nevertheless, in all these respects the phlogopites suggest that the melt of Nunatak 1390 samples was not kimberlitic, but should rather be referred to a suite of ultramafic alkaline lamprophyre melts.

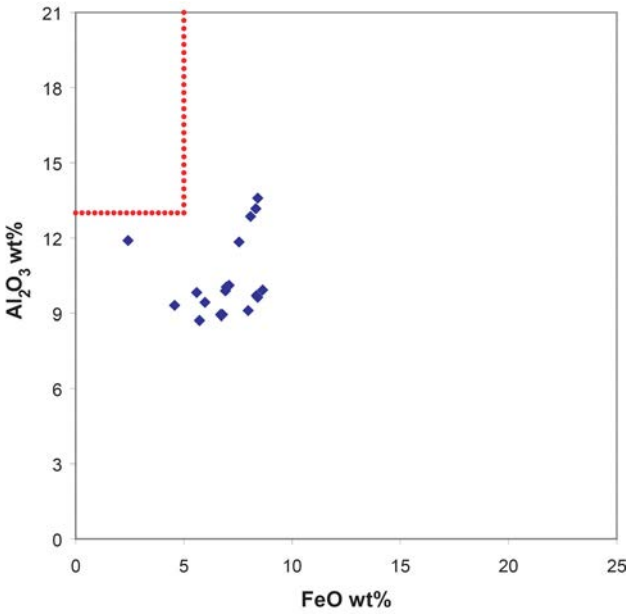

Figure 9. *Composition of phlogopite. Indicated field: groundmass phlogopite in archetypal kimberlite (Mitchell 1995).*

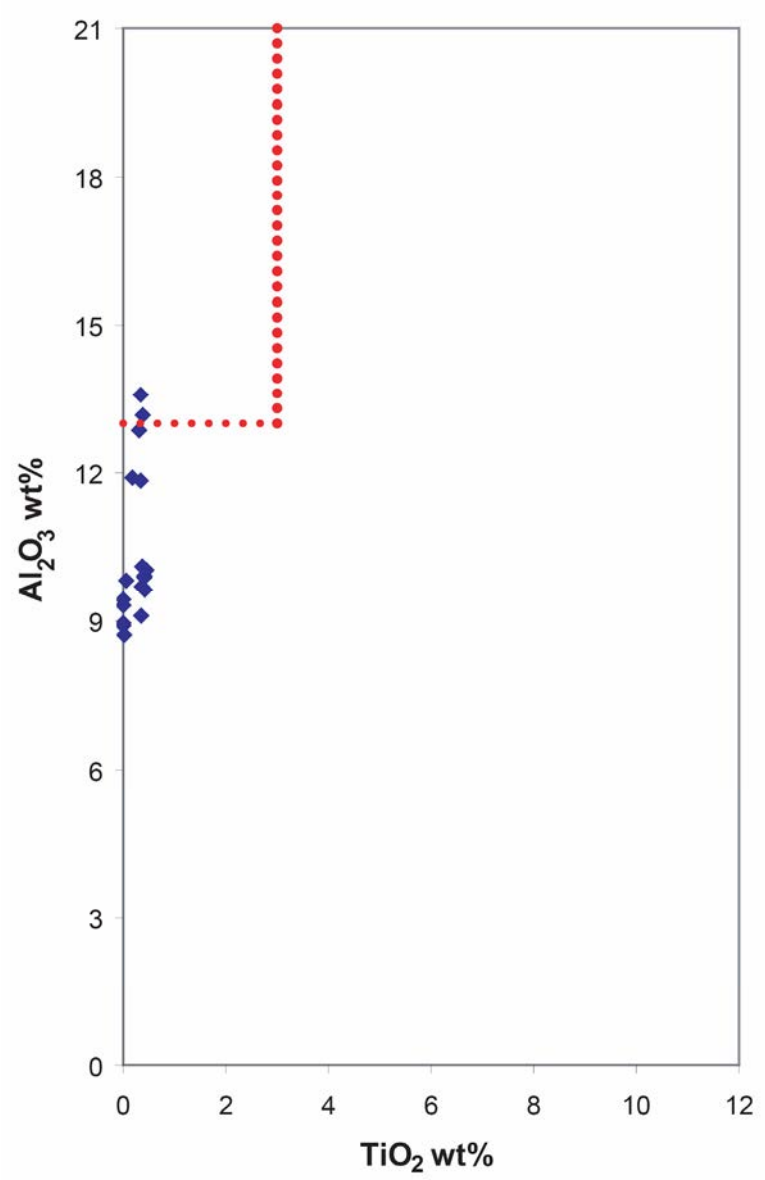

Figure 10. *Composition of phlogopite. Indicated field: groundmass phlogophite in archetypal kimberlite (Mitchell 1995)*

SiO_2	TiO_2	$Al2O_3$	Cr_2O_3	FeO	MnO	NiO	MgO	CaO	Na_2O	K2O	BaO	Total
40.42	0.45	10.04	0.21	6.96	0.00	0.07	23.31	0.10	0.06	10.46	0.00	92.08
40.10	0.37	10.11	0.18	7.09	0.00	0.10	23.43	0.08	0.10	10.53	0.06	92.15
40.61	0.41	9.89	0.24	6.92	0.11	0.12	23.22	0.06	0.09	10.48	0.00	92.15
40.62	0.00	8.90	0.08	6.73	0.04	0.11	24.66	0.07	0.11	10.36	0.01	91.68
41.10	0.00	9.31	0.08	4.57	0.01	0.13	26.73	0.10	0.11	9.36	0.03	91.52
40.82	0.00	8.95	0.06	6.70	0.10	0.16	25.20	0.03	0.10	10.28	0.01	92.40
40.86	0.00	8.95	0.11	6.78	0.09	0.11	25.18	0.02	0.11	10.72	0.12	93.05
38.80	0.18	11.90	0.67	2.42	0.05	0.00	26.12	0.16	0.05	9.58	2.78	92.73
40.75	0.31	12.86	0.11	8.08	0.06	0.03	22.99	0.02	0.14	10.32	0.22	95.90
40.92	0.34	11.84	0.09	7.55	0.03	0.00	24.24	0.00	0.14	9.49	0.17	94.80
39.93	0.34	13.59	0.11	8.41	0.09	0.05	22.65	0.01	0.13	10.30	0.19	95.79
40.15	0.38	13.17	0.21	8.32	0.14	0.00	23.08	0.06	0.12	10.09	0.29	96.00
41.99	0.35	9.10	0.10	7.97	0.05	0.12	25.51	0.06	0.09	9.69	0.14	95.17
42.00	0.41	9.92	0.10	8.64	0.02	0.16	24.34	0.03	0.08	10.50	0.19	96.39
41.91	0.36	9.70	0.11	8.35	0.03	0.17	24.53	0.02	0.08	10.36	0.03	95.65
41.75	0.42	9.63	0.09	8.41	0.07	0.15	24.83	0.01	0.09	10.53	0.08	96.06
42.03	0.06	9.82	0.08	5.59	0.04	0.16	26.21	0.02	0.10	10.75	0.16	95.02
42.13	0.00	9.43	0.12	5.97	0.03	0.16	26.27	0.03	0.13	10.76	0.14	95.17
42.54	0.02	8.71	0.04	5.72	0.03	0.07	27.28	0.00	0.08	9.82	0.00	94.31

Table 2. *Random groundmass phlogopite in sample 492572, Nunatak 1390.*

Hematite-rich ilmenite

Ilmenite grains are rare in the groundmass. Only few grains were found in a random search during EMP investigation. The ilmenites are generally poor in MgO (< 5 wt%, Fig. 7, Table 3) and this alone disqualifies the ilmenites as products of kimberlite melt crystallisation. The hematite content calculated on basis of assumed stoichiometry suggests significant oxidation and a hematite content near 30%. As the low MgO content, the high hematite component sets Nunatak 1390 apart from all other investigated occurrences of kimberlites and ultramafic lamprophyres in southern West Greenland. No similar compositions have hitherto been recorded. The rare occurrence of ilmenite indicates – as generally observed within the province (Nielsen et al. 2006) - that Nunatak 1390 samples are to be referred to an ultramafic lamprophyre suite.

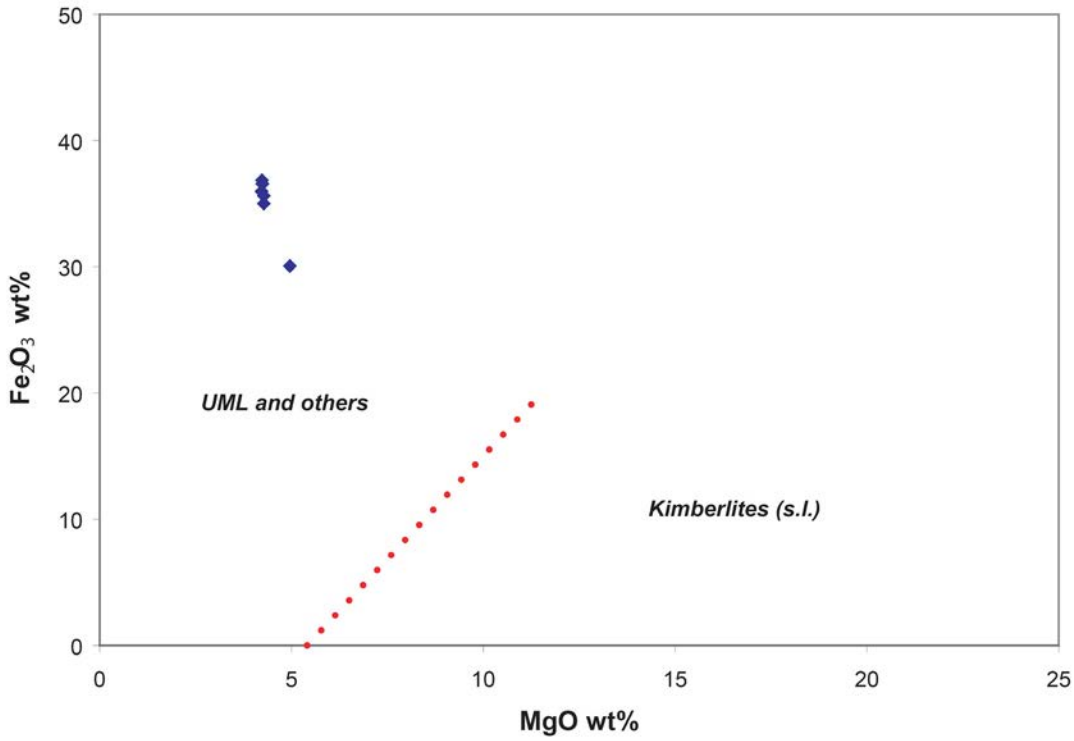

Figure 11. *Composition of groundmass ilmenite (Table 3). Fe_2O_3 calculated assuming stoichiometry.*

SiO_2	TiO_2	$Al2O_3$	$Cr2O_3$	FeO	MnO	NiO	MgO	CaO	Na_2O	K2O	BaO	Total	hea-matite	ilmen-ite	gie-kielite	pyro-phanite
0.03	38.51	0.08	0.03	52.54	0.30	0.05	4.96	0.09	0.00	0.01	0.10	96.70	28.09	52.93	18.35	0.63
0.01	35.29	0.11	0.04	55.42	0.19	0.00	4.28	0.23	0.00	0.00	0.00	95.57	33.17	50.36	16.06	0.41
0.05	35.10	0.05	0.03	55.72	0.26	0.05	4.28	0.08	0.00	0.02	0.05	95.68	33.67	49.75	16.03	0.55
0.00	34.84	0.04	0.02	55.92	0.25	0.00	4.22	0.17	0.02	0.00	0.05	95.53	34.06	49.58	15.83	0.53
0.00	34.64	0.10	0.00	56.49	0.28	0.01	4.23	0.29	0.00	0.00	0.05	96.08	34.74	48.88	15.79	0.59
0.00	34.48	0.01	0.04	56.21	0.14	0.06	4.24	0.22	0.00	0.02	0.04	95.45	34.67	49.12	15.92	0.30

Table 3. *Random groundmass ilmenite grains in sample 492572, Nunatak 1390. The composition of hematite, ilmenite and pyrophanite is given in mol % and is calculated using stoichiometry.*

Chromite and spinel

Chromite and spinel grains are common in the groundmass. As shown in Figure 12 and Table 4 all the observed spinel compositions fall outside the empirically determined field of kimberlitic spinels (Mg-rich tinanomagnetites) in southern West Greenland (Nielsen et al. 2006), and due to high Fe# in the field of ultramafic alkaline lamprophyres. The classification based on the spinel composition is not unique as some kimberlites (i.e. magmatic trend 2 (T2), Mitchell (1995); Figure 12) can have compositions recalling the here observed compositions.

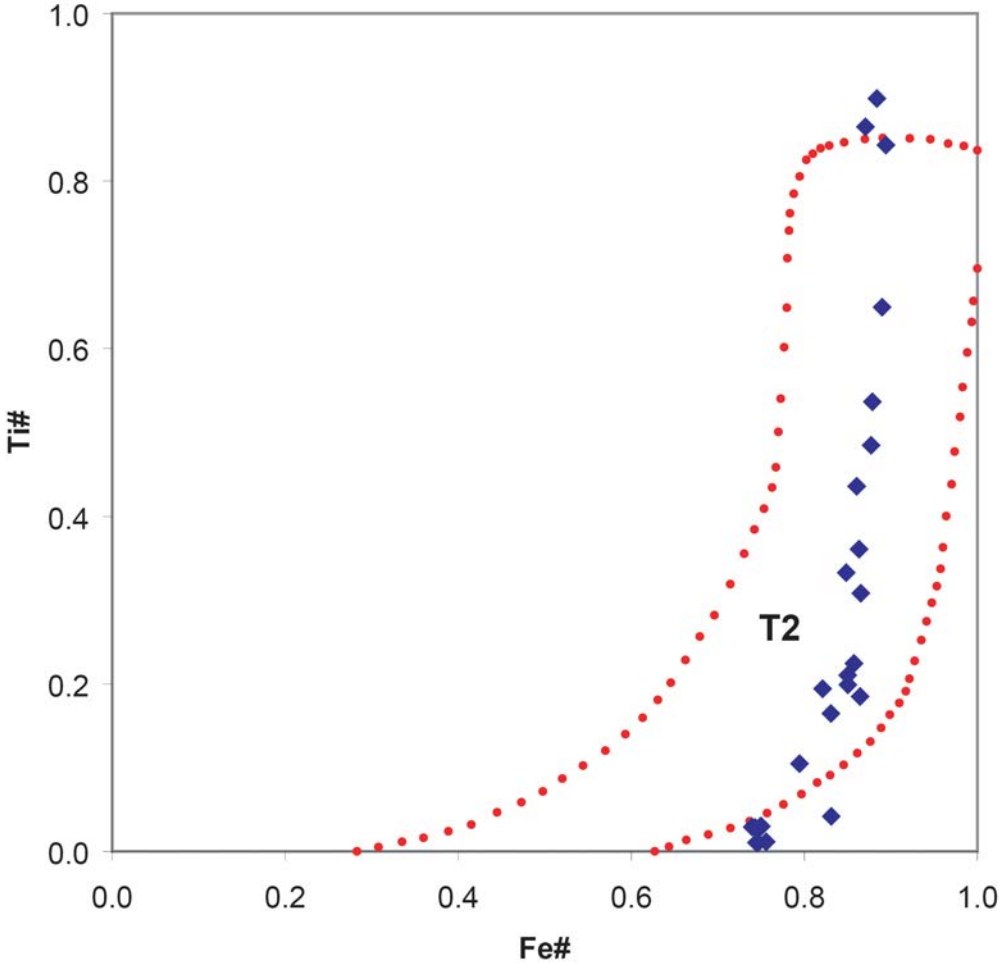

Figure 12. *Compositions of groundmass spinels. Fe# = Fe^{2+}(total) / (Fe^{2+}(total) + Mg) and Ti#: Ti/(Ti+Cr+Al), see Mitchell (1995). T2: anomalous kimberlite field (Mitchell 1995).*

SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	NiO	MgO	CaO	Na2O	K_2O	BaO	Total	Ti#	Fe#
0.00	0.57	0.52	53.23	36.80	0.70	0.12	7.03	0.05	0.02	0.00	0.06	99.10	0.01	0.75
0.01	0.60	0.46	51.38	37.93	0.62	0.14	7.24	0.05	0.00	0.00	0.01	98.44	0.01	0.75
0.05	1.63	1.19	51.33	35.65	0.56	0.11	6.92	0.00	0.06	0.07	0.11	97.67	0.03	0.74
0.08	1.72	1.12	51.23	36.02	0.66	0.10	6.73	0.00	0.00	0.04	0.11	97.80	0.03	0.75
0.00	1.67	1.21	51.16	35.86	0.49	0.16	7.08	0.00	0.00	0.08	0.06	97.77	0.03	0.74
0.05	0.58	0.52	51.08	38.33	0.67	0.09	7.38	0.04	0.08	0.03	0.03	98.88	0.01	0.75
0.05	1.69	1.13	50.84	36.26	0.50	0.10	6.82	0.00	0.06	0.08	0.10	97.63	0.03	0.75
0.00	0.61	0.48	49.40	38.63	0.78	0.13	7.00	0.01	0.01	0.00	0.09	97.14	0.01	0.76
0.19	1.83	0.28	39.52	48.31	0.58	0.15	5.51	0.35	0.04	0.02	0.00	96.77	0.04	0.83
0.05	4.90	0.35	39.26	45.25	0.41	0.15	6.57	0.03	0.02	0.03	0.12	97.14	0.11	0.79
0.03	6.36	0.45	30.01	52.42	0.65	0.18	6.00	0.01	0.00	0.01	0.00	96.12	0.17	0.83
0.17	6.80	0.50	26.09	53.92	0.85	0.18	6.59	0.08	0.00	0.03	0.07	95.28	0.19	0.82
0.08	7.29	0.41	25.40	57.77	0.63	0.23	5.72	0.03	0.05	0.00	0.00	97.61	0.21	0.85
0.06	6.15	0.36	25.24	57.94	0.56	0.20	5.10	0.00	0.03	0.00	0.00	95.64	0.19	0.86
0.06	6.63	0.25	25.01	57.14	0.54	0.18	5.65	0.40	0.00	0.01	0.00	95.86	0.20	0.85
0.11	7.16	0.47	22.84	59.37	0.50	0.22	5.54	0.06	0.00	0.02	0.08	96.36	0.22	0.86
0.00	7.53	0.20	15.77	65.84	0.59	0.28	5.75	0.03	0.02	0.00	0.05	96.06	0.31	0.87
0.79	7.12	0.24	13.21	67.55	0.62	0.26	6.78	0.04	0.03	0.03	0.00	96.65	0.33	0.85
0.11	7.28	0.12	12.08	68.61	0.47	0.18	6.10	0.04	0.00	0.00	0.00	94.99	0.36	0.86
0.09	7.43	0.30	8.72	70.88	0.59	0.29	6.45	0.30	0.00	0.02	0.00	95.07	0.44	0.86
0.03	8.05	0.11	7.99	72.52	0.59	0.14	5.70	0.05	0.00	0.00	0.00	95.18	0.48	0.88
0.06	8.03	0.12	6.43	74.22	0.58	0.17	5.76	0.19	0.03	0.00	0.00	95.59	0.54	0.88
0.11	8.24	0.09	4.10	76.26	0.64	0.21	5.30	0.31	0.00	0.01	0.00	95.26	0.65	0.89
0.12	8.28	0.06	1.38	79.41	0.57	0.24	5.27	0.22	0.00	0.01	0.13	95.70	0.84	0.89
0.14	8.25	0.06	1.14	77.87	0.70	0.15	6.49	0.03	0.00	0.01	0.04	94.88	0.87	0.87
0.16	8.50	0.09	0.78	79.24	0.59	0.16	5.85	0.25	0.00	0.04	0.00	95.65	0.90	0.88

Table 4. *Random groundmass spinels in sample GGU 492572, Nunatak 1390. Fe# = Fe^{2+}+Fe^{total}/ (Fe^{2+}+Fe^{total} + Mg) and Ti#: Ti/(Ti+Cr+Al), assuming stoichiometry*

Discussion on classification

It is argued that the recorded mineral compositions do not suggest that the melt of Nunatak 1390 samples was kimberlitic. The general petrographic characteristics, however, recall the kimberlites at Koidu, Sierra Leone (Tompkins, et al. 1985). The authors are left with the contradiction that Nunatak 1390 samples appear best to be compared to the “Koidu kimberlite,” but that this type of nodule- and diamond-bearing ultramafic rock may in fact not classify as a kimberlite, but as a variety of kimberlitic UML.

It is a main concern in the attempt to classify the melt on the basis of the groundmass mineralogy that phlogopite is extensively replaced. It is thus not clear to what extend the groundmass minerals have been altered and equilibrated in the post-solidification state and classifications based on the oxidation state of ilmenite may not be valid. However, assuming that the remaining phlogopite is primary in composition and that the low content of ilmenite and its low MgO content are primary features, it has to be concluded that the melt of Nunatak 1390 samples could not have been kimberlitic in nature.

P and T estimates from xenoliths

Petrography and geothermobarometry

Geothermobarometry has been applied to seven mantle peridoties from the Nunatak 1390 samples. Three samples appear to be wehrlites, one is harzburgitic, one is lherzolitic, and one is websteritic. One of the harzburgites (B) and the websterite (D) may, however, be lherzolites with strongly altered clinopyroxene and olivine, respectively. Preliminary pressure and temperature estimates on these mantle xenoliths strongly indicate chemical disequilibrium between orthopyroxene and clinopyroxene (Figure 13). The disequilibrium is indicated by disagreement in estimated temperatures and pressures of equilibration between orthopyroxene and clinopyroxene based thermometry. Single-clinopyroxene thermobarometry ($P/T_{Nimis\&Taylor}$) (Nimis and Taylor 2000) yields the lowest pressures and temperatures (489-592°C). Temperature formulations based on olivine and garnet ($T_{O'Neill}$) (O`Neill and Wood 1979) or orthopyroxene and garnet (T_{Harley}) (Harley 1984) yield higher values (697-759°C and +116°C respectively, refer to Table 5 and 6). Thermometers considering both pyroxenes ($T_{Ca\text{-}in\text{-}opx}$ in Brey and Köhler (1990); and T_{BKN} in (Brey and Köhler 1990)) are generally considered to be most accurate (e.g. Smith 1999), but can here only be applied to the lherzolitic sample (A1ah) and yield the highest temperatures of equilibration (~887 °C) (Table 5).

Pressures and temperatures are calculated iteratively for orthopyroxene-bearing samples. Wehrlitic temperatures are calculated at a preset pressure of 2.5 GPa (P_{fixed}) due to the lack of orthopyroxene in these rocks. For orthopyroxene-bearing samples the pressures are calculated using the barometer of Brey & Köhler (1990) and McGregor (1974). The orthopyroxene-based barometers always agree within error (+/- 0.5 GPa) indicating equilibrated orthopyroxene.

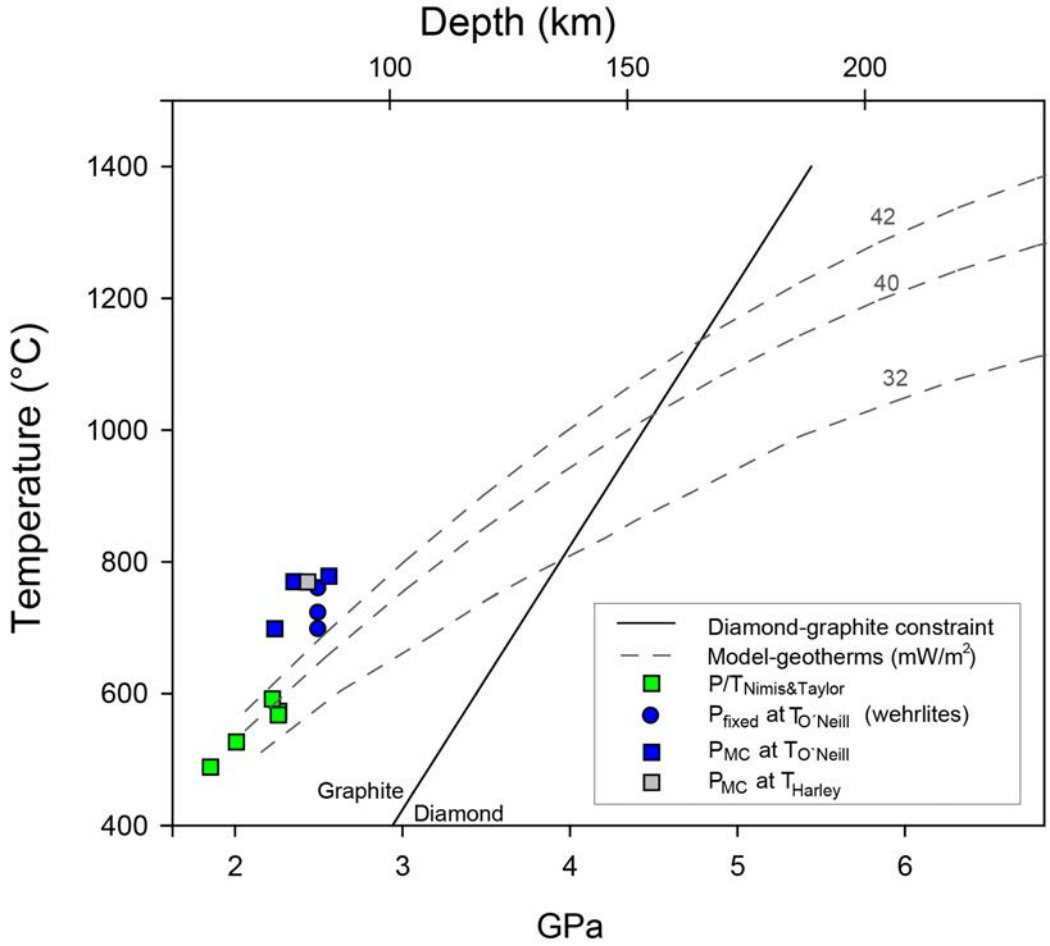

Figure 13. *Graph of calculated pressure vs. temperature of the Nunatak 1390 samples using various P/T formulations. The clinopyroxene-based geothermometer ($P/T_{Nimis\&Taylor}$) is observed to yield lover P/T conditions that garnet-based thermometers and orthopyroxene-based barometers. This indicates lack of equilibrium of the samples. For reference are shown the model-geotherms of Chapman and Pollack (1977). The diamond-graphite constraint is from Kennedy and Kennedy (1976).*

Sample	Lithology	$P/T_{Nimis\&Taylor}$		P**	$T_{O'Neill}$**	P_{MC}	$T_{O'Neil}$	P_{BKN}	$T_{O'Neil}$	P_{MC}	T_{Harley}	P_{BKN}	T_{Harley}
nuna_A1	wehrlite	2.3	573	2.5	722								
nuna_A1ah	lherzolite	1.9	489			2.2	698	2.4	705	3.1	838	3.1	837
nuna_A1bh	wehrlite	2.2	592	2.5	759								
nuna_A2	wehrlite	2.3	568	2.5	697								
nuna_B	harzburgite	0.0				2.6	778	2.3	761	3.1	868	2.7	844
nuna_C	harzburgite	0.0				2.4	770	1.7	731	3.1	894	2.4	852
nuna_D*	pyroxenite?	2.0	527							2.4	770	1.9	740

Table 5. *. Resulting P/T estimates. *No olivine is observed in the sample and it classifies as a pyroxenite, however, abundance of serpentine suggests severe serpentinisation of a lherzolite. ** Temperatures are calculated form a fixed pressure of 2.5 GPa due to lack of orthopyroxene.*

	P (Gpa)	TBKN
PBKN	3.4	886
PMC	3.4	888
	P (Gpa)	**Tca**
PBKN	3.4	886
PMC	3.4	888

Table 6. *Resulting P/T estimates. Four combinations of orthopyroxene based barometry (PBKN and PMC) in combination with pyroxene-garnet thermometry (TCa ($T_{Ca\text{-}in\text{-}opx}$) assumes equilibrium with clinopyroxene) yields similar results.*

Diamond potential

Common for all pressure and temperature estimates is that the samples all fall in the field of graphite stability as defined by Kennedy and Kennedy (1976). The P/T estimates are considered to be minimum values, and do not exclude the occurrences of diamond. More samples and further investigations are needed in order to estimate the diamond potential of this new region.

Diamond test

A diamond test of Nunatak 1390 kimberlite like UML was conducted on a 96 kg combined and representative sample (GGU 492572) from the moraine boulder field. The analytical test was carried out by the SRC (Saskatchewan Research Council, Geoanalytical Laboratories, Saskatoon, Canada). The test procedure included caustic fusion and screening for +106 micron diamonds. The result of the diamond test was negative as no diamonds were discovered in the fraction +106 microns. The analytical result is shown in Table 7 and the flow-sheet for the test is shown in Figure 14.

SRC Geoanalytical Laboratories
125 - 15 Innovation Blvd., Saskatoon, Saskatchewan, S7N 2X8
Tel: (306) 933-8118 Fax: (306) 933-5656 Email: geochem@src.sk.ca

Report No: 06-1811

Caustic Fusion Diamond Report

GEUS
Attention: Karsten Secher
PO #/Project:
Samples: 12

March 21, 2007

1) Original Sample Weight in kilograms (SWT)
2) Bottom Sieve Size in microns (Sieve)
3) Diamonds > 500 microns (Macro)
4) Diamonds < 500 microns (Micro)
5) Weight of Diamonds > 500 microns in milligrams (Wt+)
6) Weight of Diamonds >75microns < 500 microns in milligrams (Wt-)
7) Number of QC/QA Tracers (-212+180microns) Recovered Fusion (QC 1)
8) Number of QC/QA Tracers (-300+250microns) Recovered Chemical Treatment (QC 2)
9) Number of synthetic diamonds recovered (whole and fragments) (SYN)

Sample #	SWT	Sieve	Macro	Micro	Wt+	Wt-	QC 1	QC 2	SYN
492572 1/12	6.00	106	0	0	0	0	10/10	10/10	0
492572 2/12	6.00	106	0	0	0	0	10/10	9/10	0
492572 3/12	6.00	106	0	0	0	0	10/10	10/10	0
492572 4/12	6.00	106	0	0	0	0	10/10	10/10	0
492572 5/12	6.00	106	0	0	0	0	10/10	10/10	0
492572 6/12	6.00	106	0	0	0	0	9/10	10/10	0
492572 7/12	6.00	106	0	0	0	0	10/10	10/10	0
492572 8/12	6.00	106	0	0	0	0	10/10	10/10	0
492572 9/12	6.00	106	0	0	0	0	10/10	10/10	0
492572 10/12	6.00	106	0	0	0	0	10/10	10/10	0
492572 11/12	6.00	106	0	0	0	0	14/14	10/10	0
492572 12/12	6.00	106	0	0	0	0	10/10	10/10	0

Table 7. *Results of diamond test.*

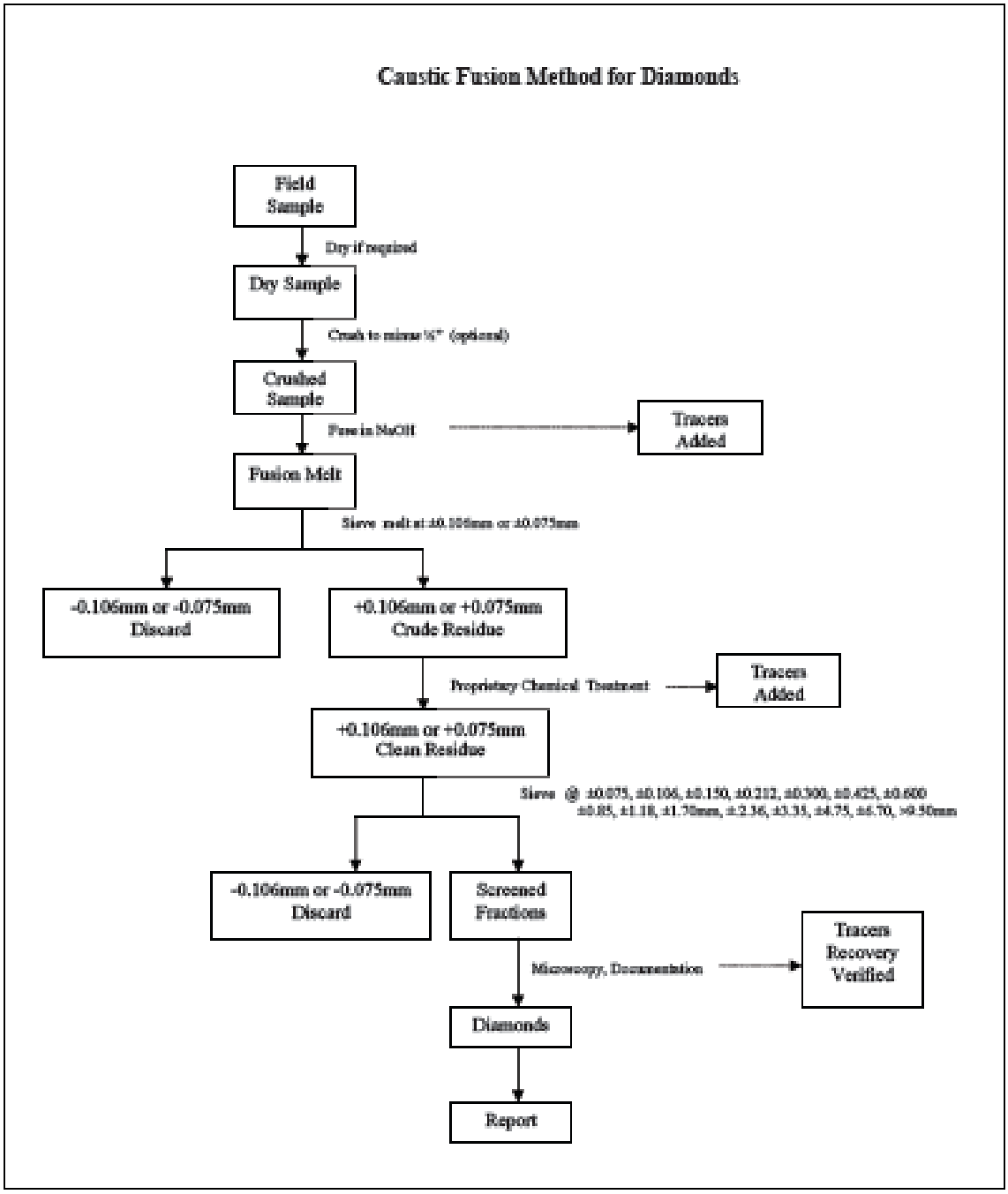

Figure 14. *Flow-sheet for the diamond test performed on sample GGU 492572 from Nunatak 1390.*

Concluding remarks

A new find of kimberlitic UML rocks as floats on Nunatak 1390 has been evaluated for the possibility of being a diamondiferous rock type. Based on the investigated features it has to be concluded that the melt of Nunatak 1390 samples, despite the similarity to the Koidu “kimberlites”, can not be kimberlitic in nature. Additionally, the estimated pressure and temperature for mantle nodules in these rocks indicate a low possibility for diamonds. A diamond test carried out on a representative 96 kg sample by caustic fusion resulted in no diamonds in the fraction +106 microns. Whether the sample could contain smaller microdiamonds is speculative. However, the estimated pressure and temperature of the mantle nodules in the graphite stability suggest that the diamond potential is low.

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