DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2017/13

Investigation of corundum occurrences in the Nattivit area, South-East Greenland

SEGMENT 2015 Field report

Majken D. Poulsen, Nynke Keulen
& Helene Heide-Jørgensen

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF ENERGY, UTILITIES AND CLIMATE

G E U S

DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2017/13

Investigation of corundum occurrences in the Nattivit area, South-East Greenland

SEGMENT 2015 Field report

Majken D. Poulsen, Nynke Keulen
& Helene Heide-Jørgensen

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF ENERGY, UTILITIES AND CLIMATE

GEUS

Contents

Introduction

This report describes the field observations and data collected in 2015 for the South-East Greenland Mineral Endowment Task (SEGMENT) project in the Nattivit area. The SEGMENT project is a collaboration between the Ministry of Mineral Resources, Government of Greenland (MMR) and the Geological Survey of Denmark and Greenland (GEUS) on the evaluation of the geological potential of South-East Greenland. The report covers the period from 24th of July to the 9th of August. The team (SEGMENT team 2) consisted of the following three persons:

Nynke Keulen (NTK), GEUS
Majken Djurhuus Poulsen (MADP), GEUS
Helene Heide-Jørgensen (HEHJ), MMR

The fieldwork area is located West of Tasiilaq in South-East Greenland in the area between Isortoq and Kap Tycho Brahe (Figure 1). Camp 1 was close to Aqqaajaq and camp 2 was placed at the head of Tasiilaalik fjord. The aim of the field work was to collect more information on the ruby and corundum occurrences that were described after the 2014 field work (Van Hinsberg & Poulsen, in press) and field work for the Ph.D. Project for MADP with supervision by NTK. HEHJ was participating for MMR's work on corundum occurrences in Greenland. The visited area contains the Ujarassiorit locality, where Vittus Sakæussen collected a prize-winning ruby sample in 2009. This locality will informally be referred to as "Vittus Ruby Island".

Structural measurements of planes are recorded as dip direction/dip. All measurements have been corrected for magnetic inclination for the area in South-East Greenland.

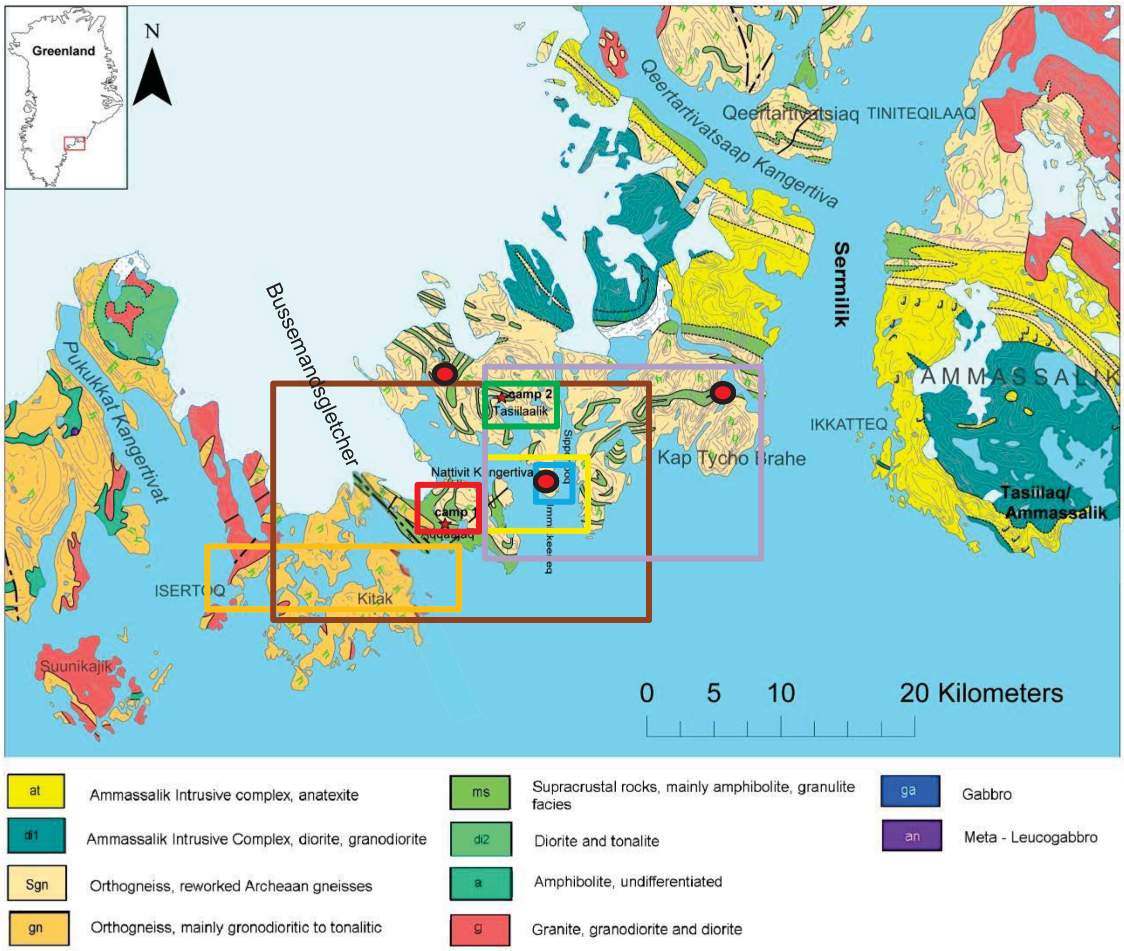

Figure 1. *Map of the 2015 field work area East of Tasiilaq in South East Greenland, where camp 1 and 2 are marked near Aqqaajaq and Tasiilaalik. Scale 1:125000. The red circles are reco stops (day 2) Red (days 3–6), blue (days 8 and 10), green (day 9), yellow (day 11), orange (day 12), lilac (day 13), and brown (day 14).*

Geological background

The Nagsussugtoqidian orogen of South-East Greenland have been divided in four different terranes; 1) the Schweizerland Terrane, 2) the Kuummiut Terrane, 3) The Ammassalik Intrusive Complex, 4) Isortoq Terrane (Kolb 2014).. The fieldwork described here was performed in the Isortoq Terrane, which, according to Kolb (2014) is part of the North Atlantic Craton, while the rocks of the other three terranes are part of the Rae Craton.

The Isortoq Terrane contains hornblende-biotite-bearing orthogneisses (grey gneisses) and orthopyroxene-bearing orthogneisses (brown gneisses) with model Sm-Nd ages around 2.8-3.0 Ga and 2.2 Ga, respectively (Hall et al. 1989; Kalsbeek et al. 1993). The orthogneisses found north of Aqqaajaq contain abundant enclaves of amphibolite, metagabbro and ultramafic rocks, as well as supercrustal rocks called the Siportôq Supracrustal Association (Wright et al. 1973; Hall et al. 1989), or Kap Tycho Brahe Unit (Kolb, 2014). The age of the Siportôq Supracrustal Association is not known, but indicated as <1910 Ma. (Kolb, 2104). The rocks in the Siportôq Supracrustal Association were metamorphosed to amphibolite facies conditions and contain rocks with garnet-sillimanite-graphite-kyanite paragneisses, undifferentiated amphibolites, ultramafic rocks and thin layers of marbles (Escher, 1990). Structural isoclinal folds and nappes, with E-W to NW sub-horizontal fold axes (Bridgwater & Gormsen, 1968, 1969), dominate the area.

Corundum in the Nattivit area

Corundum in the Tasiilaq area was observed during geological fieldwork in the 1980s, and described very briefly by Hall *et al.* (1989). In 2009 Vittus Sakæssen from Tasiilaq sent a sample of pink corundum to the Ujarassiorit programme from the Nattivit area (west of Tasiilaq) and won 1st prize that year (see figure 1 and 2).

For the 2014 fieldwork this local mineral collector was contacted and he helped in locating the corundum locality. The corundum sits in a hydrothermal vein in an ultramafic rock that has reacted with a felsic pegmatite. The pegmatites lose silica during reaction with the ultramafic rocks and new mineral phases are developed until the silica content reaches under-saturation and the corundum forms, provided that the Al content is high enough in the remaining melt. The Sipportooq Supercrustal Sequence is the host of the ultramafic rocks that occur as thin boudinaged layers. The ultramafic rocks in the Nattivit Kangertivat area were in contact to amphibolite with felsic stringers, that seems partly migmatitic. In several localities a malachite staining of the amphibolite could be observed. Calc-silicate rocks, schist and paragneisses were also present close to the ultramafic bands. The ultramafic rocks were often two parallel bands, and the relationship between the two bands is not obvious from field observations; it is uncertain whether they represents two separate sheets of ultramafic rocks that are related and have been pulled apart, or have been formed separately as two individual sheets.

The pegmatites cross-cutting the ultramafic rocks seemed to be at least two different generations, with slightly different geochemistry and age. The first generation of pegmatites was folded together with the ultramafic bands. The youngest generation of the pegmatites is not following the main foliation in the area and seems to be have triggered the corundum formation in the area.

Field observations and data

Day 1, 24th of July 2015

NTK: Flight from Copenhagen via Keflavik and Reykjavik to Kulusuk together with team 1. In Kulusuk, we located the containers with material that were sent by boat. We arranged food from supermarket that could be taken into the field and transport of our gear to the airport. We stayed in hotel Kulusuk, where we also had dinner.

Day 2, 25th of July 2015

NTK: Bought fresh food in supermarket, sorted out gear for team 2 from the container and packed all things for transport. We arranged jet fuel and petroleum for the heating and electricity (generator). We have a large amount of luggage. MADP and HEHJ arrived after a slight delay by plane from Nuuk. During a short chat at the hotel together with team 1, we were notified that our helicopter had left the airport after waiting for us for some time. This was earlier than previously arranged, due to a cancellation by a third party. After a telephone call to Tasiilaq airport the helicopter flew back to Kulusuk and we said farewell to team 1. Flew with a Bell212 to our first campsite, which was south of Nattivit and Aqqaajaq (figure 2), and unloaded the helicopter. After that we had a short Reco:

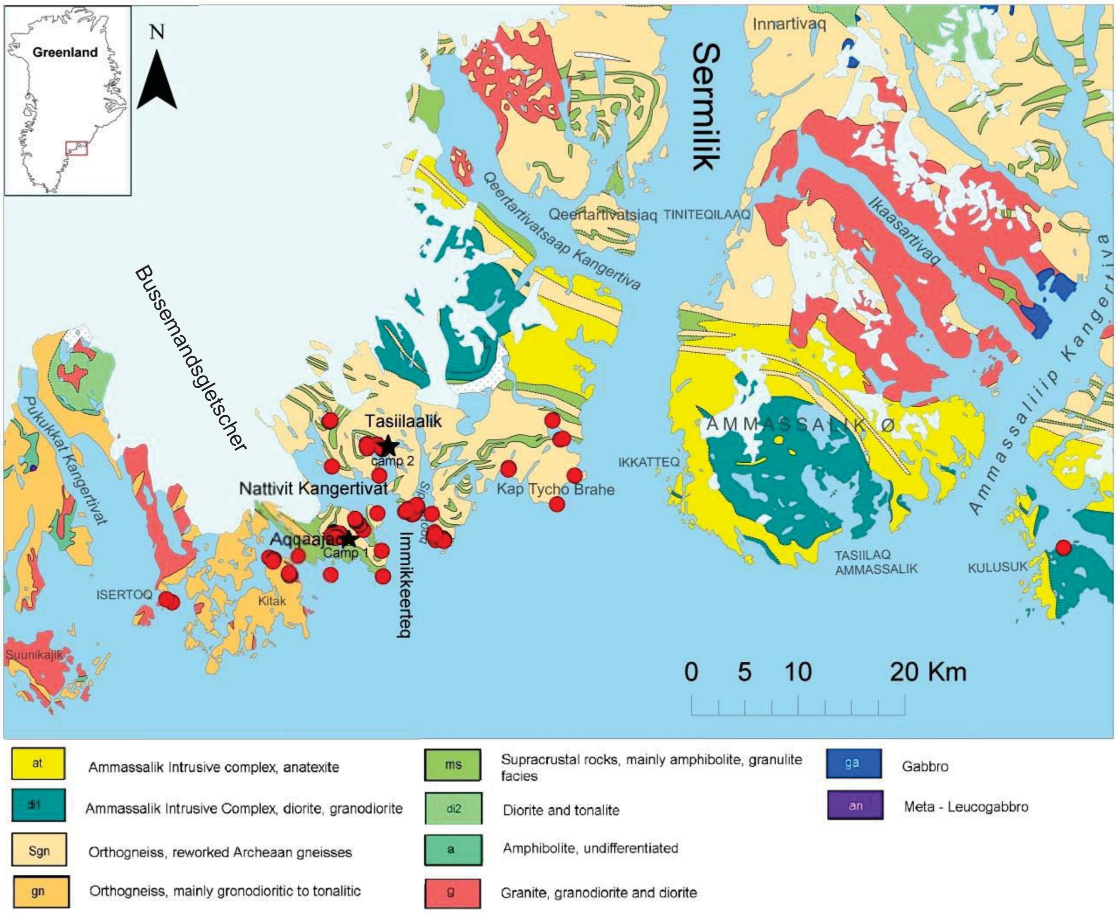

Figure 2. *Map showing the localities visited for the field work in 2015 (red circles).*

Locality 2- Reco stop 1 (15ntk03)

GPS: N65.6961°, E-38.6426°

Rusty zone on top of the mountain in the bottom of the Nattivit Kangertivat (figure 1 and 3). The rusty zone looked like a hydrothermal alteration zone with yellowish-brown gossanous colours. The rocks contains graphite, quartz, and sulphides. The rusty rock was sitting in amphibolite with lenses of ultramafic rocks. Three samples were collected here, one from a pegmatite, one from the rusty zone and a garnet amphibolite. The garnet amphibolite contained garnets with rims of plagioclase around the garnets (retrogression).

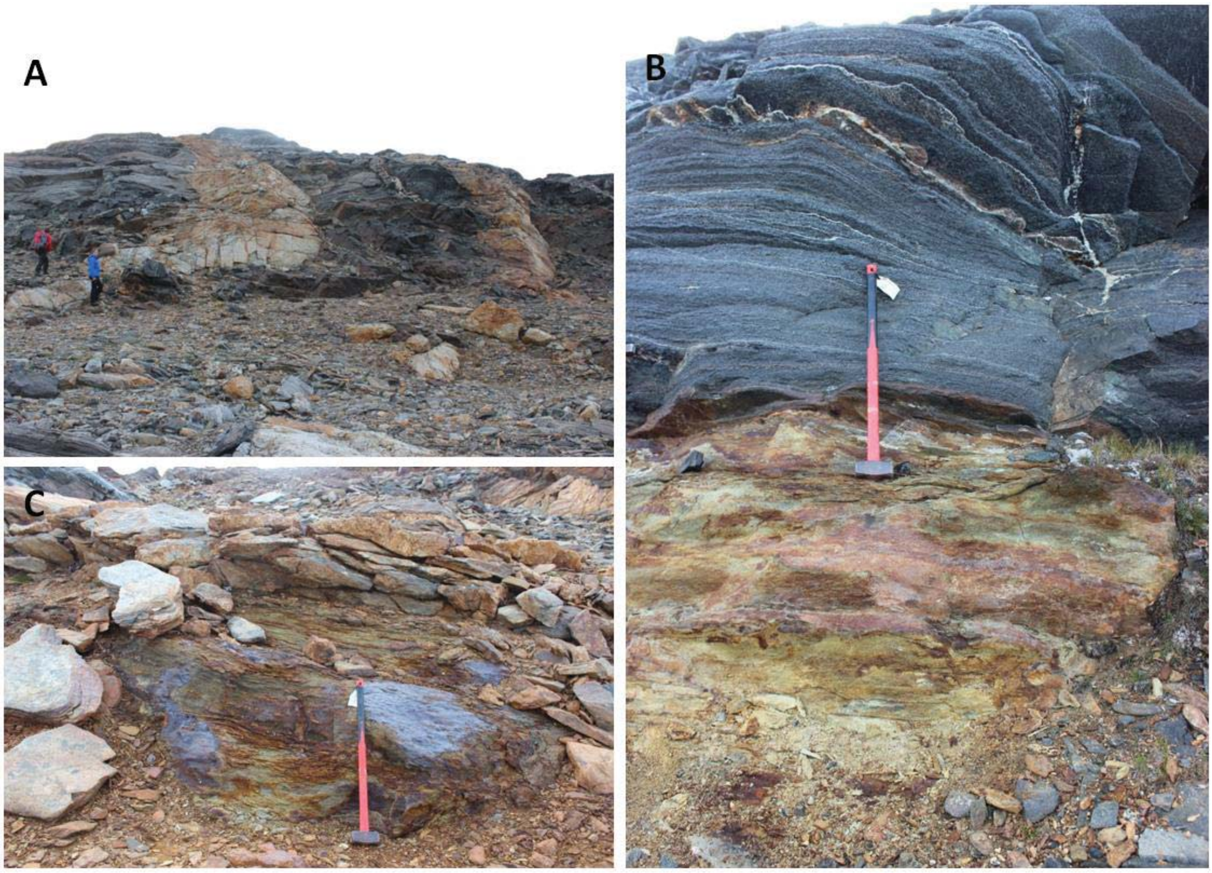

Figure 3. *The outcrops sampled at Reco stop 1; A)Pegmatite crosscutting the amphibolite. B) Garnet amphibolite in the top and sulphide rich layer below, C) Sulphide and graphite bearing rock.*

Locality 4 (15nkt04):
GPS: N65.6965°, E-38.6397°
Sample 564101 - Felsic pegmatite for geochem + geochron

Locality 5 (15nkt05):
Sample 564102 - Garnet amphibolite for P/T
GPS: N65.6973°, E-38.6400°
Sample 564103 – Sulphide and graphite bearing rock (same locality as 15ntk03)

Locality 6 + 7- Reco stop 2 (15ntk6 + 15ntk7)
GPS: N65.6799°, E-38.1650°
Locality north of Kap Tycho Brahe (figure 1) near the lake Torsukattak and the Fjord at Ajangitap Kangertiva, showing amphibolite with reddish brown weathering. The rocks did not look like the ultramafic rocks that we were looking for from last year's fieldwork, and therefore we decided to take a quick stop at the small island (Vittus Ruby Island) in order to get NTK and HEHJ familiar with the ruby forming setting in this particular area.

Locality 8 - Reco stop 3 (15ntk08)
GPS: N65.6207° , E-38.4852°

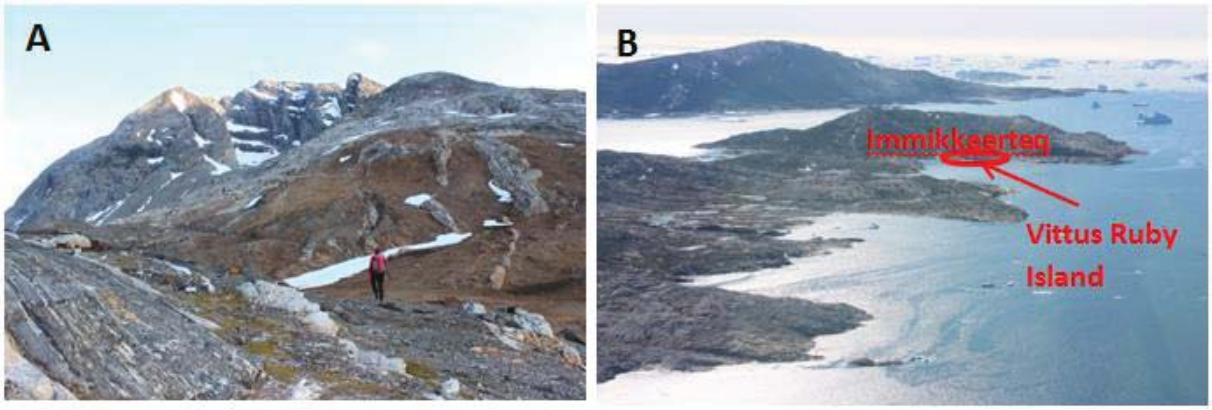

Figure 4. *A) Rusty rocks at reco stop 2, resembling the rocks from reco stop 1, but are rusty amphibolite and not UM. B) Reco stop to an unnamed small island next to Immikkeerteq, where the local rock collector Vittus Sakæussen found corundum in 2009, now referred to in this report as Vittus Ruby Island.*

A quick stop was done with helicopter at Vittus Ruby Island (figure 1 and 3) to see the ultramafic rocks, the hydrothermal veins and pegmatites on the island. The island of Immikkeerteq could also be seen from the small island and the ultramafic lenses that can be followed from the small island and onto Immikkeerteq.
Back in camp, we put up our tents and polar bear alarm. Went to bed just before 2:00 am.

Camp 1 (15nkt09)

GPS: N65.6021°, E-38.6237°

Aim of the camp:

- Investigate if corundum can be found south of Nattivit, close to Aqqaajaq, especially in the series of ultramafic lenses that are indicated on the map.
- Check the regional geology in relation to the ruby occurrence on Vittus Ruby Island

The camp site was well situated between two small lakes connected by a small stream. Good drinking water in the lower lake. The area is protected against strong wind and provides enough space for several tents on soft underground. A few snow patches were present for cooling meat and vegetables. We had some issues with a fox-family living near the camp. Areas to the east, south and west are easily accessible.

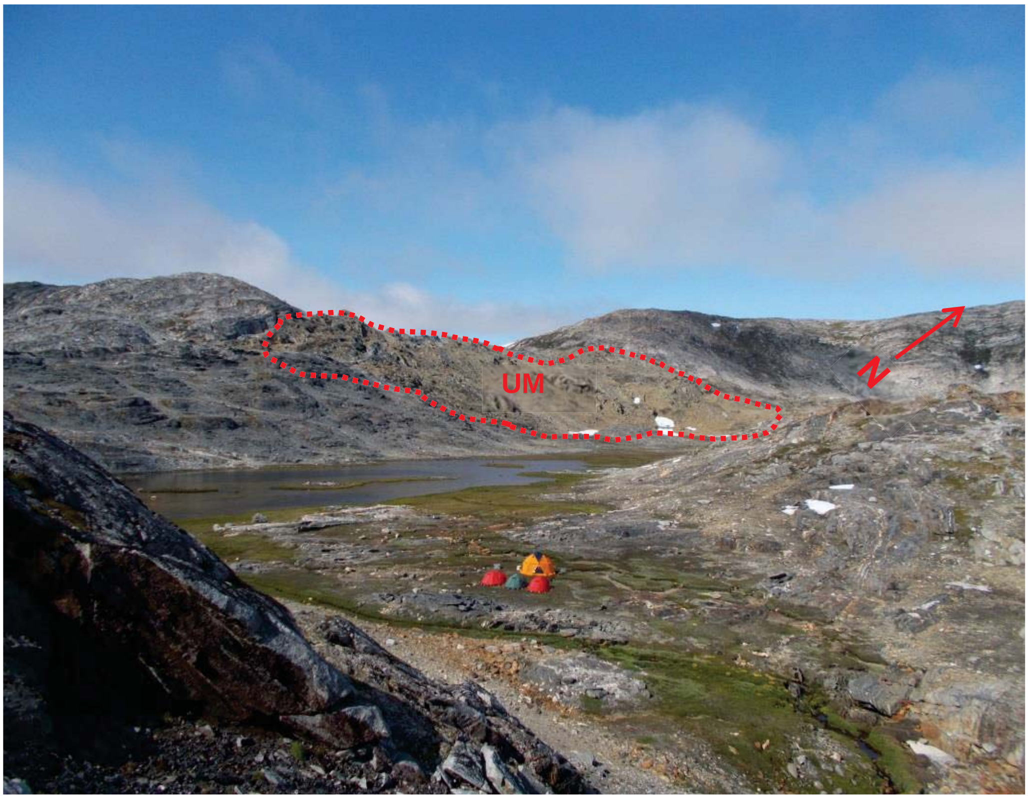

Figure 5. *Camp 1 close to Aqqaajaq. A large ultramafic body (UM) can be seen northwest of the camp.*

Day 3, 26th of July 2015

We started the day with unpacking the rest of our gear and revolver shooting practice. In the afternoon and collected rocks along a profile south-west of our camp site (figure 5 and 6). The rocks around the camp are foliated amphibolite, aluminous schists and orthogneisses.

Figure 6. *Locality map for days 3 – 6. Localities are shown in yellow (day 3-4), blue (day 5) and red (day 6), The location of this area is shown in more regional context in the small map inserted. Green colour are supracrustal rocks (ms) and light orange is orthogneiss (Sgn), and orange are orthogneiss(gn).*

Locality 10 (15ntk010): lunch stop, Isoclinal folded amphibolite (figure 7).
GPS: N65.5994°, E-38.6261°
Fold axis 42°/58°

Figure 7. *Folded amphibolite, hammer placed approximately in the fold axial plane. View towards East, locality 10.*

Locality 11 (15ntk11): Orange-green weathering lenses, which later on were identified as a mafic dyke cutting through the rock sequence (figure 8). The rock contains pyroxene and (?) quartz

GPS: N65.5997°, E-38.6273°

Sample 564104 – Mafic dyke

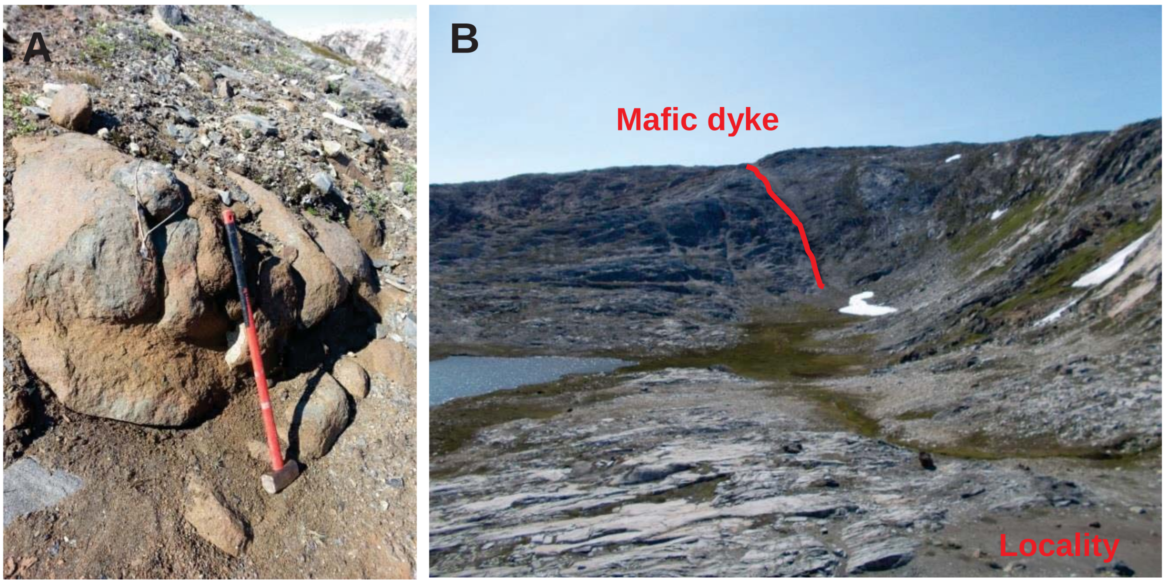

Figure 8. A*) Orange green weathered rock. The rock was later identified as a dyke cross-cutting the profile we were walking and is marked as a mafic dyke on B).*

Locality 12 (15nkt12): Ultramafic boudin sitting in amphibolite (figure 9). The ultramafic rocks are partly metasomatised, and contain hydrothermal veins, which a few cm thick, cutting through and altering minerals into needle-like asbestos minerals, altered light green minerals resembling skarn, green pyroxene, black amphibole/pyroxene, and light green mica. Along strike, towards NW, more ultramafic lenses can be found.
GPS: N65.5996°, E-38.6276°
Sample 564105 – Light green mica
Sample 564106 – Green altered um- resembling skarn
Sample 564107 – Fine-grained ultramafic rocks, least altered
Sample 564108 – Green pyroxene
Sample 564109 – Reaction zone with anthophyllite (asbestos)

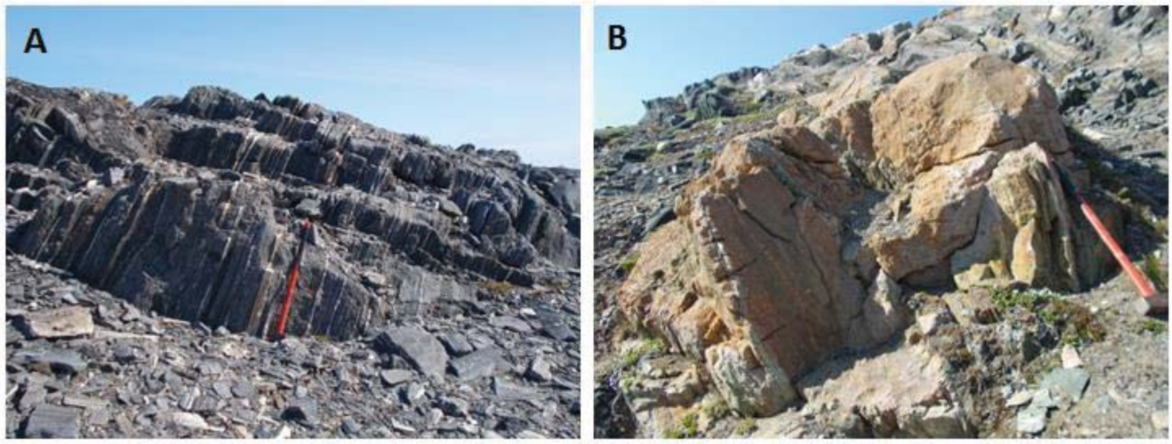

Figure 9. *A) Amphibolite adjacent to the ultramafic boudin. B) Hydrothermally altered ultramafic rock. Samples were taken from the different mineral phases and also the least altered part of the ultramafic rock.*

Locality 13 (15nkt13): Loose block or broken up band of ultramafic rock with silicified asbestos veins (figure 10), could be anthophyllite or grey crocidolite (Hawk's eye).
GPS: N65.5992°, E-38.6276°
Sample 564110 – Silicified asbestos minerals

Figure 10. *Silicified asbestosveins in ultramafic rock, locality 13.*

Locality 14 (15nkt14): Light coloured orthogneiss (figure 11) for geochronology.
GPS: N65.5990°, E-38.6285°
Sample 564111 - Orthogneiss

Figure 11. *Light coloured orthogneiss, sample 564111.*

Locality 15 (15ntk15): Large ultramafic rock lenses (figure 12).
GPS: N65.5985°, E-38.6311°
Sample 564112 - Reaction zone with amphibole and plagioclase
Sample 564113 – Reaction zone with anthophyllite and another mineral phase in the centre
Sample 564114 – Asbestos mineral (anthophyllite?), has been silicified
Sample 564115 – Ultramafic rock –least altered, contains pyroxene + olivine

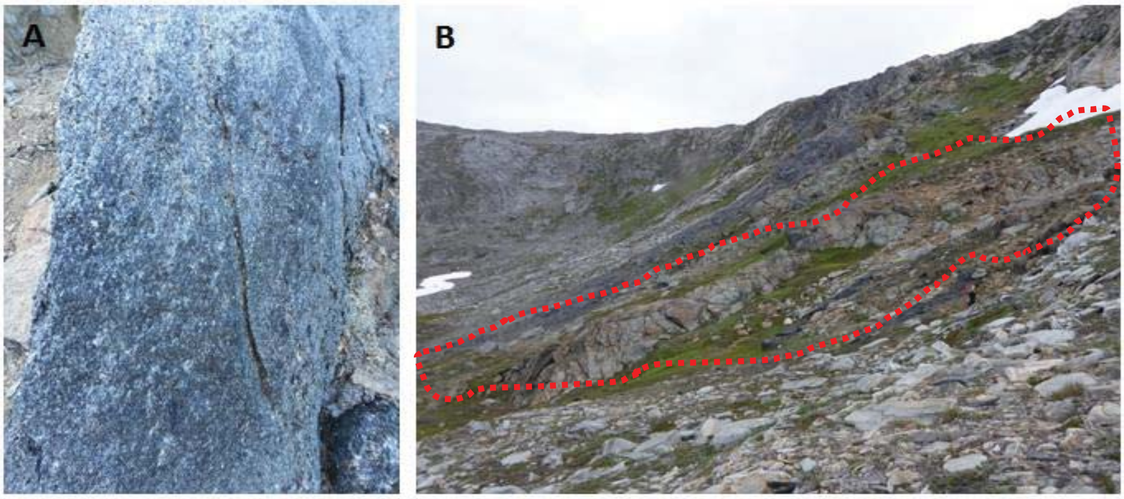

Figure 12. *A) Sample 564112, reaction zone between ultramafic rocks and felsic pegmatites with plagioclase and amphibole. B) Area with many large ultramafic lenses have been highlighted in the photo, note person for scale.*

Locality 16 (15nkt16) - Same area with ultramafic bodies as locality 15, but the area with ultramafic lenses is quite large, and at this locality we found a pink mineral, possible corundum in situ (figure 13).
GPS: N65.5984°, E-38.6311°
Sample 564116 – Reaction zone with amphibole + plagioclase + corundum. The corundum is light pink in colour and has a white reaction zone around the corundum grains.

Figure 13. *Light pink mineral, possibly corundum, in amphibole and plagioclase rich rock.*

Day 4, 27th of July 2015

We decided to work southwest of our camp again near locality16, where we found corundum. We continued to look at the rocks along the profile that we started on day 3.

Locality 17 (15nkt17): Loose boulder in gneiss with amphibolite lenses and with a light pink mineral- (?)thulite, and biotite, amphibole (figure 14). Check for thulite.
GPS: N65.5988°, E-38.6289°
Sample 564117- Light pink mineral, possible thulite

Figure 14. *Sample 564117,the pink colour looks different than normal K-feldspar. Dark minerals are biotite and amphiboles.*

Locality 18 (15nkt18): Loose block. Leuco-gabbro (figure 15). One of many here. Scree with mainly gneiss and amphibolite. Minerals identified are amphibole, plagioclase and biotite. Very coarse grained rock. The leuco-gabbro could have been transported with glaciers from further inland close to the inland ice (Bussemandsgletscher), where some of the rocks are plotted on the geological map as Ammassalik Intrusive Complex anatexites. There could possibly be leuco-gabbro and diorites present underneath the inland ice as well as the anatexites.
GPS: N65.5988°, E-38.6289°
Sample 564118 – Loose block of leuco-gabbro.

Figure 15. *Sample 564118 of leuco-gabbro. The leuco-gabbro is most likely transported by a the glacier nearby that has retreated, and the locality for the leuco-gabbro is possibly to be found underneath the inland ice at Bussemandsgletcher.*

Locality 19 (15nkt19): Large ultramafic lenses, same as locality 15. The ultramafic rocks have been metasomatised. The area with ultramafic rocks contains two bands of ultramafic rocks that are separated by amphibolite. The first band was sampled at locality 16, and a sample was collected at this second band of lenses to see if there are any major differences in geochemistry between the two bands of ultramafic rocks.
GPS: N65.5984°, E-38.6330°
Sample 564119 – Ultramafic rock

Locality 20 (15nkt20): Same ultramafic lenses higher up on the hill.
GPS: N65.5985°, E-38.6331°
Sample 564119 – Ultramafic rock

Locality 21 (15nkt21): A loose boulder of corundum were found (figure 16), but seems to come from approx. three meter further uphill where the corundum was found in situ.
GPS: N65.5983°, E-38.6323°
Sample 564120 – Corundum in amphibole, float

Figure 16. *Locality 21, reaction zone between an ultramafic rocks and pegmatitic vein with talc and black amphibole rich layer.*

Locality 22 (15nkt22): Same as locality 16, corundum locality at the ultramafic rock (figure 17 and 18)
GPS: N65.5983°, E-38.6309°
Sample 564121 – Pink corundum in amphibole- rich layer
Sample 564122 – ?Serpentine-rich mineral phase in contact to amphibole
Sample 564123 – Ultramafic rock, altered to anthophyllite minerals
Sample 564124 – Ultramafic rock, least altered

Figure 17. *Sample 564121 light pink minerals could be corundum*

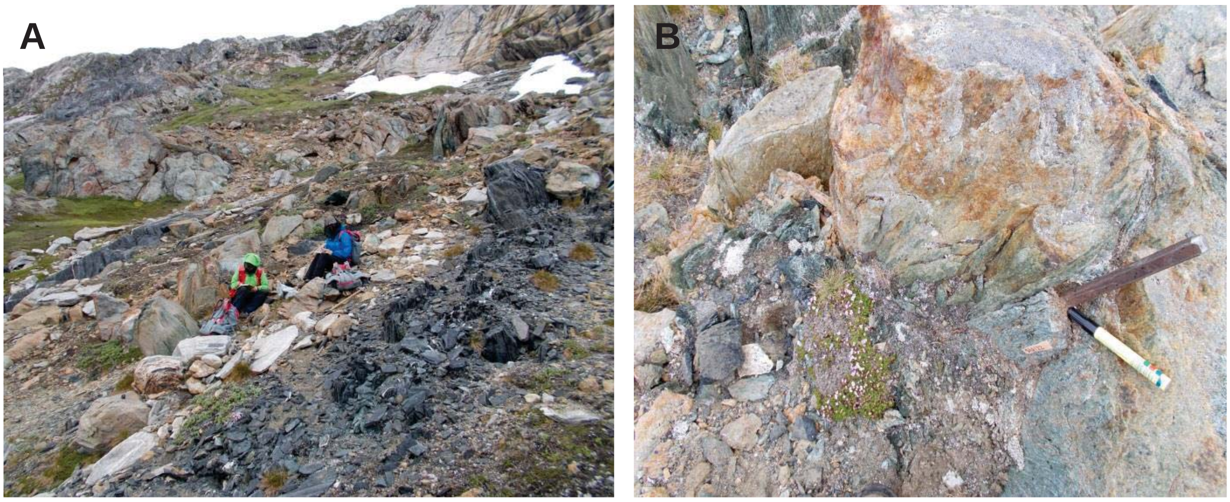

Figure 18. *A) Pink mineral locality (corundum?)16 and 22. B) Sample 564122, serpentine-rich layer.*

Locality 23 (15nkt23): ?Metasediment. Aluminous Garnet bearing schist (figure 19)
GPS: N65.5998°, E-38.6265°
Sample 564125 – Meta-sediments close to camp
Foliation plane 58°/70°

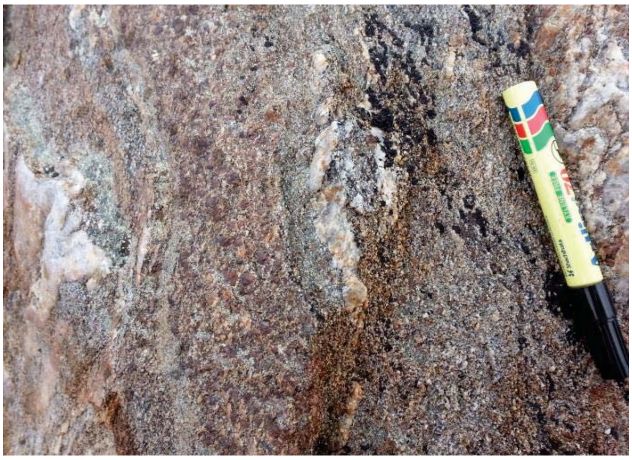

Figure 19. *Sample 564125, garnet-bearing schist.*

Day 5, 28th of July 2015

We walked northwest of the camp towards the large ultramafic rock close to camp, see figure 5 and 6.
The dyke we saw on locality 11 was found again close to camp, and cuts through the rock types we have looked at in Day 2 and 3. The dyke continues towards east and can be seen on the hill behind the big lake.

Locality 24 (15nkt24): The amphibolite is in contact to a layer of meta-diorite and they are both cross-cut by px-qtz dyke (see locality 11). Several felsic veins with quartz and sulfides are seen in the amphibolite. Amphibolite is massive, nearly no schistosity. On top of the amphibolite loose blocks of leuco-gabbro very similar to the one we found at locality 18 (figure 20) were found. The course grained leuco-gabbro contains fragments of greyish diorite and finer grained darker greyish diorite.
GPS: N65.6018°, E-38.6234°
Sample 564126 – Meta-diorite/amphibolite close to camp (this is the sample where the fox did his thing on the plastic bag and we needed to collect a fresh one).

Figure 20. *Boulder of coarse grained leucogabbro with fragments of diorite (marked with blue) and more fine-grained diorite outlined with green)). The leucogabbro has not been seen in the Isortoq area last year, thus is likely to come from the nearby area.*

Locality 25 (15nkt25): the ultramafic lenses are slightly folded in the area and the fold axis could be measured in the amphibolite and gneiss (figure 21). The gneiss in the amphibolite has M-folds. The folding axis seem to be a late folding phase, where the direction of folding is different from what was measured at the lunch spot (locality 10) on day 3.
GPS: N65.6031°, E-38.6345°
Fold axis: 102°/ 61°

Figure 21. *Amphibolite and gneiss. Hammer show direction of fold axial plane. Camp is faintly visible on second photograph on the left-hand side of the lake.*

Locality 26 (15ntk26): Below the big ultramafic lenses, a float with Biotite-gedrite-rich rock with small green minerals, apatite? (figure 22).
GPS: N65.6026°, E-38.6349°
Sample 564127 – Green mineral in amphibole rich rock,

Figure 22. *Float of amphibole-rich reaction zone with small green minerals (apatite?).*

Locality 27 (15ntk27): Corundum was found in large ultramafic lenses. Large ultramafic bodies with hydrothermal veins. Different phases are ultramafic rock, light green altered ultramafic rock, a green amphibole phase, mica (or serpentinite) layers, mica (or serpentinite) + amphibole layer, and amphibole + corundum (figure 23). The reaction zone is about 2 m wide with the different mineral phases. The ultramafic rock at the large ultramafic rock lenses are intersected by wide hydrothermal veins (1-2 m wide). Several places big areas of serpentinite layers are seen next to the amphibole layers. In some places the hydrothermal veins have been deformed and the amphibole layers resemble amphibolite, but are often surrounded by serpentinite layers and must be hydrothermally altered ultramafic rock and not normal amphibolite. Biotite layers are rarer here compared to the hydrothermal vein at Vittus Ruby Island. Silicified asbestos is also found at this locality.
GPS: N65.6025°, E-38.6349°
Sample 564128 – Amphibole with pink corundum
Sample 564129 – Ultramafic rock least altered
Intersection lineation: 243°/52°

Figure 23. *A) Sample 564128- amphibole rich rock with pink corundum B) Sample 564129 - ultramafic rock least altered.*

Locality 28 (15ntk28): Felsic material reacting with the ultramafic rock to a gedrite and green amphibole-rich rock. Thin layers of fine grained felsic mineral (?feldspar) which is folded and sheared. There were many large pink corundum crystals found. K-feldspar and aplitic material in same zone of weathered material (figure 24). Big lenses on map scale, means these are lenses consisting of smaller lenses. The ultramafic lenses were approx. 10x15x5 m in dimension. Several similar lenses were in the same area (figure 25). One amphibolite rock had a crosscutting felsic vein, but the felsic veins seem to be disrupted and could not be traced any further (figure 25.B). GPS: N65.6023°, E-38.6345°

Sample 564130 - Greenish black amphibole with corundum in situ up to 2-4 cm

Sample 564131 - Asbestos layer

Sample 564132 - Pegmatite floats close to the vein

Sample 564133 - Least altered ultramafic rock

Axial plane: 328°/52°, Foliation: 320°/68°

Figure 24. *A) Pink corundum found at locality 28. The bigger pieces were loose and could be found in the soil in a band continuous for several meters. B) Asbestos sample 564131. C) Pegmatite floats, sample 564132. D) Least altered ultramafic rock, sample 564133.*

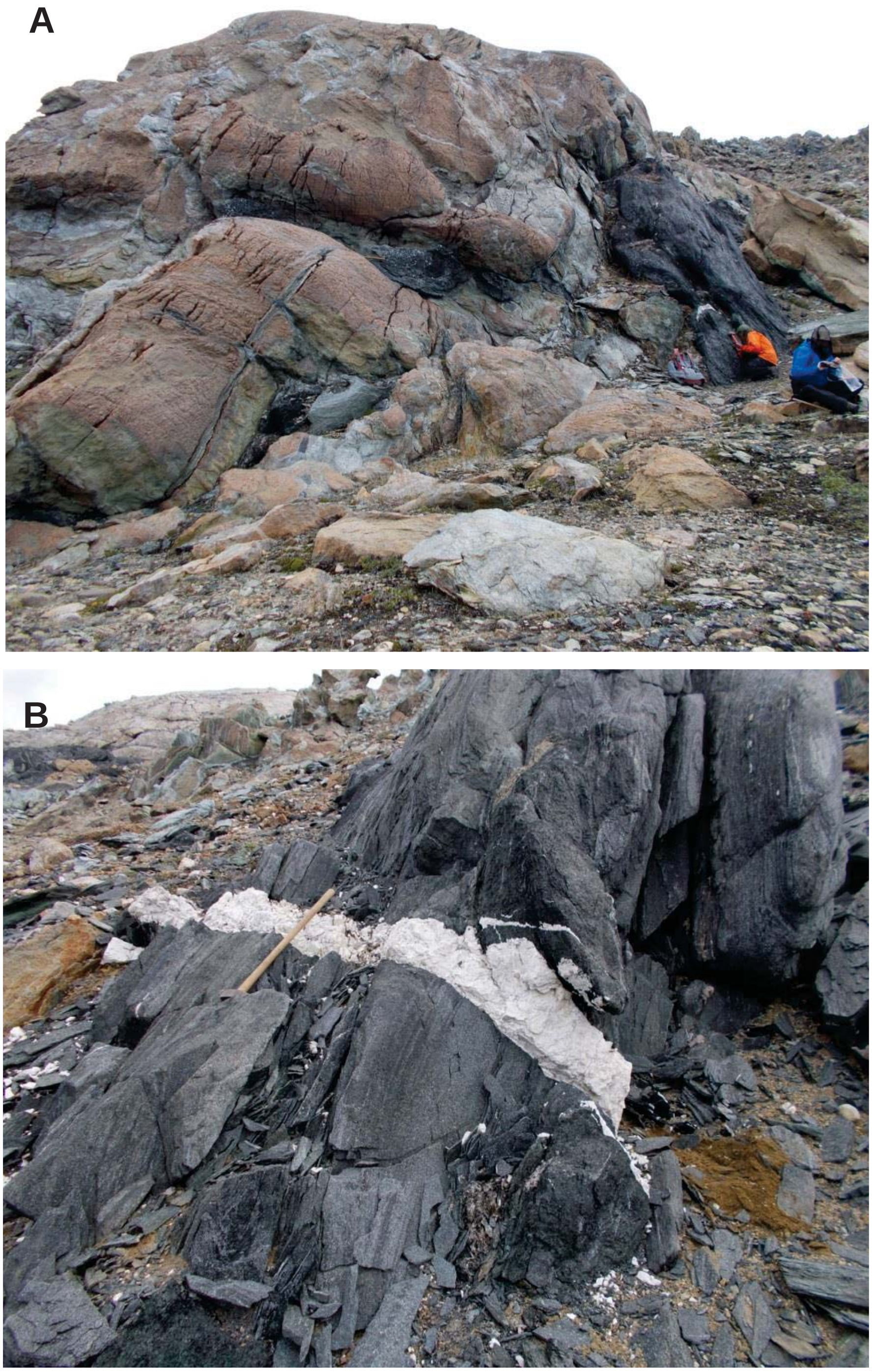

Figure 25. *A) A large ultramafic lenses of approx.. 10x15x5 m with an amphibole layer in a hydro-thermal reaction zone at locality 28. B) Some amphibolite layers are being cut by very white felsic veins but the pegmatite veins cannot be traced beyond the amphibolite.*

Locality 29 (15ntk29): Amphibolite cutting ultramafic rock lenses. No contact zone between um and amphibolite. Garnet amphibolite situated in ultramafic rock lenses.
GPS: N65.6020°, E-38.6350°
Sample 564134 – Garnet epidote amphibolite

Locality 30 (15ntk30): Approx. 10 m wide reaction zone with green amphibole and corundum (figure 26). Check minerals. Loose block, but found in situ too.
GPS: N65.6020°, E-38.6350°

Figure 26. *Locality 30*, *a 10 m wide reaction zone with amphibole layer, serpentinite and light green altered ultramafic rock. Amphibole layers seem to have been deformed later resembling amphibolite.*

Locality 31 (15ntk31): The rock resembles amphibolite, but also contained lighter coloured more felsic parts, resembling diorite. The rock types could be amphibolite and metadiorite, but looks more like deformed reaction zones in ultramafic rocks. Locally, the rock contains grey, black and green amphiboles? Strange large amphibole-rich (or amphibolite) folded unit with lumps of ultramafic rock in the folds (figure 27). The green parts of the rock resemble a hydrothermally altered rock.
GPS: N65.6016°, E-38.6374°
Fold axis: 24°/78° second generation, 334°/80° third generation

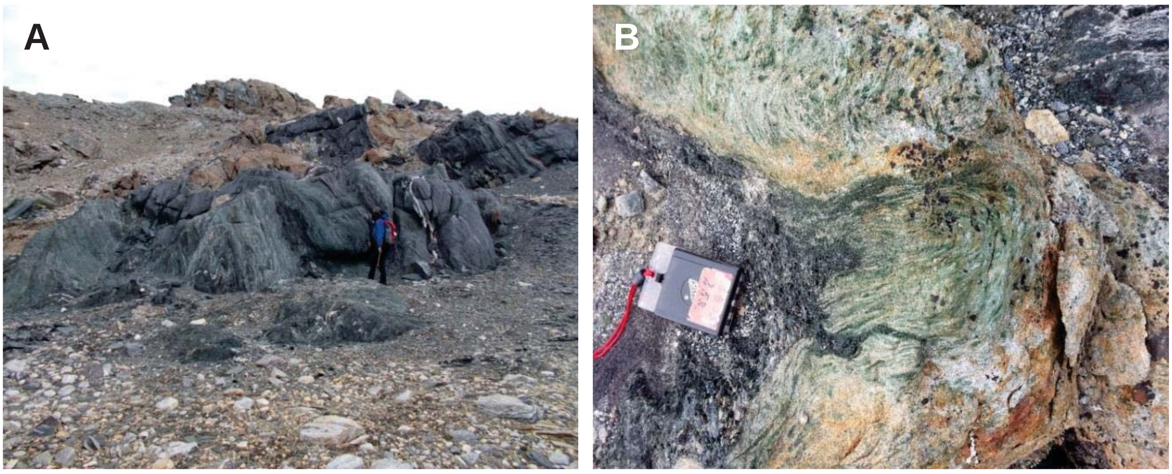

Figure 27. *Locality 31. A) large area with folded layers of which it is difficult to tell whether it is amphibolite or a hydrothermal vein that has been deformed. But the texture resembles the hydrothermal veins we have seen before. B) One of the folds in the altered ultramafic rock with the folded amphibole layers. Green amphibole is found in the altered ultramafic rock.*

Locality 32 (15ntk32): Ultramafic rock with corundum bearing reaction zone. Corundum in green amphibole and mica-rich rocks. There is an alteration rim around corundum (figure 28). Check mineral around corundum. The ultramafic rock has been altered and shows layers of asbestos and green alteration minerals. There is green amphibole/pyroxene with corundum and there are light coloured mica minerals around the corundum. The corundum is light pink colour and has elongated crystals, which look like deformation and does not reflect their original shape. The ultramafic rock + hydrothermal veins have also been deformed/sheared slightly.
GPS: N65.6013°, E-38.6379°
Sample 564135 - Sample with corundum

Figure 28. *Green amphibole with pink corundum and white feldspar. Note that the corundum grain is slightly elongated. A pegmatite is next to the corundum bearing rock.*

Locality 33 (15ntk33): Reaction zone with isoclinally folded pegmatite (figure29)
GPS: N65.6009°, E-38.6391°
Sample 564136 - Folded pegmatite in reaction zone
Sample 563137 - Garnets in serpentinite layers
Sample 563138 - Sample from green amphibolite.

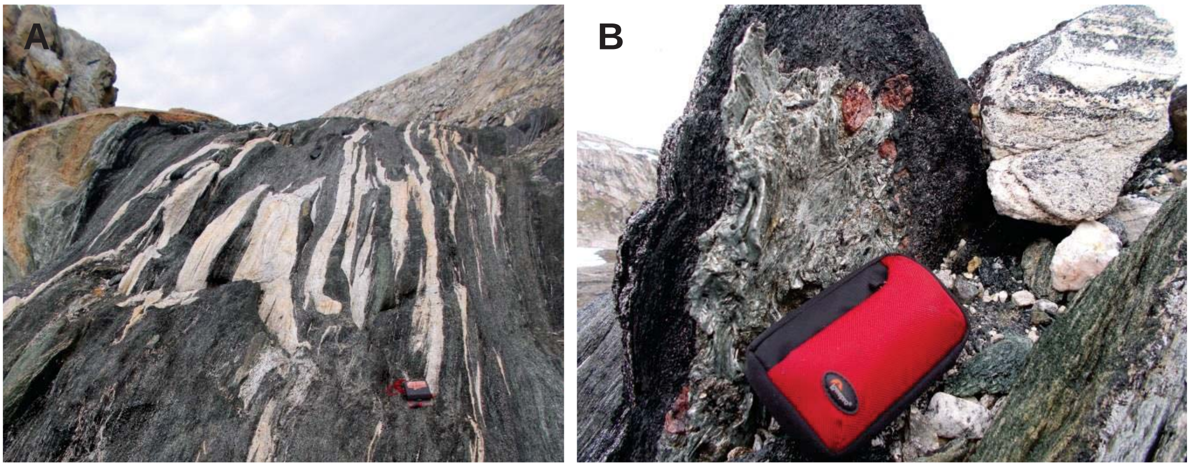

Figure 29. *Locality 33. A) Isoclinally folded pegmatite in deformed amphibole layer. B) Serpentinite reaction zone with cm sized garnets or spinel close to the amphibole layer.*

Locality 34 (15ntk34): Check blue mineral in reaction zone (figure 30). Black reaction zone with nice blue mineral overgrowth in random orientation. The reaction zone is sitting in hydrothermally altered ultramafic rock rocks.
GPS: N65.6010°, E-38.6346°
Sample 564139 - Bright blue minerals in reaction zone, could be kyanite.

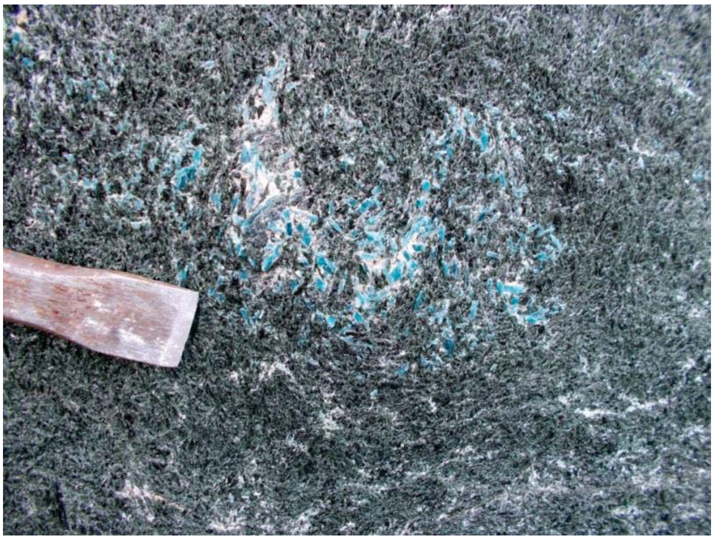

Figure 30. *Randomly oriented blue minerals in reaction zone with amphibole at locality 34. SEM analysis after the field season showed that the mineral is an alumnosilicate.*

Day 6, 29th of July 2015

This day we decided to walk southeast of the camp to finish the profile of the different rock types in the area around our camp (see also figure 6).

Locality 35 (15ntk35): Contact between metasediment (micaschist) and amphibolite. From the locality a folded diorite could be seen (figure 31). The rocks near camp were rusty and folded together with amphibolite. The rusty rocks contained abundant garnets, and the rust could come from Fe in the garnets. The folding fits the foliation and deformation trend for locality 23.
GPS: N65.6021°, E-38.6219°
Fold axis: 68°/66°

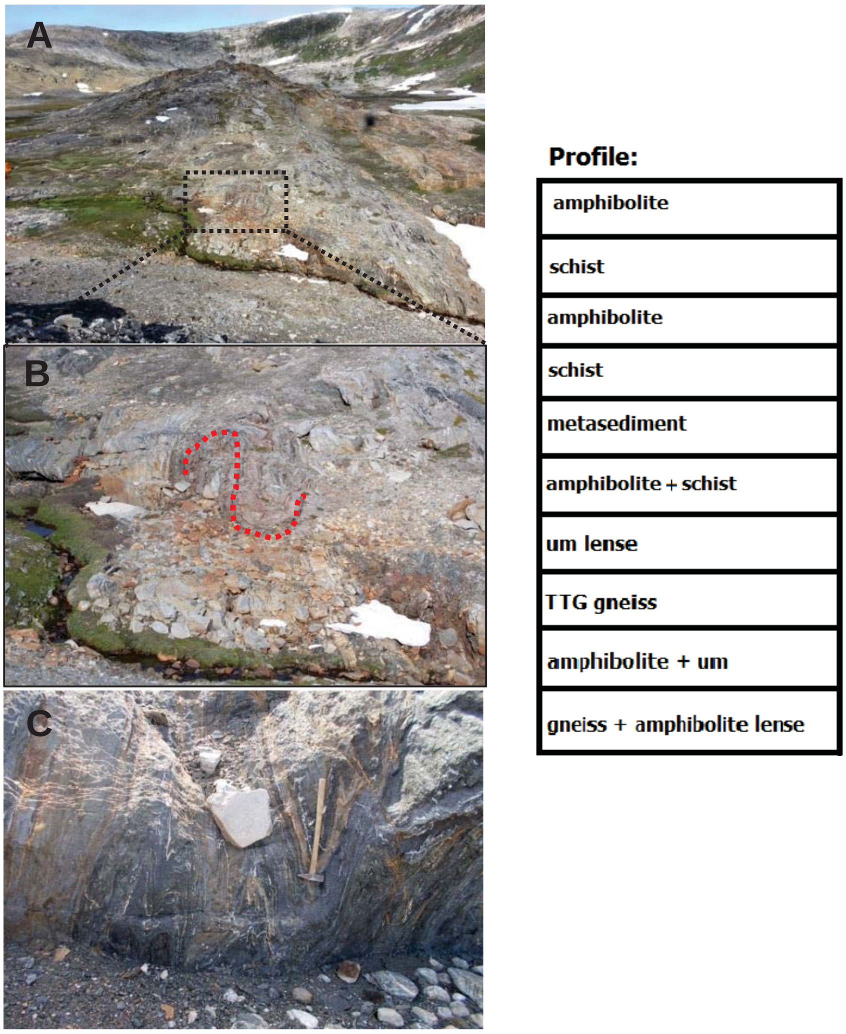

Figure 31. *Profile of the rock types in the area was continued. The first 4 rock types in the profile were described on day 5. A) Overview of the area of the camp from the south-east. The black box is zoomed in B) where folding in the "garnetite" layer is visible. C) Show the foliation and folding in the amphibolite. Hammer indicate the orientation of the folding axis.*

Locality 36 (15ntk36): Large massive lenses in felsic schist. Very rich in quartz, and white mica. Internal structure looks like possible cross-bedding (figure 32). The felsic lense was disrupted one meter up in sequence in amphibolite. The felsic lense and amphibolite were folded together. Could the felsic rock be a sandstone? Or an aplite with flow structures?
The felsic schist contains quartz, muscovite, and in some of the small veins there are garnets. Sample collected for zircon U-Pb dating.
The possible sandstone is medium grained and about 1.5 m wide. The rock is placed between amphibolites.
GPS: N65.6010°, E-38.6203°
Sample 564140 – Felsic schist for geochronlogy

Figure 32. *Light felsic schist maybe a sandstone? Or a felsic dyke? The (possible) crossbedding or flow structures can be seen in the unit. The thickness of the light felsic unit was very consistent in the area. Locality 36.*

Locality 37 (15nkt37): Photo stop, overview photos of the area around camp (figure 33)
GPS: N65.6001°, E-38.6204°

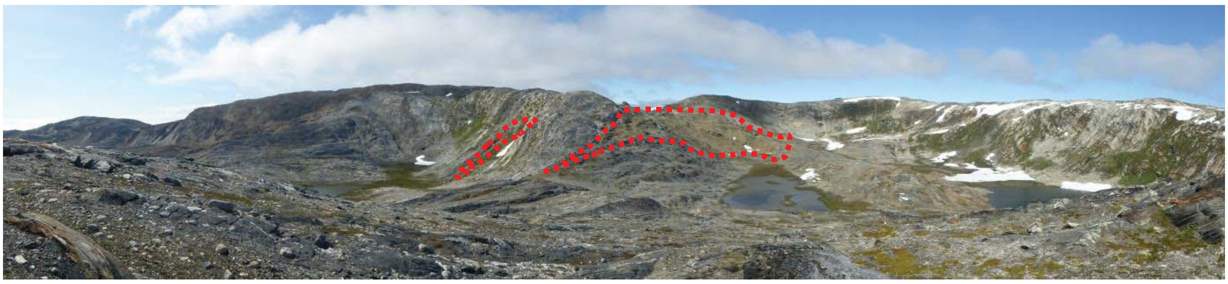

Figure 33. *Overview photo of the area around camp 2.1. Note the big ultramafic rock in the middle of the photo.*

Locality 38 (15ntk38): Garnet-rich layer in a felsic unit, maybe a sandstone or a felsic dyke. “Garnetite” garnet schist for sample close to an aplite/sandstone? Reference sample collected.
GPS: N65.6000°, E-38.6200°
Sample 564141 – Garnet rich schist, reference sample

Locality 39 (15ntk39): Light felsic rock similar to locality 36. The rock could be a felsic dyke (aplite) or a sandstone with soft sediment deformation structures (figure 33). The felsic unit sits in amphibolite. It seems that amphibolite precursor lies on top of sandstone but this could also be an effect of tectonic activity. Note the cuspate boundaries in the greyish rock pointing towards the lighter coloured parts. If the rock had a sedimentary precursor, the cuspate boundaries could be created during compaction of silt-rich parts overlain by lower porosity sandstone. While the compaction continues, the water from the silt-rich layers will escape forming pillar structures. The sandstone will therefore be slightly younger than the siltstone and the cuspate shape points towards the younging direction, which is upward in figure 34. If the felsic rock had a magmatic origin the cuspate boundaries could be formed when there is difference between the two different magmas, where the cuspate shape will point towards the more viscous magma.
GPS: N65.6001°, E-38.6223°

Figure 34. *Sandstone or aplite? with small domains with more mafic minerals with cuspate boundaries pointing towards the lighter coloured part of the rock.*

Locality 40 (15ntk40): Ultramafic lenses in amphibolite (figure 35).
GPS: N65.6003°, E-38.6230°

Figure 35. *Ultramafic lenses in amphibolite and with small pods of felsic material mixed in the amphibolite.*

Locality 41 (15ntk41): Sandstone or aplite in contact to amphibolite. There are slight curved layers inside the felsic unit, could these be slumping structures in sedimentary rock? Or flow structures in a magmatic rock? Within two meter there is a transition from amphibolite with ultramafic rock lenses to the felsic rock and to more mica rich felsic gneiss (figure 36).GPS: N65.6003°, E-38.6232°
Sample 564142 – Light felsic rock, maybe a sandstone

Figure 36. *Light grey felsic gneiss and transition to a more felsic unit towards the contact to the amphibolite. Could the unit be sandstone or a metamorphosed aplite?*

Locality 42 (15ntk42): Amphibolite with folded aplitic veins (figure 37). The aplitic veins and amphibolite resemble a bit the “amphibolite with stringers” that we saw on field work in 2014 in the Immikkeerteq island. The aplite contains quartz, feldspar and biotite. The amphibolite also contains ultramafic rock as stringers. Folded aplite in amphibolite: Very close to altered ultramafic rock, but do not seem to be associated to ultramafic rockmetasomatism.
GPS: N65.6005°, E-38.6234°
Sample 564143 – Aplite in amphibolite
Sample 563144 – Amphibolite together with the aplite

Figure 37. *Amphibolite with folded aplitic veins and small ultramafic pods, locality 42.*

Locality 43 (15ntk43): Reference samples MMR collected near 15ntk016.
GPS: N65.6021°, E-38.6238°
Sample 564145 - To MMR representative sample

Camp 2 (15nkt44)

GPS: N65.6771°, E-38.5656°
Sample 564184 – orthogneiss at camp, cut with rock saw

Aim of the camp:

- Follow up on work from fieldwork in 2014
- Cut a profile with a rock saw at Vittus Ruby Island
- Investigate the rocks in the area around Nattivit, and Immikkeerteq.
- See the extent of the corundum occurrences towards the South and North of Nattivit area

We got contact to the local boatsman Dan Reimer from Tasiilaq who sailed with GEUS last year too. We had 6 days of reco by boat and went to the Island of Immikkeerteq, Vittus Ruby Island, and to the peninsula of Siportooq, to Kap Tycho Brahe, Kitak and Isortoq.

The camp site is situated between two small lakes (figure 38). Drinking water in the upper lake. The lake might dry up during the field season and with only little water available more and more small animals appear in the water. The area is protected against strong wind from most sides. Enough space for four-five tents and soft ground. A single snow patch was present for cooling meat and vegetables. Good trout fishing spots near river outlet ca. 200m to South, where many local persons come to fish. Areas to the east, north and west are accessible.

Figure 38. *Camp 2.2 in the small fjord Tasiilaalik in the Nattivit kangertivat. Apparently the best trout place in the whole Tasiilaq area.*

Day 7, 30th of July 2015

Camp move to new locality in the Nattivit area. We were picked up by helicopter early in the morning and moved most of gear to the new camp site at Tasiilaalik in the Nattivit kangertivat. The helicopter could not bring all our gear in one flight, so one of us returned to camp 1 and picked up the rest of the gear together with the pilot. During the transit flight a lot of aerial photographs were taken of the area at Niaqernartivaq and Aqqaajaq (figure 39).

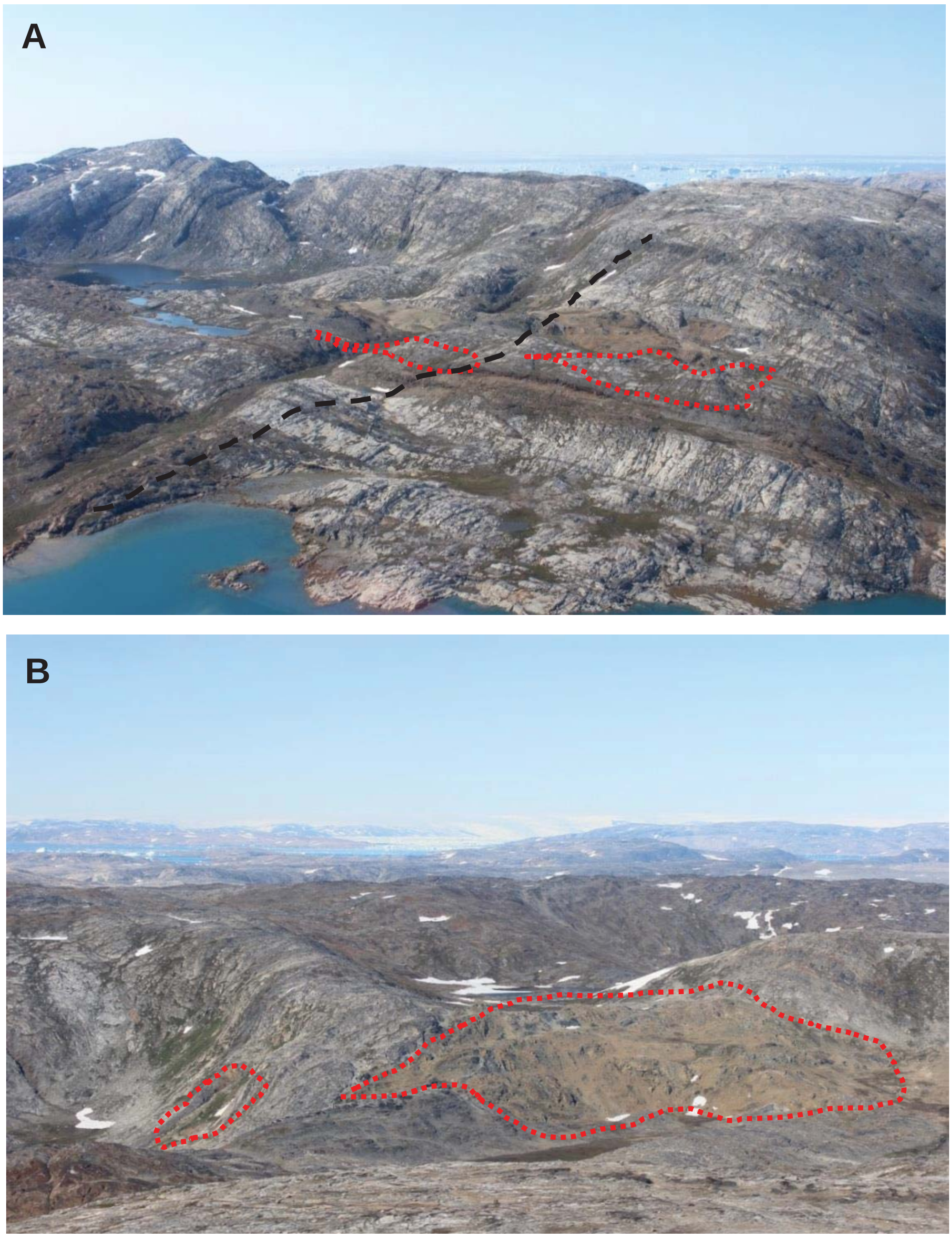

Figure 39. *A) Ultramafic lenses in the area on south of Nattivit kangertiva. A series of lying along a strike measuring approx. 50m x 30m. Note the black dashed line in the photograph, which shows a major dike that cross-cut our camp 1 area as well as the northern side of the Nattivit kangertiva B) The two ultramafic lenses from camp 1. This large lens measured approx. 100m x 50 m*

Day 8, 31st of July 2015

Field work by boat. We started at the small island on the small peninsula on the NW side of Immikkeerteq (figure 40). After having worked there we were sailed to the NE side of the Immikkeerteq Island and walked from the shore and up to the highest point on the island and towards the opposite side of the island. Lunch was on top of the highest peak on the island.

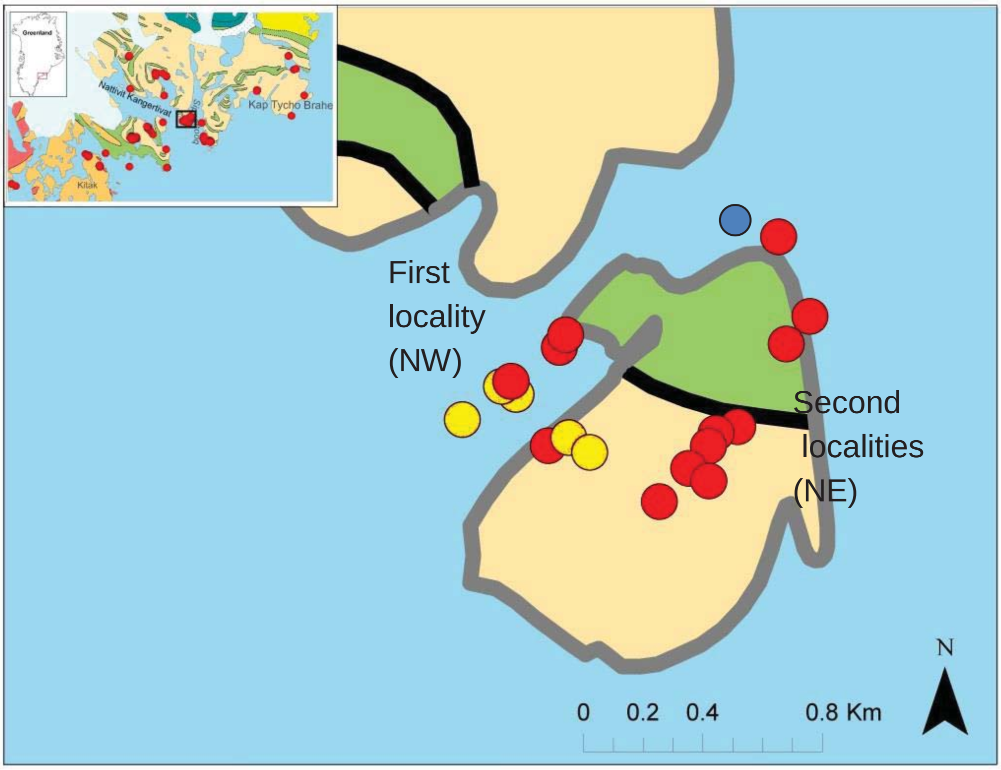

Figure 40. *Locality map for days 8 and 10 at Immikeerteq and Vittus Ruby Island Localities are shown in red (day 7) and yellow (day 9) blue (day 13). The location of this area is shown in more regional context in Figure 2. Green colour on the map indicates supracrustal rocks (ms) and light orange is orthogneiss (Sgn).Note that Vittus Ruby Island is too small to appear on the regional map and localities therefore seem to plot in the sea.*

Locality 45 (15ntk45): Sandstones on southern tip of small peninsula on NW side of Immikkeerteq (figure 41). A sandstone unit with thin layers of amphibolite and with ultramafic rock. Cross-bedding top to amphibolite. Sandstone with more and less foliated sandstone layers. Not seen garnet as was seen on the aplite/sandstone rock at locality 41close to camp 1. The locality has also been described by Hall *et al.* (1989).. They call the rock a quartz-calcite-plagioclase-microcline-biotite paragneiss. Amphibolite is found next to the sandstone unit and the cross-bedding shows way-up criterion towards the amphibolite in a NE direction (see also Chadwick & Vasudev, 1989).
Ultramafic rock and amphibolites have been folded several times in the sandstone unit. Same sandstone unit was seen on fieldwork in 2014 continuing on the island Immikkeerteq. The sample 564146 is a possible tuff layer, for geochronology. The sandstone unit sample 564147 is sampled close to the tuff layer.
GPS: N65.6222°, E-38.4820°
Sample 564146 - Tuff?
Sample 564147 – Sandstone

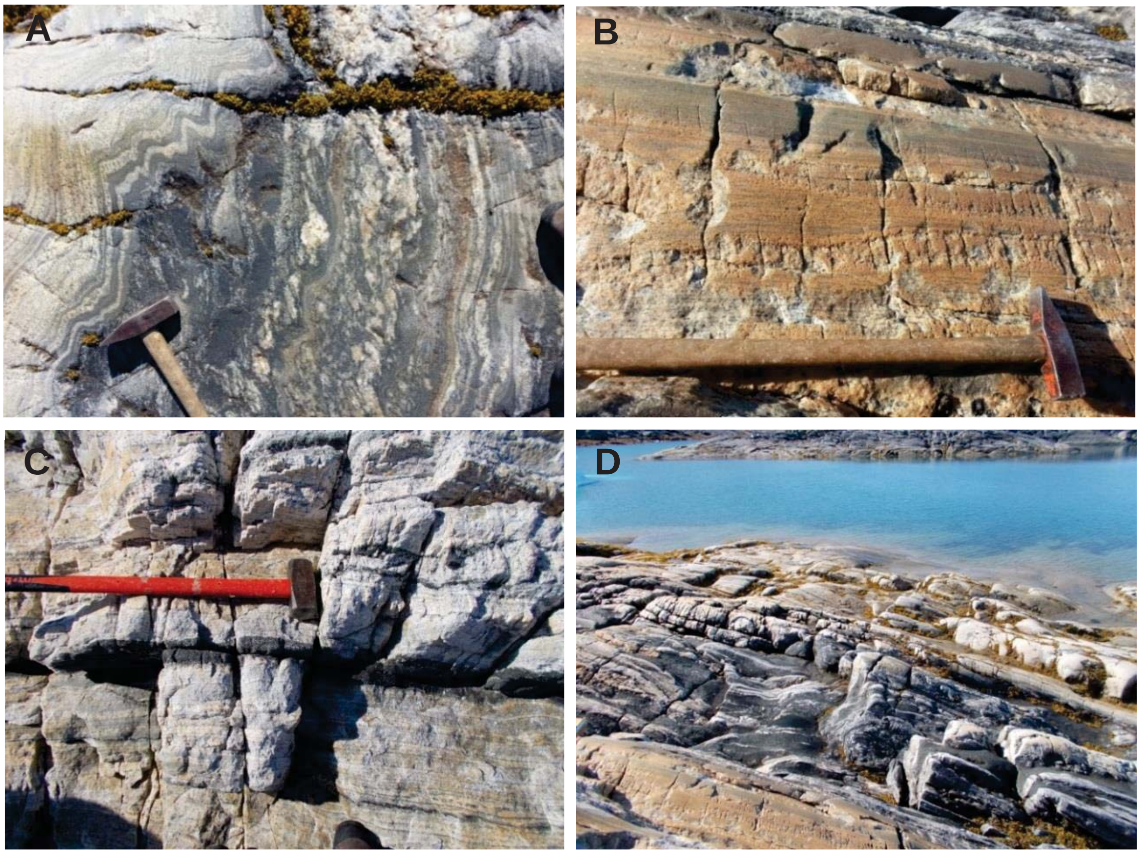

Figure 41. *A) Paragneiss - old pelitic rocks and sandstones. The paragneiss have been folded with a folding axis in a NE direction. B) Sandstone unit with possible cross-bedding. C) Mafic coarse grained layer, could this be a tuff? D) View from the eastern tip of the small island where we have crossed the rocks shown in A and B.*

Locality 46 (15ntk46): Pegmatite cuts amphibolite but is folded into amphibolite. Amphibolite folded into sandstones and cut by coarse grained pegmatite. Pegmatite contains quartz, biotite, kali-feldspar, magnetite and muscovite.
GPS: N65.6225°, E-38.4815°
Sample 564148 – Pegmatite
Sample 564149 - Sandstone with muscovite + biotite

Figure 42. *Locality 46, folded pegmatite and folded paragneiss*

Locality 47 (15ntk47): NE point of Immikkeerteq island. Probably meta-sediments. Also light coloured amphibolite, which might be altered ultramafic rockwith partly melted felsic parts(figure 43). Amphibolite more greyish with altered ultramafic rock. Interfolded at a very small scale. The area on this NE point of the island shows strong folding. The rocks have rusty parts and some rocks in between that could be altered ultramafic rock or amphibolite and the rusty parts looks like meta-sediments. The darker parts of the rock contain amphibole, epidote, plagioclase, pyroxene and quartz. The rusty parts contain the minerals biotite, plagioclase and quartz.
GPS: N65.6230°, E-38.4637°
Sample 564150 - Altered ultramafic rock with felsic material or amphibolite? Check green mineral epidote or green px. Quartz, biotite, green mineral.
Sample 564151 - Well developed schistosity. Rusty weathering.

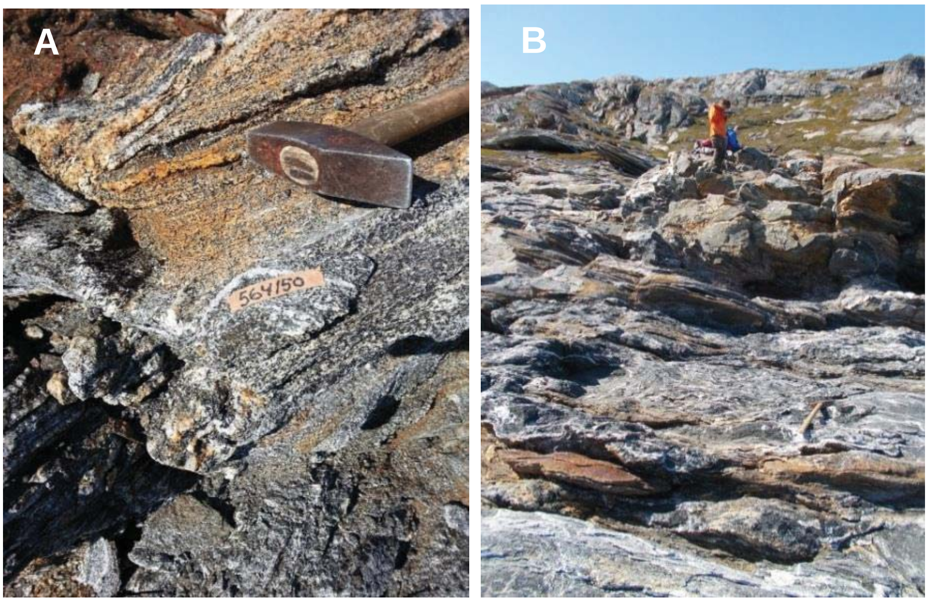

Figure 43. *A) Altered ultramafic rock or amphibolite? B) Folded rocks with areas with rusty horizons. The rusty parts were sampled for 564151 and sample 564150 is the dark parts that could be altered ultramafic rock or amphibolite***.**

Locality 48 (15ntk48): Folded orthogneiss (figure 44). Transition from rusty meta-sediments and into light TTG gneisses. After the gneiss we walked into the meta-sediments again.
GPS: N65.6222°, E-38.4655°
Sample 564152 – Gneiss for geochronology
Fold axis: 238°/30°

Figure 44. *Folded orthogneiss from locality 48.*

Locality 49 (15ntk49): Top of Immikkeerteq. Malachite in altered ultramafic rock or amphibolite lens in metasediments (figure 45). The amphibolite resembles the amphibolite with stringers that we saw on fieldwork in 2014 on the SW side of the island next to the ultramafic rock. We also found the same sequence on the NE side of the island, so this locality is most likely shows the continuation of the same layer of amphibolite.
GPS: N65.6197°, E-38.4691°
Sample 564153 - Representative sample of malachite

Figure 45. *Folded amphibolite with malachite staining*

Locality 50 (15ntk50): Boundary to amphibolite after metasediments (figure 46). The amphibolites are folded with a folding axis in a SW direction. This locality is also 14vivh023
GPS: N65.6195°, E-38.4706°
Fold axis: 200°/85°

Figure 46. *Folded amphibolite locality 50 but similar to locality 49*

Locality 51 (15ntk51): Amphibolite with black lenses that look like altered ultramafic rock (figure 47), amphibolite with mafic lenses. Just after this sequence we saw a section of amphibolite with leucosome stringers. Same as 14vivh024. This rock type also resemble 14vivh020.
GPS: N65.6191°, E-38.4712°
Sample 564154 – Ultramafic rock in amphibolites, sample of the amphiboltic part

Figure 47. *amphibolite with stringers on locality 51*

Locality 52 (15ntk52): Black wall. Black amphibolite part of reaction zone. Very rich in amphibole (figure 48). The black wall is along the contact to ultramafic rock. Sample of the black wall and ultramafic rock was taken.
N65.6185°, E-38.4726°
Sample 564155 – Black wall along the ultramafic rock. For geochem + thin section?
Sample 564156 – Ultramafic rock with fibrous minerals, brown zone
Sample 564156 – Ultramafic rock with asbestos minerals

Figure 48. *A) Black wall next to the northern ultramafic band. B) Ultramafic rock with asbestos minerals, locality 52.*

Locality 53 (15nkt53): Ultramafic lense with a hydrotermal vein containing corundum (figure 49). The lense is approx.. 10mx10m, but is part of a series of boudins of ultramafic rocks that can be traced across the Island. Same as 14vivh037. Ultramafic rock is cut by a felsic pegmatite. The ultramafic rock is in contact to an amphibolite on one side and light-coloured felsic rocks resembling a sandstone on the other side. The latter host rock contains quartz and biotite and is either sandstone or felsic gneiss.
GPS: N65.6181°, E-38.4712°
Sample 564157 - Pegmatite
Sample 564158 - Pegmatite
Sample 564159 - Pegmatite
Sample 564160 - Pegmatite
Sample 564161 - Pegmatite
Sample 564162 - Pegmatite
Sample 564163 - Amphibole + corundum
Sample 564164 - Green reaction zone
Sample 564165 - Pegmatite furthest down
Sample 564166 - Ultramafic rock - altered
Sample 564167 - Least altered ultramafic rock
Sample 564168 - Green contact minerals close to metasediments
Sample 564169 - Rock next to the ultramafic rock, possible metasediment, contains quartz and biotite

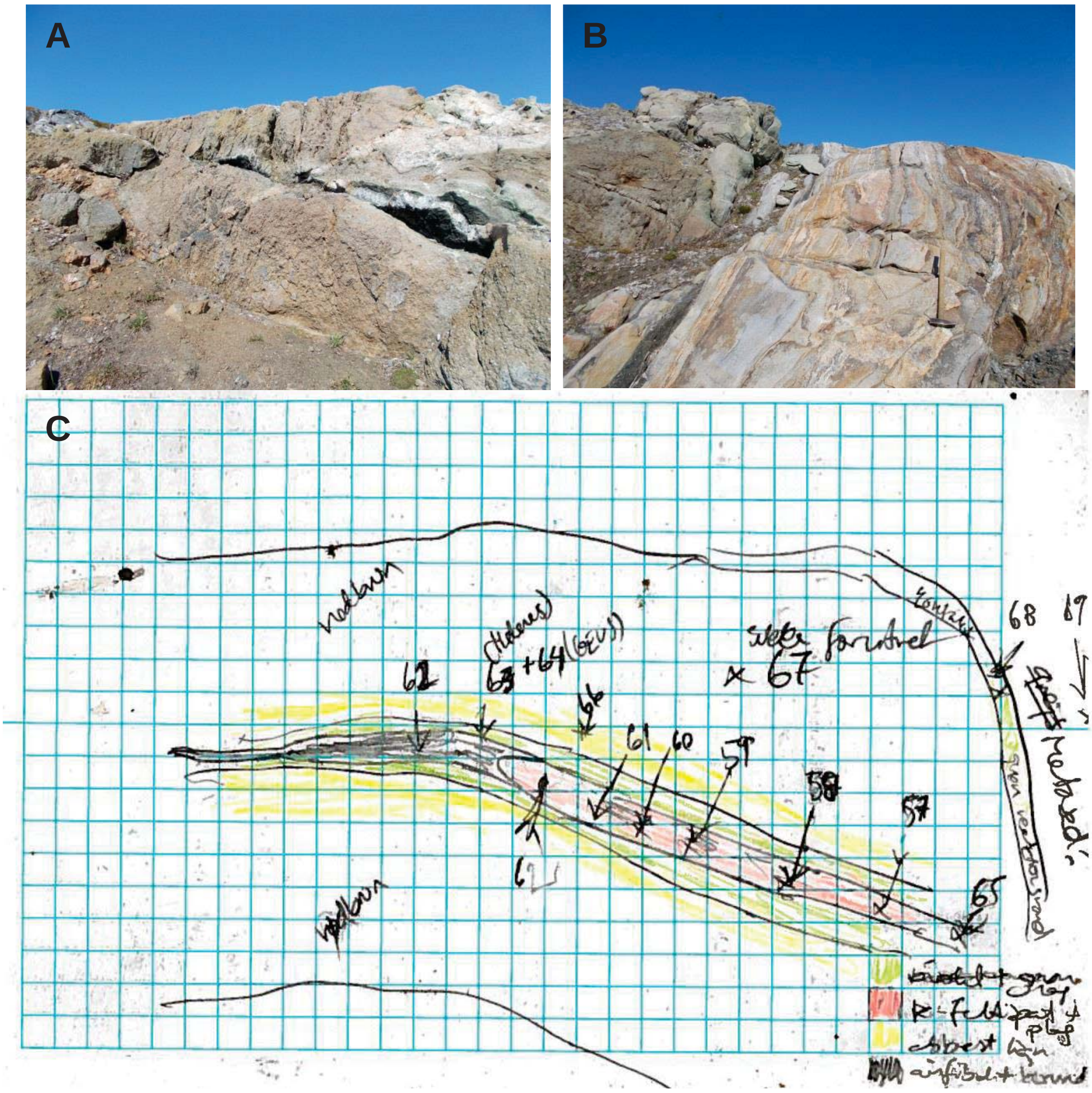

Figure 49. *A) UM lenses crosscut by a felsic pegmatite. The pegmatite stops and amphibole + corundum are found. B) The contact to ultramafic lenses and pegmatite. is a felsic quartz and mica rich rock, looks like sandstone. C) The sketch shows the same area as the photograph in A, and indicates where the samples were taken.*

Locality 54 (15ntk54): Walking further towards SE we cross the second band of ultramafic lenses that crosscuts the Island. From NW to SE we cross a sequence that contains a black wall with very fine-grained amphibolite, then ultramafic rocks and then a green gneissic rock, which might be a calc-silicate rock (figure 50). Next to the green gneiss a 1 m wide pegmatite was seen. Thereafter follows a grey-black garnet amphibolite layer and a mica-rich schist.
GPS: N65.6175°, E-38.4748°

Figure 50. *Locality 54, the second band of ultramafic lenses on Immikkeerteq Island.*

Locality 55 (15ntk55): Garnet amphibolite. Garnet amphibolite forms a thin layer in amphibolites (figure 51). Other layers that resemble flattened pillows with epidote. Original layering is isoclinally folded. Fold axial plane lies relatively flat. Layer underneath are metasediments, resemble sandstone with sulphide.
GPS: N65.6192°, E-38.4829°Sample 564193 - Garnet amphibolite. Sample 564194 - Sulphide-rich metasediment/sandstone

Figure 51. *Garnet amphibolite with chocolate bar as scale (10x10cm), locality 55.*

Day 9, 1st of August 2015

Today we walked around the area close to camp 2 (figure 52). We walked along the coast in an eastern direction. We started the morning with testing the rock saw. This took some time as no instructions on how to blend the fuel was present with the saw. But we were successful and cut a section in the gneisses near the harbour of our camp site.

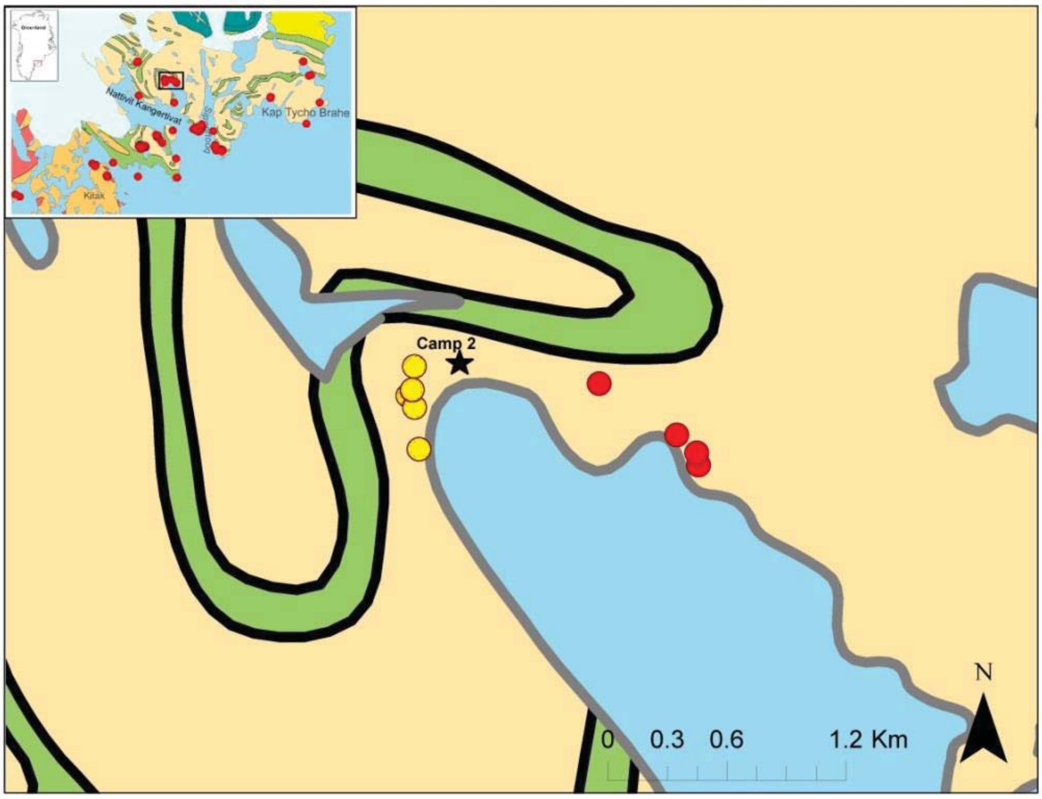

Figure 52: *Locality map for days 9 and 14 (only a selection of the total number of localities from day 14 – the remainder are shown in figure (9). Localities are shown in red (day 9) and yellow (day 14). The location of this area is shown in more regional context in Figure 2. Green colour are supracrustal rocks (ms) and light orange is orthogneiss (Sgn).*

Locality 56 (15ntk56): Very weathered ultramafic rock with spinel (figure 53). Spinel in blobs of small grains, seem to be reaction product of other mineral (?Garnet). This ultramafic lense lies in TTG gneiss, not in amphibolites as seen previously. Field interpretation: Old dyke that is folded with gneiss or remaining thin layer that predates the gneiss intrusion.
GPS: N65.6763°, E-38.5454°
Sample 564170 – Ultramafic rock with red/brown spinel or garnets

Figure 53. *Ultramafic rock with red/brown spinel or garnets.*

Locality 57(15ntk57): Ultramafic lenses with black reaction zone in TTG. Large lens of several hundred meters, which continues east of the lake. Reaction zone shows black amphibolite with stringers, green amphibolite, pale brown amphibolite, locally fibrous central zone with black amphibole, unknown brown mineral?, a carbonate mineral? and plagioclase (figure 54). Serpentinite was seen next to some of the ultramafic rock. The ultramafic rock is altered and contains veins of biotite + amphibole, but the coarsest parts of the vein contain plagioclase + carbonate minerals, where some crystal shapes are visible. The rock is white and resembles marble with tiny spots of more translucent parts.

GPS: N65.6726°, E-38.5345°
Sample 564171 - White veins in ultramafic rock reaction zone
Sample 564172 - Pegmatite in amphibole layer
Sample 564173 - Green mineral, amphibole or pyroxene?
Sample 564174 - Biotite + pegmatite
Sample 564175 - Coarse grained centre of the reaction zone; amphibole + plagioclase
Sample 564176 - Serpentinite
Sample 564177 - Asbestos
Sample 564178 - Ultramafic rock least altered
Sample 564179 - Pegmatite for geochronology, taken above the ultramafic rock
Sample 564199 - TTG close to locality 57

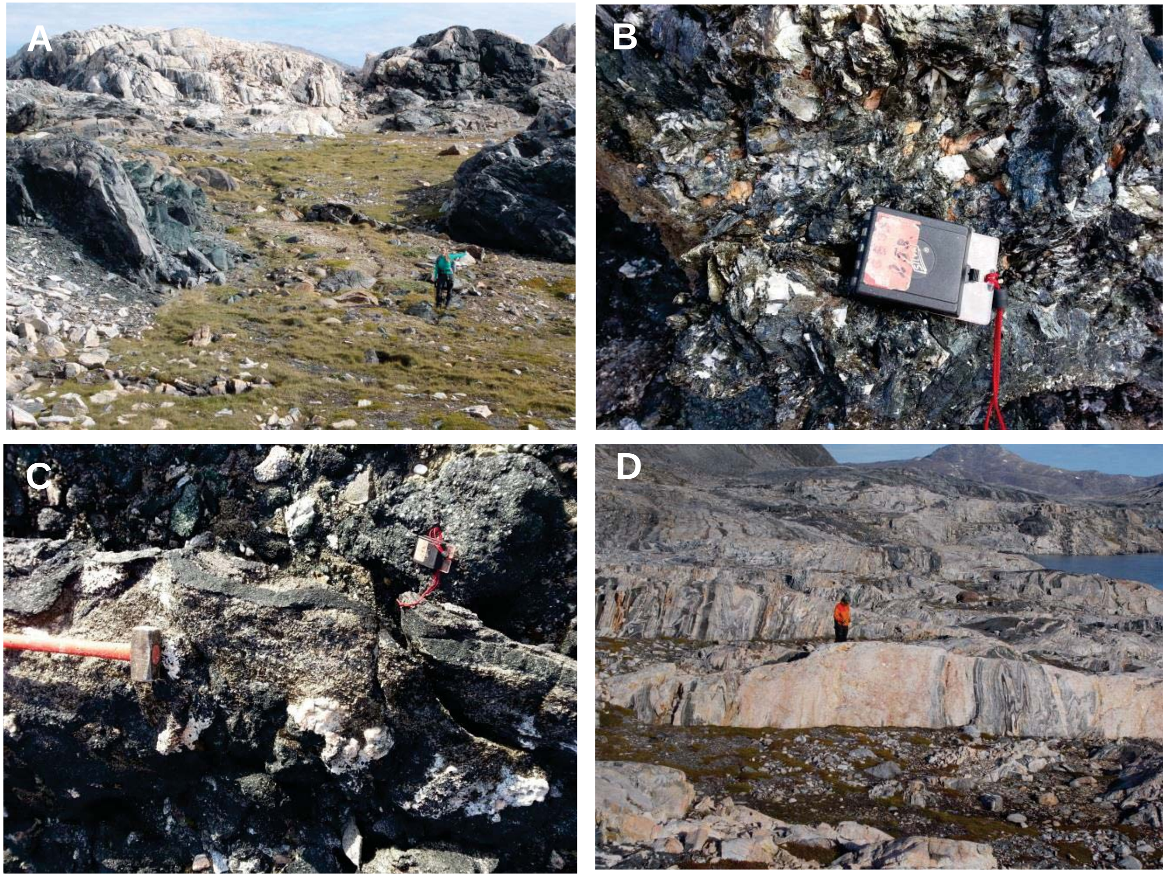

Figure 54. *A) Several larger lenses of ultramafic rock with reaction zones with felsic pegmatite. The ultramafic lenses behind the person are defined as locality 57 and the lense at the left side of the photo is locality 58. B) Very coarse grained centre of the reaction zone with biotite and a white mineral, maybe calcium carbonate or feldspar? C) Amphibole rich reaction zone with small irregular veins of felsic pegmatite material. D) Wide pegmatite close to the UM lenses (with person standing on top of it)*

Locality 58 (15ntk58): Next to previous big ultramafic lens (figure 55). Corundum in green amphibolite. Corundum in one thin layer close to contact with the wall rock. TTG gneiss in between both lenses.
GPS: N65.6731°, E-38.5347°
Sample 564180 - Corundum
Sample 564181 - Green zone next to corundum zone
Sample 564182 - Ultramafic rock with pyroxene
Sample 564183 - Reaction zone with plagioclase + pyroxene/amphibole, looks like a gabbro

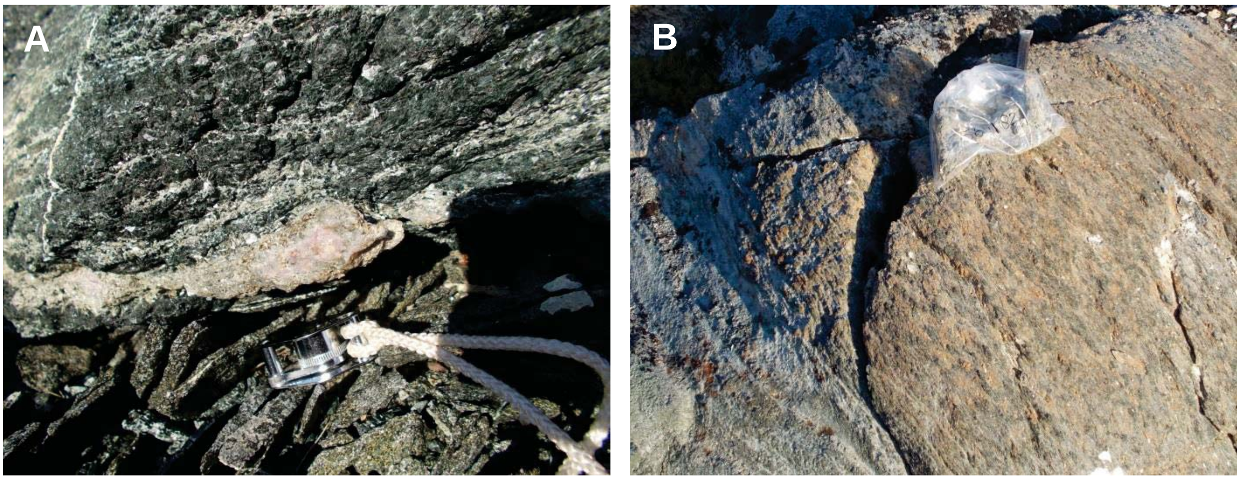

Figure 55. *A) Light pink corundum in ultramafic rock. B) Ultramafic rock with pyroxene phenocrysts. Locality 58*

Locality 59 (15ntk59): Malachite staining in amphibolite (figure 56). Malachite staining on fine grained amphibolite. The amphibolite is in contact to a TTG.
GPS: N65.6739°, E-38.5369°

Figure 56. *Malachite staining on rock sitting next to a TTG gneiss, small part of amphibolite with stringers?*

Day 10, 2nd of August 2015

We were sailed to Vittus Ruby Island and cut a profile through the reaction zone with corundum with the rock saw. The afternoon was spent on Immikkeerteq.

Locality 60 (15ntk60): Vittus Ruby Island (figure 57 and 58). Samples of the different rock types were collected around the corundum vein, as well as from the vein itself. The samples from the vein were cut by a rock saw.
GPS: N65.6211°, E-38.4855°
Sample 564185 - Corundum + amphibole zone, cut with rock saw
Sample 564186 - The green altered ultramafic rock zone next to corundum zone, cut with rock saw
Sample 564187 - Fibrous altered ultramafic rock, cut with rock saw
Sample 564188 - Green gneiss
Sample 564189 - Pegmatite above the vein
Sample 564190 - Ultramafic roc least altered
Sample 564191 - Plagioclase rich pegmatite close to the vein, an offshoot from the main pegmatite or an older one?

Figure 58. *The work carried out on the vein. First we cut a profile with the rock saw and afterwards the samples could be chipped out.*

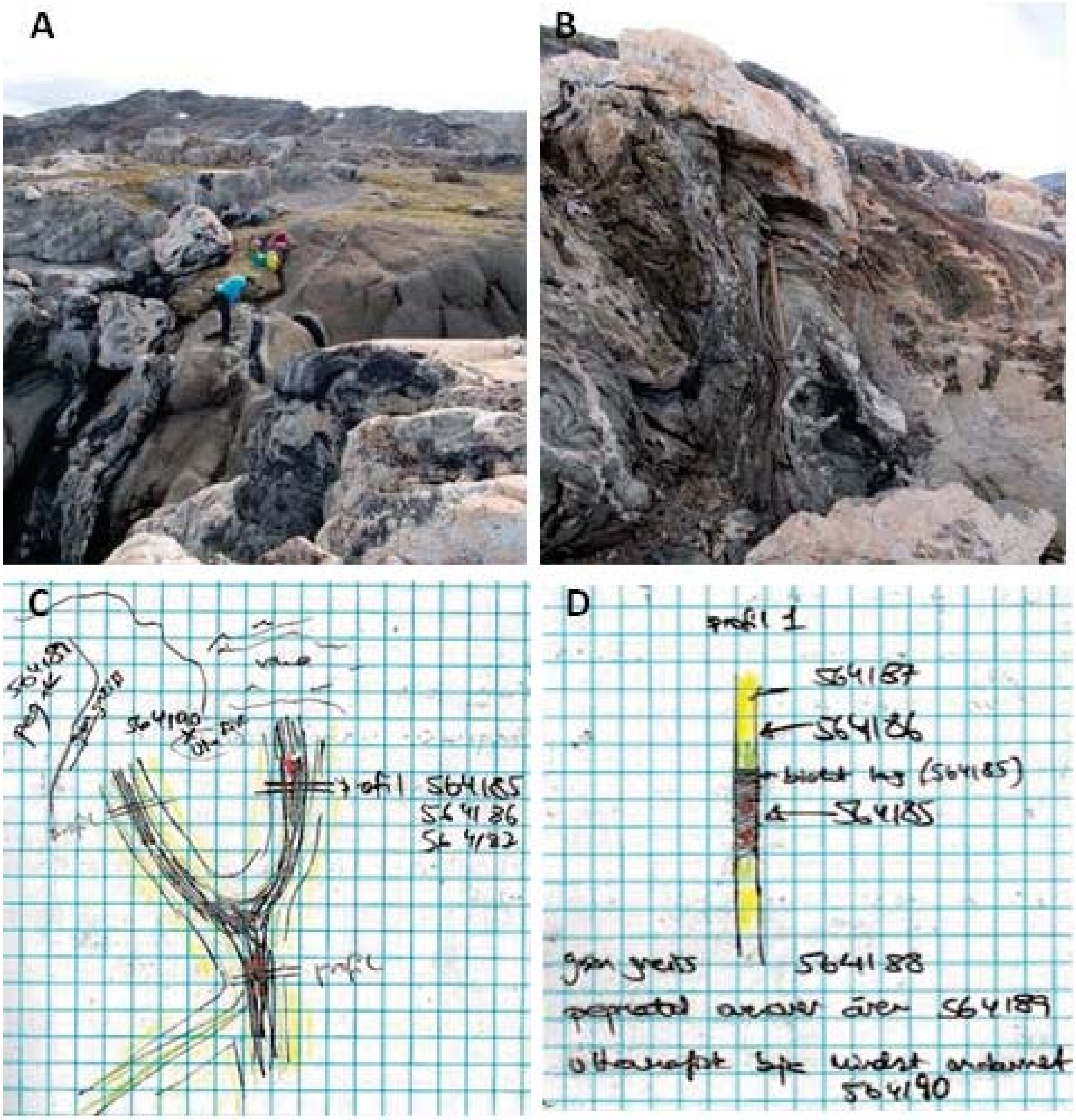

Figure 3. *A) Ultramafic rock with vein on Vittus Ruby Island. Nynke is looking at the vein. B) Pegmatite and folded green gneiss in front of UM rock. C) Sketch of vein and marked where the profile was cut with a saw. D) Profile 1 with the different samples collected fromthe different zones.*

Locality 61 (15ntk61): Amphibolite with stringers (figure 59). Malachite staining in some of the leucosome stringers.

The amphibolite consists of disseminated stringers of pegmatite or partial melt?, which are foliated and folded together with the amphibolite. Their texture is migmatitic and they are very regularly spaced. Locally, the stringers are associated with lenses of black amphibole/ultramafic rock, therefore they could potentially be a partial melt and a restite? Or represent small parts of altered ultramafic rock in amphibolite?

GPS: N65.6210°, E-38.4862°

Sample 564192

Figure 59. *Amphibolite with stringers on Vittus Ruby Island*

Locality 62 (15ntk62): Immikkeerteq Island, the southern band of ultramafic rock close to the shore (figure 60). Amphibolite with stringers is seen next to the lenses ofultramafic rock and In contact to approx. 1 m wide felsic pegmatite. There is a transition after the pegmatite into a green gneiss approx. 3m wide. The ultramafic lenses are ca.10-15m wide and 30m along strike. The ultramafic band is the second band on Immikkeerteq. This pegmatite is parallel to the ultramafic lenses and could be an older generation of pegmatite.
GPS: N65.6194°, E-38.4814°
Sample 564195 - Pegmatite

Figure 60. *A) Pegmatite next to the southern ultramafic band, with a person for scale. The pegmatite follows the same direction of the ultramafic rock bands. Amphibolite with stringers lies next to the ultramafic rock. B) Green gneiss next to pegmatite*

Locality 63 (15ntk63): Immikkeerteq Island. Reaction zone in fine grained layer of ultramafic rock. The reaction zone is plagioclase-bearing in the center and contain other mineral phases around it with brown amtohopyllite, green amphibole and black amphibole and biotite. Adjacent to the ultramafic rock with reaction zone lies amphibolite with stringers with malachite staining (figure 61).

GPS: N65.6190°, E-38.4799°
Sample 564196 - Fresh ultramafic rock
Sample 564197 - Reaction zone with amphibole + plagioclase + biotite

Figure 61. *Amphibolite with malachite staining locality 63.*

Locality 64 (15ntk64): Pegmatite on the southern Island next to Immikkeerteq and Vittus Ruby Island (figure 62). A 13m wide pegmatite was seen and the direction of the vein is oriented towards Vittus Ruby Island. This wide pegmatite cuts through foliated garnet-bearing mica schist.
GPS: N65.6200°, E-38.4891°
Sample 564198 – Garnet-bearing mica schist

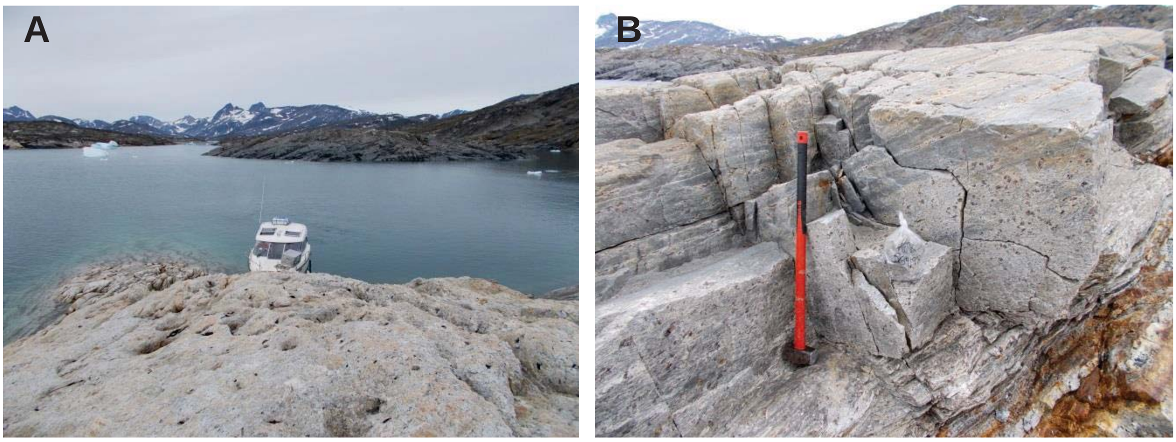

Figure 62. *A) Wide pegmatite on small Island next to Immikkeerteq. The pegmatite strikes towards Vittus Ruby Island, which is seen behind the boat. B) Garnet-bearing mica schist next to the pegmatite.*

Day 11, 3rd of August 2015

We were sailed to the southern side of the Nattivit kangertiva close to the big dyke (see figure 39A). The dyke is marked on the geological map and also continuous into camp 1. The dyke was sampled on 2014 year's fieldwork.

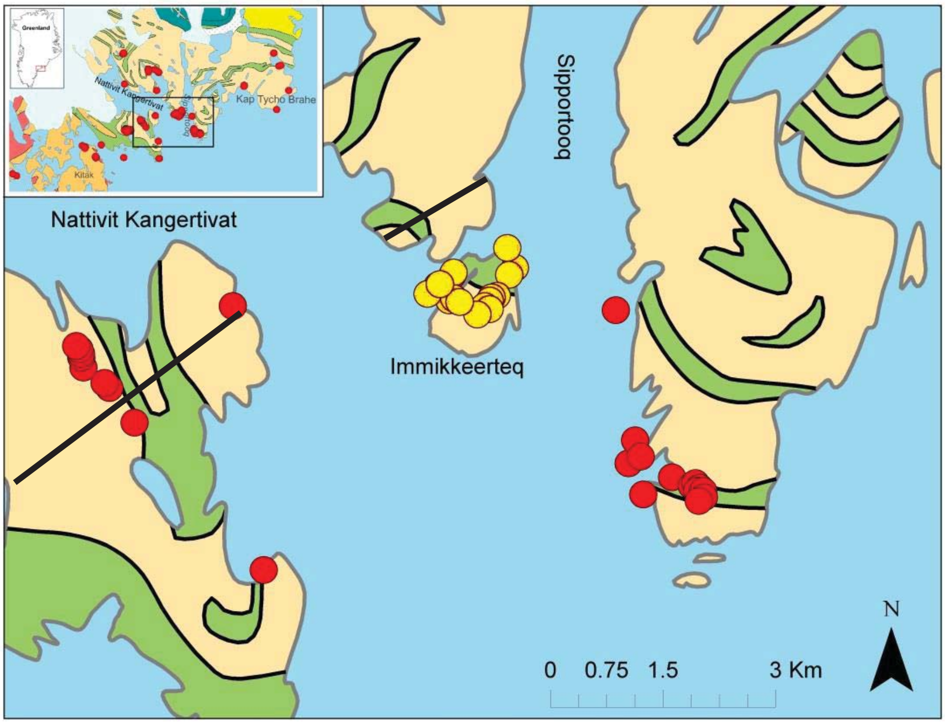

Figure 63: *Locality map for day 11 (red), note Immikkeerteq (yellow) was day 8. Green colour is supracrustal rocks (ms) and light orange is orthogneiss (Sgn).*

Locality 65 (15ntk65): Large ultramafic lens in series of lenses. Pink mineral (possibly corundum) in between black amphibole minerals of the reaction zone (figure 64). Several small zones of ultramafic rocks. Lens towards SW seems to have no large reaction zones (seen from distance). The reaction zone look like it has been moderately sheared.
GPS: N65.6049, °E-38.5742°
Sample 569601 – Pink corundum in reaction zone with amphibole
Sample 569602 – Fresh ultramafic rock

Figure 64. *Reaction zone with pink mineral (corundum?) and amphibole. The reaction zone seems sheared.*

Locality 66 (15ntk66): Ultramafic lens in folded amphibolite (figure 65). The folded amphibolite could also be a sheared reaction zone with plagioclase and amphibole.
GPS: N65.6090°, E-38.5814°

Figure 65. *Folded amphibolite next to an ultramafic lens. It is difficult to see if it is a typical amphibolite, or a sheared and folded reaction zone with amphibole and plagioclase.*

Locality 67 (15ntk67): Ultramafic lens (figure 66). No reaction zones with corundum seen
GPS: N65.6096°, E-38.5828°

Figure 66. *The area with ultramafic rocks with the pink mineral (corundum?) seen from a distance.*

Locality 68 (15ntk68): Folded contact between amphibolite and TTG with flat-lying (near horizontal) fold axial plane, ca. 220/20°. The contact between the TTG and amphibolite units is intrusive. Main foliation in adjacent TTG gneisses is steep-dipping with a 150° strike (figure 67).
GPS: N65.6115°, E-38.5889°

Figure 67. *Folded amphibolite and TTG at locality 68.*

Locality 69 (15ntk69): Ultramafic rock with reaction zone with plagioclase in the middle of the reaction zone. The minerals seen are tremolite, serpentinite, asbestos, biotite, plagioclase and amphibole (figure 68).
GPS: N65.6127°, E-38.5895°

Figure 68. *Reaction zone with asbestos, tremolite, serpentinite, biotite, amphibole + plagioclase.*

Locality 70 (15ntk70): Ultramafic lens with large brown black shiny minerals, most likely anthophyllite. Locally as brown nuummite (figure 69).
GPS: N65.6131°, E-38.5895°
Sample 569603 – Brown anthophyllite

Figure 69. *Brown anthophyllite, looks like nuummite*

Locality 71 (15ntk71): Malachite staining in amphibolite with stringers (figure 70).
GPS: N65.6137°, E-38.5900°
Sample 569604 – Malachite representative sample

Figure 70. *Malachite staining from amphibolite with stringers, next to the ultramafic rocks.*

Locality 72 (15ntk72): Green radiant amphibolite (figure 71). Seems to be nuummite.
GPS: N65.6141°, E-38.5910°
Sample 569605 – Green amphibole minerals, representative sample

Figure 71. *Green amphibole minerals, look like a nuummite*

Locality 74 (15ntk74): Head of Niaqernartivaq. Folded amphibolite (figure 72) and not ultramafic rock as was indicated on Chadwicks map. There are also amphibolite with stringers. The ultramafic rock might be found higher up, but we could not locate it from the coast.
GPS: N65.5871°, E-38.5371°

Figure 72. *Folded amphibolite at Niaqernartivaq.*

The next five localities were taken from the boat while sailing along the coast of Sipportooq peninsula:
Locality 75 (15ntk75): View to ultramafic rock along strike
GPS: N65.5958°, E-38.4272°

Locality 76 (15ntk76): Two ultramafic bands uphill
GPS: N65.5978°, E-38.4188°

Locality 77 (15ntk77): Ultramafic rock on tip of peninsula and on small island to South
GPS: N65.5995°, E-38.4314°

Locality 78 (15ntk78): More outcrop of same series of ultramafic lenses
GPS: N65.6023°, E-38.4294°

Locality 79 (15ntk79): Small ultramafic lens. More uphill
GPS: N65.6179°, E-38.4347°

Day 12, 4th of August 2015

We sailed to Isortoq settlement and also went to the island of Kitak. On the way back to camp we investigated few places along the coast of Niaqernartivaq (figure 73).

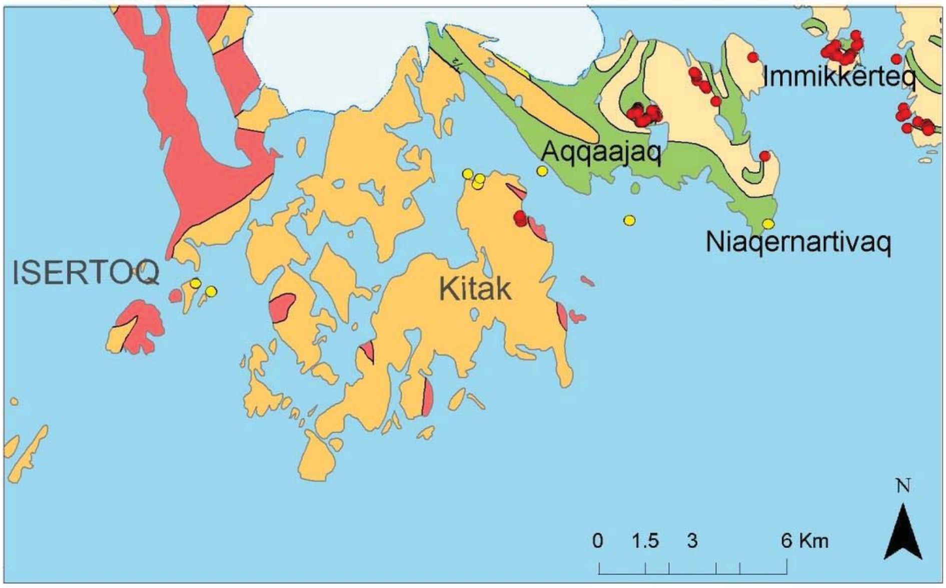

Figure 73. *Locality map for day 12 (yellow). Green colour is supracrustal rocks (ms) and light orange is orthogneiss (Sgn), orange is orthogneiss (gn), and red is granite (g).*

Locality 80 (15ntk80): Photographs taken from boat
GPS: N65.5670°, E-38.6415°

Locality 81 (15ntk81): View to large ultramafic body on Kitak (figure 74).
GPS: N65.5829°, E-38.7087°

Figure 74. *Large ultramafic rock on Kitak, seen from boat*

Locality 82 (15ntk82): Ultramafic rock near coast. This is the same ultramafic lens as is visible from other side of the peninsula. The ultramafic rock is incorporated in gneiss and pegmatite. Flat-lying orientation.
GPS: N65.5819°, E-38.7660°

Locality 83 (15ntk83): View to Isortoq (figure 75).
GPS: N65.5446°, E-38.9638°

Figure 75. *Isortoq settlement as seen from the fjord, close to the harbour. Note that the gneiss is cut by multiple pegmatite generations/orientations on the left side of the photo.*

Locality 84 (15ntk84): Isortoq. Pegmatites, coarse grained and K-feldspar-rich, have dip direction 041°. Glacier movement on granite with chatter marks show former glacier movement (figure 76). The movement has been in a southeastern direction. Small blobs of more dioritic rocks have been enclosed in the granite.
GPS: N65.5472°, E-38.9758°
Sample 569606 - Isortoq granite

Figure 76. *Chatter marks on granite. Note pen shows the direction for movements.*

Locality 85 (15ntk85): Reaction zone in pyroxene-bearing ultramafic rock with felsic medium-grained pegmatite on Kitak. Their reaction zone is plagioclase-bearing. With blobs of biotite that seem to be the replacement of another mineral. In the reaction zone, large black amphibole crystals occur. Narrow boundary with fine grained green and pale brown amphibole. The plagioclase is very pale coloured and could also be carbonate mineral (figure 76).
GPS: N65.5805°, E-38.7568°
Sample 569607 – Fresh ultramafic rock
Sample 569608 – Reaction zone of calcite or plagioclase in amphibole reaction zone

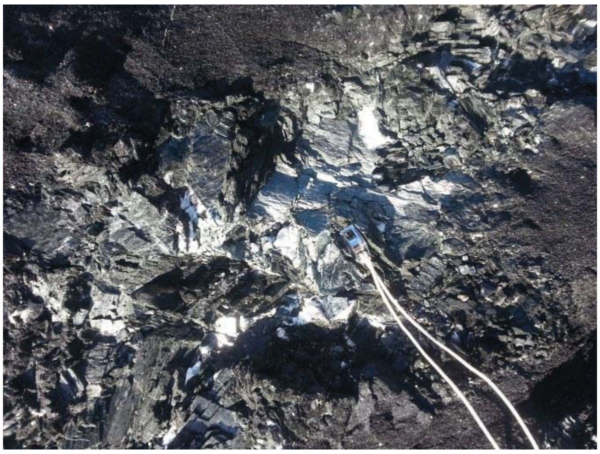

Figure 76. *Milky white minerals in the centre enclosed by biotite, could this be calcite or plagioclase?*

Locality 86 (15ntk86): Spinel-bearing reaction zone in ultramafic rock. In the same part of this large ultramafic lens, malachite and azurite staining are seen.
GPS: N65.5795°, E-38.7579°
Sample 569609 – Spinel in amphibole layer
Sample 569610 – Malachite + azurite in UM staining
Sample 569611 – Fresh ultramafic rock

Figure 77. *Spinel in amphibole rich rock sitting in UM.*

Locality 87 (15ntk87): Pegmatite cross-cutting granite (figure 78). The pegmatite is slightly lighter in colour than the granite, which is pinkish coloured.
GPS: N65.5787°, E-38.7585°
Sample 569612 - Granite
Sample 569613 - Pegmatite

Figure 78. *Pegmatite is cross-cutting the granite on Kitak, sample 569612 and 569613*

Locality 88 (15ntk88): Ultramafic lens that forms an island in ocean near Nuukajik. No visible reaction zones, but hard to access. Beautiful folding in green and black gneiss at contact. Same locality as 89.
GPS: N65.5655°, E-38.5347°

Locality 89 (15ntk89): Black reaction zone with light blue-green-turquoise mineral. ?Nuummite-appearing black amphibole. The green mineral could be apatite or corundum (figure 79).
GPS: N65.5655°, E-38.5351°
Sample 569614 – Black amphibole and a small piece of a light green/turquoise mineral

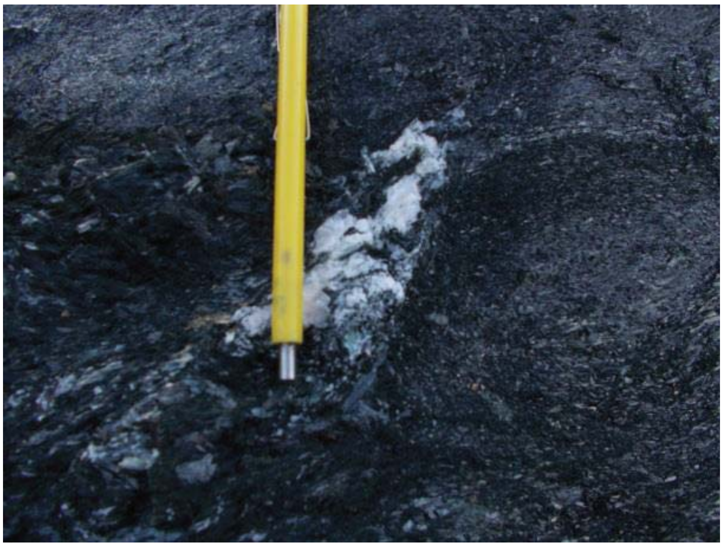

Figure 79. *Black reaction zone with light green mineral*

Day 13, 5th of August 2015

We sailed to the Sipportooq peninsula and later on we went further North past Kap Tycho Brahe and to the Ajangitap kangertiva (figure 80).
We walked from the coast and up to a small ridge on the peninsula of Sipportooq, and saw amphibolite with stringers on one side, which could be followed. Next to it we found several boudins of ultramafic rock in a band. The strike of the band is different than on Immikkeerteq, and we agree on the fold axis that has been drawn in the old field maps. There seem to be two bands of ultramafic lenses.

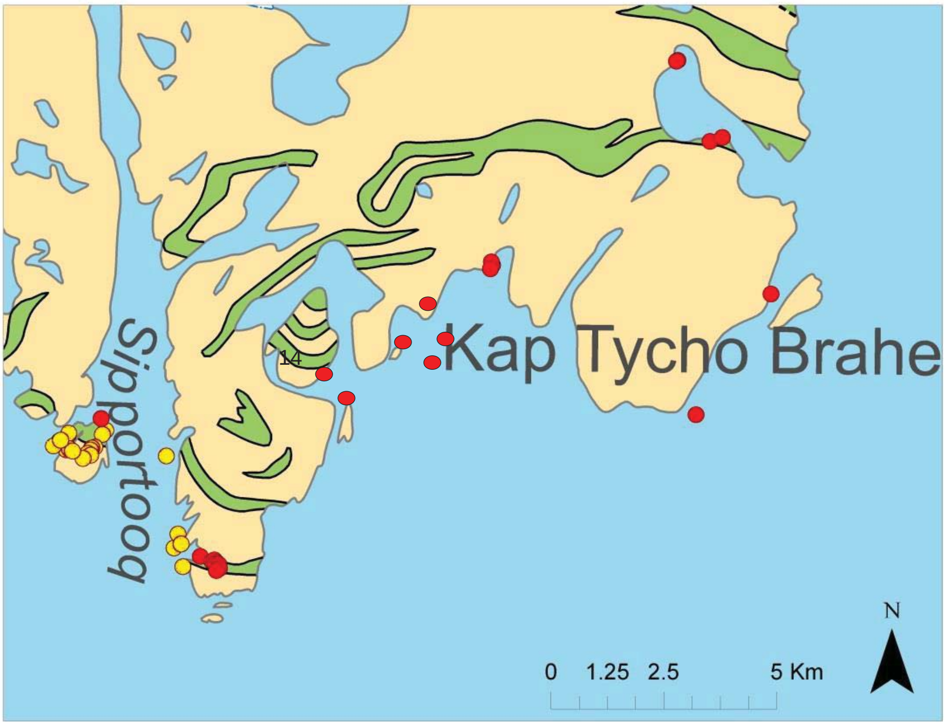

Figure 80. *Locality map for day 13 (red) to the Kap Tycho Brahe area. Green colour is supracrustal rocks (ms) and light orange is orthogneiss (Sgn).*

Locality 90 (15ntk90): Ultramafic lens on eastern side of Sipportooq. Coarse grained with large orthopyroxene crystals Reaction zone without corundum. We observed only black amphibole, and very little plagioclase in the reaction zone.
GPS: N65.5968°, E-38.4132°

Locality 91 (15ntk91): Ultramafic lens with plagioclase in reaction zones. The ultramafic rock is finer grained, more greenish in colour and contains no large orthopyroxene. The reaction zone contains plagioclase and amphibole. Amphibolite with stringers is seen along the coast between locality 90 and 91 (figure 81).
GPS: N65.5971°, E-38.4121°

Figure 81. *Amphibolite with felsic stringers near locality 91.*

Locality 92 (15ntk92): Ultramafic lens without corundum. Silica-rich veins with black amphibole (figure 82).
GPS: N65.5965°, E-38.4109°

Figure 82. *Ultramafic lens with reaction zones with feldspars and amphibole. Locality 92.*

Locality 93 (15ntk93): Ultramafic lens, without a reaction zone.
GPS: N65.5962°, E-38.4116°

Locality 94 (15ntk94): Ultramafic lens without a reaction zone.
GPS: N65.5961°, E-38.4099°

Locality 95 (15ntk95): Ultramafic lens with reaction zone. Light pink mineral, which might be corundum, and a green mineral that looks like turquoise coloured one (last stop yesterday) were observed in the reaction zone (figure 83). Malachite was also observed at this outcrop.
GPS: N65.5954°, E-38.4097°

Sample 569615 - Minerals in ultramafic reaction zone with felsic pegmatite. (Need to be checked in laboratory). Unknown green mineral and light mineral could be calcite/plagioclase.

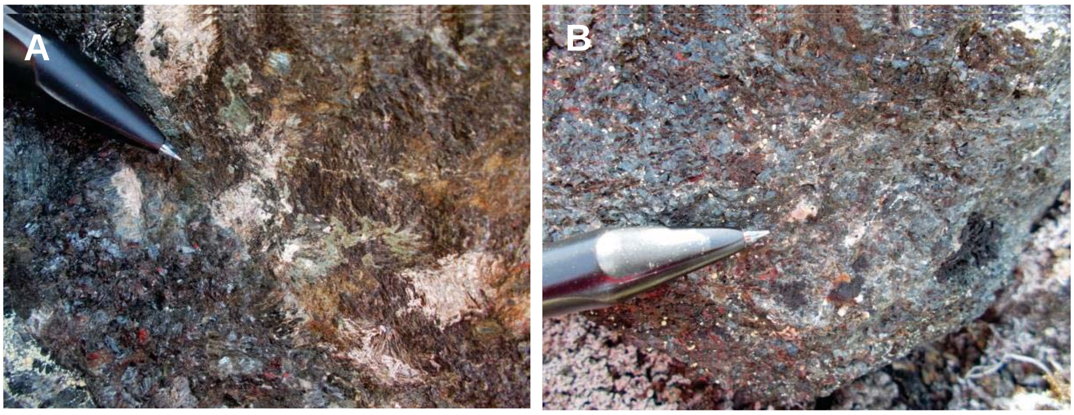

Figure 83. *A) green mineral and some white minerals, calcite? B) Light pink mineral, corundum?*

Locality 96 (15ntk96): Ultramafic lens with reaction zone with green mineral, corundum or apatite? (figure 84). Not many late coarse-grained K-feldspar-bearing pegmatites in the area. Green unknown mineral in reaction zone. Plus very plagioclase-rich reaction zone.
GPS: N65.5950°, E-38.4112°
Sample 569616 – Ultramafic lens with reaction zone with green mineral – corundum?
Sample 569617 - Plagioclase rich pegmatite next to reaction zone with greenish mineral
Sample 569618 - Fresh ultramafic rock

Figure 84. *Green mineral in reaction zone in ultramafic rock, and SEM results point towards it being apatite.*

Locality 97 (15ntk97): Malachite in ultramafic lens in cliff
GPS: N65.6249°, E-38.1795°

Locality 98 (15ntk98): Ultramafic rock with small vein. Ultramafic lense looks slightly different in composition than the other ultramafic rock we have seen earlier. This lens has more green minerals (probably pyroxene or amphibole).
GPS: N65.6954°, E-38.1859°
Sample 569619 – Vein in ultramafic rock with fresh ultramafic rock around it.

Locality 99 (15ntk99): At Ajangitap kangertiva. Ultramafic rock with different composition from the previous stop near the water. Cut by a coarse grained pegmatite ca. 80m up from the coast.
GPS: N65.6952°, E-38.1867°
Sample 569620 - Pegmatite; feldspar, quartz, biotite and plagioclase.
Sample 599621 – Ultramafic rock fresh, fine grained

Locality 100 (15ntk100): Kap Tycho Brahe, mafic rock with varying number of red mineral spinel or garnet (figure 85) and cut by thin aplitic veins that are granitic in composition, very quartz-rich. No reaction zone except a tiny thin black layer black amphibole. Could be a dyke, appears to continue on the other side of the fjord. Some parts of the rock have more coarse grains. The lower part of the ultramafic rock is more fine-grained, but seems to have the same mineralogical composition. The two different units have a fairly sharp boundary, but the more coarse grained part seems to be enclosed by the finer grained part. The rock has a beautiful colour and texture. Could this be a possible building stone?
GPS: N65.6487°, E-38.1425°
Sample 569622 – Sample of the more fine-grained part

Figure 85. *The transition from fine grained to the coarser grained part is visible. The rock is most likely a dyke, locality 100*

Locality 101 (15ntk101): Granodiorite west of Kap Tycho Brahe (figure 86). Intrusive unit or large inclusion in gneiss or part of gneiss. No obvious gneissosity. Amphibole + plagioclase + feldspar + biotite.
GPS: N65.6551°, E-38.2766°
Sample 569623 – Granodiorite/metadiorite

Figure 86. *Granodiorite at locality 101.*

Locality 102 (15ntk102): Ultramafic rock west of Tycho Brahe. Greenish colour (figure 87).
GPS: N65.6558°, E-38.2772°
Sample 569624 – Ultramafic rock for geochemistry. Collected close to granodiorite.

Figure 87. *East of Siportooq and north of Nattivit, close to Qingatak: an ultramafic rock with a different appearance from those near our camp sites. This ultramafic rock is more greenish.*

Locality 103 (15ntk103): K-feldspar-bearing coarse-grained pegmatite (figure 88) that is magnetite bearing and poor in biotite. The pegmatite has fragments of ultramafic rock inside. Black coarse-grained amphibole rim but no other reaction minerals. Strikes towards the East, cross-cutting gneissic rock and contains very reddish coloured pegmatite with K-spar, quartz, biotite + plagioclase.
GPS: N65.6544°, E-38.2777°

Figure 88. *Pegmatite, which is very rich in K-feldspar. Fragments of the surrounding gneiss have been enclosed in the pegmatite.*

Locality 104(15ntk104): Gneiss at the North side of Immikkeerteq (figure 89). Ca. 300m to south lays the folded intrusive contact to amphibolites.
GPS: N65.6254°, E-38.4660°
Sample 569625 – gneiss sample from the northern tip of Immikkeerteq Island, for geochronology.

Figure 89. *Gneiss from northern tip of Immikkeerteq*

Day 14, 6th of August 2015

This day we worked around our camp in the morning and looked at the gneisses and pegmatites there. Then we sailed to Kitak and used some hours at the eastern side of the island. Afterwards, we sailed to the Sipportooq area and looked at some ultramafic rock bands close to the coast, but away from the tip of the peninsula (figure 90). We also went close to the bottom of Nattivit kangertiva and tried to access the ultramafic rock bands near Hundeøen from the water, without any luck.

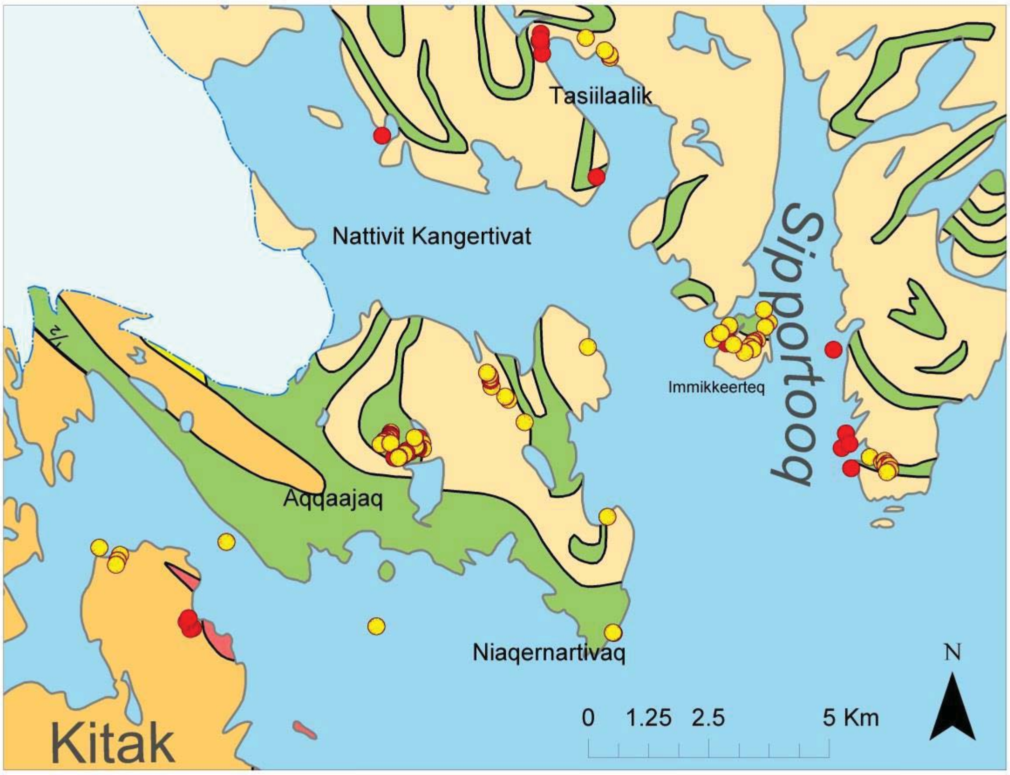

Figure 9**0.** *Locality map for day 14 (red). Green colour is supracrustal rocks (ms), light orange is orthogneiss (Sgn), orange is orthogneis (gn) and red is granite (g).*

.

Locality 105(15ntk105): Gneiss to amphibolite contact (figure 91). Light-coloured folded felsic gneiss near the shore of Kitak. There are small lenses of amphibolite in the gneiss and the gneiss is changing from more felsic parts to slightly more mafic parts. The light-coloured felsic parts contain quartz + biotite, and some plagioclase + little amphibole. The darker, more mafic parts contains larger amount of biotite and amphibole, but still contains quartz + plag/feldspar. Parts of the gneiss resemble diorite with more coarse grains and larger amphibole crystals. There are some light-coloured aplitic veins in the gneiss that contain quartz and amphibolite + biotite. One of the more coarse light-coloured veins in the gneiss contains quartz, biotite + feldspar. Biotite is found in big flakes. Some parts of the gneiss contain more amphibole than other places. At bit further up in the sequence off the shore the gneiss is more greyish in colour and has larger amphibole lenses in the gneiss is seen. Some of the amphibolite contains lenses of ultramafic units. There are few ultramafic blobs in the gneiss. The light-coloured veins in the gneiss seem to be linked to same event as the deformation and boudinage.
There have been at least two events with intrusion of pegmatites/aplite. The older veins have a white colour and resemble a quartz vein. The last pegmatites that intruded in the area seem to be the wide and pinkish pegmatites, and often strike in an East-Southeast direction. One of the wide and pinkish pegmatites has a split of the vein along the foliation plane of the gneisses and amphibolites. Samples of both types of pegmatites have been collected to hopefully get a better constrain on the age of the pegmatite intrusions and folding phase of the gneiss. The direction of the more whitish pegmatite has a different orientation than the more pinkish ones and the pinkish vein intersects the white one.

GPS: N65.6758°, E-38.5664°
Sample 569626 – Older generation of the pegmatites? For geochron
Sample 569627 – Younger generation pegmatite, more pinkish colour, K-feldspar-rich, for geochronology.

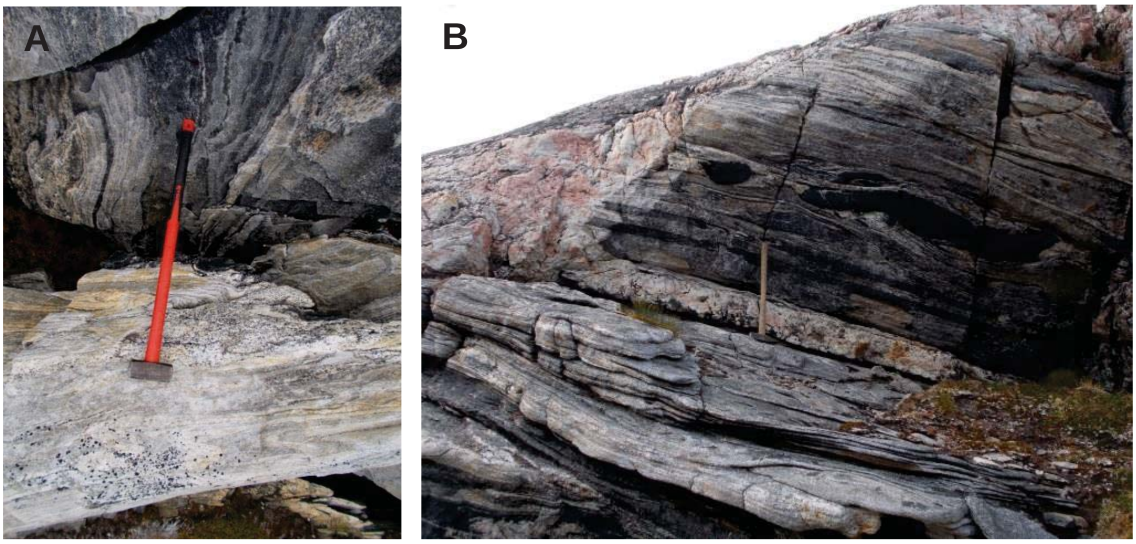

Figure 91. *A) Gneiss near the shore is felsic in composition here, but changes further up in the sequence into more amphibolitic parts. B) Light pinkish pegmatite cross-cutting gneiss with amphibolite and with an offshoot of melt following the foliation of the gneiss and amphibolites.*

Locality 106(15ntk106): K-spar coarse grained pegmatite. Contains feldspar, quartz, biotite + plagioclase. Resemble the one from sample 569627, but has a slightly different direction.
GPS: N65.6753°, E-38.5656
Sample 569628- pegmatite

Locality 107(15ntk107): Large pinkish coloured coarse grained pegmatite ca. 15m wide. One of the two cross-cutting pegmatites in the cliff face that can be seen from the water. Close to our fishing spot next to the small stream.
GPS: N65.6734°, E-38.5652°

Locality 108(15ntk108): The gneiss closer to the seashore is situated next to an amphibolite, and inside the gneiss are also some lenses of amphibolite enclosed (figure 92). Pegmatites are cross-cutting the gneiss with amphibolites. Further up in the sequence there is a change from more felsic gneiss to a higher amount of amphibolite in the gneiss. The amphibolites could have intruded into the gneiss at the amphibolite-rich part of the sequence and were folded. After the folding, further deformation formed boudins of amphibolites. The last thing to happen at this outcrop are the pegmatite intrusions, and these also occurred in several periods, as often see intersections of pegmatites with different directions are observed.
GPS: N65.6761°, E-38.5659°

Figure 92. *The sequence shows gneiss in the bottom and amphibolite in the top. The sequence has been folded and deformed before the pegmatite crosscut the gneiss.*

Locality 109(15ntk109): Malachite in cliff wall. Marie and Dan Heimer locality. Shown to us on first day with boat, 31 July 2016 (figure 93).
GPS: N65.6504°, E-38.5410°

Figure93. *Close to our camp 2 an amphibolite with stringers and malachite staining was discovered by Marie and Dan Reimer.*

Locality 110(15ntk110): Ultramafic lens on Kitak. Greenish.
GPS: N65.5669°, E-38.7240°

Locality 111(15ntk111): Reaction zone with blue-green mineral (figure 94). The ultramafic rock is greenish-coloured and has a reaction zone with altered ultramafic rock, serpentinite layer and an amphibole + plagioclase. The centre of the reaction zone contains a mineral with a metallic grey lustre. It is slightly magnetic and is possibly ilmenite. Locally, the centre of the reaction zone resembles a diorite with a salt-pepper texture. There are some greenish minerals in the reaction zone, which seems to a have zonation with a more green rim and a more yellowish-green centre.
GPS: N65.5667°, E-38.7252°
Sample 569629 – Reaction zone with plagioclase and green mineral
Sample 569630 - Grey reaction zone, plagioclase + amphibole? Appearance of a diorite
Sample 569631 - Ultramafic rock serpentinite rich part of reaction zone
Sample 569632 - Metallic grey mineral in reaction zone
Sample 569633 - Fresh ultramafic rock

Figure 94. *A) Ultramafic lenses with greenish mineral in reaction zone. B) Close up photo of greenish mineral in reaction zone with amphibole. Note the zonation in the greenish mineral with green rim and a more yellowish centre.*

Locality 112(15ntk112): Same complex of ultramafic lenses including a green mineral with an orange core.
GPS: N65.5680°, E-38.7268°

Locality 113(15ntk113): Two granites: granite 1 is more fine-grained and more greyish coloured. Granite 2 is lighter in colour and seems to intrude into granite 1. Granite 2 has large amphibole minerals and more 'speckled' texture (figure 95). This granite resembles one of the pegmatites that we walked past earlier this same day, close to the ultramafic rock of locality 111.
GPS: N65.5687°, E-38.7259°
Sample 569634 - Granite pale colour
Sample 569635 - More greyish and fine grained granite

Figure 95. *A) Floats of gneiss cross-cut by a felsic pegmatite with large amphibole crystals. Could be a slightly different type of pegmatite? B) Greyish granite is cut by lighter coloured granite with large amphibole crystals. The lighter coloured granite has an offshoot of melt cutting further into the grey granite, and must therefore be younger than the grey granite.*

Locality 114(15ntk114): Ultramafic lens in Sipportooq fjord near tip of the peninsula. Very similar reaction veins to Vittus Ruby Island, but more plagioclase in pegmatites and hence no corundum (figure 96).
GPS: N65.6003°, E-38.4279°

Figure 96. *Pegmatite vein cross-cutting an ultramafic lens. The vein is very thick and felsic. There were also noted some quartz-rich parts of the vein. The upper part of vein contains quartz. Note the green pencil for scale.*

Locality 115(15ntk115): Ultramafic lenses behind Hundeøen. Cannot be sailed to, water too shallow, even though it is nearly high tide.
GPS: N65.6583°, E-38.6377°

Day 15, 7th of August 2015

Packing down our camp and around 13 pm two boats picked us up and sailed us and the gear to Kulusuk. Boatsmen: Dan Heimer and Hans Chr. Florian Sørensen. There was a lot of pack ice in the sea and harbours around Kulusuk. Friendly reception by team 1. Stayed at Hotel Kulusuk and had dinner there too. Started packing gear for return transport by ship.

Day 16, 8th of August 2015

We packed the last of our gear into a container and prepared for shipping our gear for both teams back to Copenhagen. After lunch both teams were travelling home. HEHJ and MADP had to go back to Nuuk, and NTK went with Thomas and Jesper from team 1 to Reykjavik, Iceland. Dinner in town, followed by a ride to Keflavik. NTK: Short night at the airport hotel in Keflavik, followed by a flight home to Copenhagen. Arrival in early afternoon.

Summary

This report gives the results of a two weeks field work in the Nattivit area in South-East Greenland. The overall aim of the field work, to collect more information on the ruby and corundum occurrences in the area, has been achieved.

Several new localities with corundum have been discovered north and south of the Nattivit kangertiva near camp 1 and east of camp 2. The occurrences on Vittus Island have been resampled and the tectonostratigraphy on Immikkeerteq has been studied in more detail, including the corundum localities, in order to collect data to be able to put the corundum-forming reaction in a regional geological context.

In 2014 after a visit to Ruby Island together with Vittus Sakæssen, another corundum locality was found on Immikkeerteq Island. In 2015 more investigations and sampling were performed on ultramafic rocks in the Nattivit Kangertivat area, and several new localities were found. The corundum occurrences found in 2014-2015 were all pink colour, and are located in hydrothermal veins in ultramafic rocks. Some of the hydrothermal veins cross-cutting ultramafic rocks seemed to have too much silica present in the pegmatite melt and instead feldspar rich veins were developed. Camp 1 was situated near Aqqaajaq close to a large ultramafic body, and camp 2 was in the bottom of the Tasiilaalik fjord close to bands of ultramafic pods.

All visited corundum occurrences are small occurrences with only a very limited amount of corundum. Often only one or a few veins exist. The size of the corundum in most places is small, with the exception of one vein on Vittus Ruby Island/Immikkeerteq. Most of the observed corundum is of non-gem quality: the stones are heavy included and often very pale in colour. A few translucent stones of an acceptable colour have been observed. It is likely that more localities can be found in the area, but based on the current observations mining activity in the area should not be encouraged.

References

Bridgwater, D., Gormsen, K., (1968). Precambrian rocks of the Angmagssalik area East Greenland, p. 61-71. Report of Activities, 1967, GGU rapport 15.

Bridgwater, D., Gormsen, K., (1969). Geological Reconnaissance of the Precambrian rocks of the South-East Greenland. Report of Activities 1967, in GGU rapport 19, p. 43-50.

Escher, J.C. 1989-1990. Geological map of Skjoldungen, scale 1:500.000

Van Hinsberg, V.J., Poulsen, M.D., 2014. Field report for Team 6, South East Greenland,

Pedersen, S., Bridgwater D., (1978). Isotopic re-equilibration of Rb-Sr whole rock systems

during reworking of Archaean gneisses in the Nagssugtoqidian mobile belt, East Greenland, in GGU rapport 89, p. 133-146.

Hall, R.P., Chadwick, J.C., Escher, J.C., Vasudev, V.N., (1989). Supercrustal rocks in the Ammassalik region, South – East Greenland. In Kalsbeek (ed) 1989, GGU rapport 146. Geology of the Ammassalik region, p. 17-22.

Chadwich,J.C, Vasudev, V.N., (1989). Some observation of the structure of the early Proterozoic Ammassalik Mobile Belt, in the Ammassalik region, South East Greenland. In Kalsbeek (ed) 1989, GGU rapport 146. Geology of the Ammassalik region, p. 29-40.