DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2002/106

Preliminary report on dimension stone and aggregates: field observations in West, South and East Greenland 2002

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Summary

A total of 22 localities have been examined during the 32 days in the field. Waiting and travelling days comprise 13 days.

The locality types are 16 dimension stone, five aggregate and one garnet sand.

Ten samples for evaluation of dimension stone quality were sampled. 5 x 100 kg of aplite and granite were sampled for testing the aggregate quality and one sample of garnet sand is collected for analysing the quality of garnet.

From the evaluation in the field, the most promising rocks for dimension stone are (without priority):
Locality 1. Charnockite on Uummannaq (Rifkol), West Greenland.
Locality 4. A flame structured migmatite in Nassuttooq (Nordre Strømfjord), West Greenland.
Locality 17. Two Kakortokite types in the Ilímaussaq intrusion, South Greenland.
Locality 21. A red sandstone with sedimentary structures near Sillisit, South Greenland.
Locality 22. A pale pink granite from the cape 1.5 km east of Tiniteqilaaq, East Greenland.

The less promising rocks for dimension stone, examined in the field at the localities, during this project are (without priority):
Locality 2. Charnockite on Maniitsoq.
Locality 5-9. All the grey rapakivi granite localities examined in South Greenland.

The analyses of the polished samples and thin sections from the localities will give more detailed critical knowledge about the dimension stone potential.

The potential for high quality aggregates will be evaluated after the samples have been tested, and presented in the final report.

Contents

Introduction

This is a preliminary field report descriping the field activity and observations in the field.

The work has been conducted by GEUS for Greenland Resources A/S.

The first objective was to collect large rock samples for analyses from specified localities and evaluate the quality of the rock for dimension stone production. A second objective was to collect rock samples from specified localities to test their qualities for a possibly high-grade aggregate production. A third objective was to visit a garnet sand locality for to collect and evaluate the area for garnet sand production.

Participants: Thomas V. Rasmussen (project leader) and Paarvo Härmä (Geological Survey of Finland) natural stone consultant.

Period: 22/7-22/8 2002.

Local transport: M/S Søkongen in West Greenland, M/S J.F. Johnstrup in South Greenland and M/S Ra VI in East Greenland.

All directions are given with reference to true North.

Structural data are given with dip direction.

Figure 1. Collecting a sample with black powder in South Greenland

West Greenland

Date 22/7.

Weather: Sunny and calm.

Arrived in Aasiaat by aeroplane and went on board Søkongen. Sailed immediately to Inuarutllikkat with two other geologists from GEUS. Late in the evening high winds forced us to anchor in lee.

Date: 23/7.

Weather: Grey and drizzling.

Locality: 1, Uummannaq (Rifkol) (Appendix A map A)

Water depth: 5-7 meters limit because of an underwater threshold outside the bay.
Sample GPS position: 67°57'468N 53°47'209W.

The target rock on Uummannaq island is a post-tectonic charnockite on the central part of the island located by GEUS in 2001 (Kalvig et al. 2002) as a potential source for dimension stone. The Charnockite is white with black elongated spots including small red garnets. The white parts are quartz and feldspar crystals of medium grain size. The black elongated spots consist of medium grained orthopyroxene (Fig. 2).

The surface colour is reddish brown and the alteration depth is approximately 10 cm.
On larger surfaces the elongated black spots give an impression of a wavy pattern.
The elongated spots are strained in the approximate direction of 180°/23°.

Subhorizontal exfoliation fractures are pronounced in the area and control the thickness of the benches. The exfoliation structure gives op to 2 m high benches (Fig. 3).
The charnockite in this area is sound[1] and massive and is measured to cover an area of approximately 300-m x 1000m.

The spacing of the East-West (90°-270°) vertical cracks are 2-25 m and are on the surface mainly controlled by the pronounced exfoliation structures (Fig. 3). Perpendiculars to the vertical fractures along the benches there are vertical cracks with spacing from 1-6 m.

The topography in the area is relatively low and it will probably be a problem for traditional dimension stone mining, because the mine soon will bee under normal sea level (figure 3). To avoid this scenario we made a reconnaissance to the northern part of the island where the topography is high. In the northern part the charnockite is often very heterogeneous

[1] 'Sound' means that the rock gives a characteristic clear resonance when you hammer on it.

with a lot of inclusions, differences in mineral content and appearance. In a few small places in the northern part of the island the charnockite is homogeneous, massive and sound. But the overburden is enormous.

The sampling was done in the central part of the island, were a ca. 150-kg sample was brought out (Figs. 4, 5 and 6).

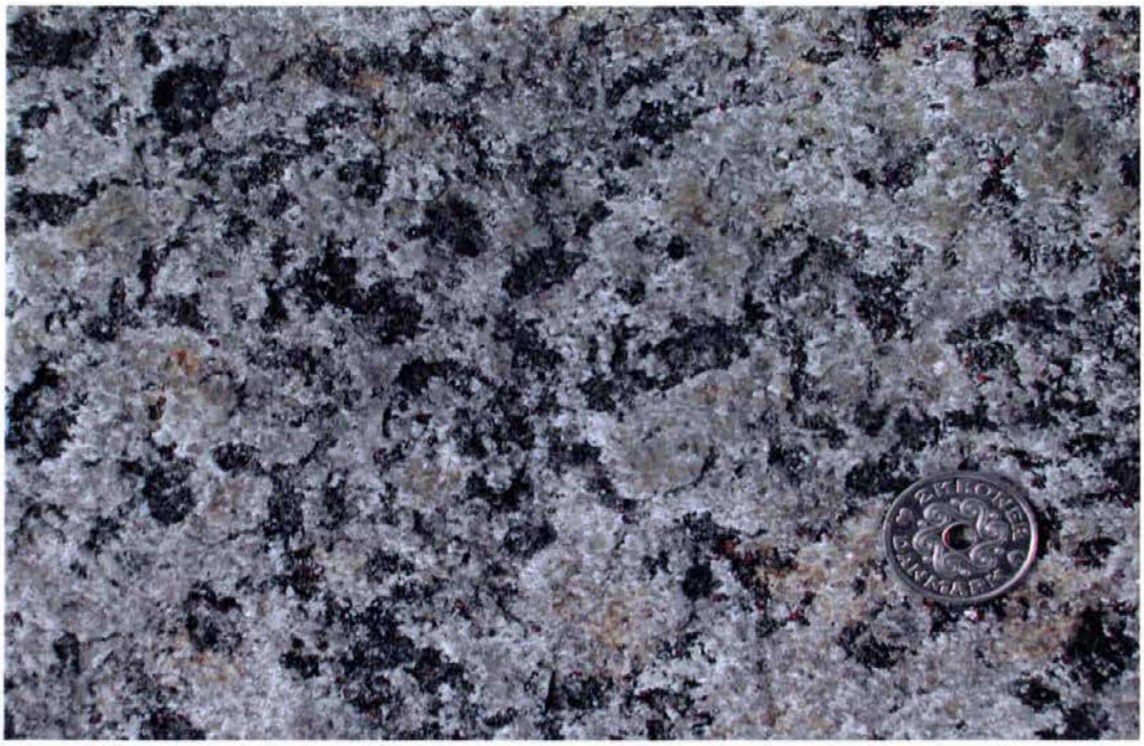


Figure 2. Close view of the charnockite on Uummannaq.

Figure 3. Pronounced exfoliation benches in the middel part of Uummannaq.

Figure 4. Sample site on Uummannaq after explosion.

Figure 5. The free primary block and the sampling site in the background.

Figure 6. Bringing the sample on board Søkongen.

Sample description and sample evaluation is in progress.

Date: 24/7.

Weather: Grey and drizzling.

On the way to Maniitsoq we sailed near the shore of Uummannaq. First up to the north-eastern part and then near the south and southwestern part to have a close look from the boat on the landing possibilities other places. The conclusion is that the bay we anchored in is the best natural harbour on the island.

Locality: 2, Maniitsoq island (Appendix A map A)

Water depth: 25 meter 30 meters from land and the cliffs go steep in to the water.

Sample GPS position: 67°49'885N 53°49'719W.

The target rock on Maniitsoq island is a charnockite situated on the south side of the island located by GEUS in 2001 (Kalvig et al. 2002) as a potential source for dimension stone. The charnockite looks like augen gneiss with large rounded feldspar clasts surrounded by blueish quartz veins with minor small garnets (Fig. 7).

The surface colour is brownish-green (Fig. 8) and the alteration depth is approximately 40 cm.

The rock is open[2], at least near the surface for more than 1½ m.

The entire island consists of this charnockite but the most massive parts are restricted to local areas divided by brittle faults. The fault directions are 80°/90° and 10°/90°. The local more massive areas are 100 by 100 m large with a fracture density of 5-7 m. The fracture directions in the more massive areas are sub parallel to the direction of the dominating faults.

It is very difficult to find a suitable place to take a good sample (Figs. 9 and 10), because of minute fractures which are not visible before the sample actually breaks along the fracture.

After several attempts a big sample was brought to the boat.

[2] Open means that the rock has a lot of small fractures often in same direction internally in the minerals. This means that the rock is not sound.

Figure 7. The Charnockite with large rounded feldspar clasts surrounded by bluish quartz veins

Figure 8. The surface colour is brownish-green and the free blocks are large, but they are fractured by minute cracks.

Figure 9. Sampling site on Maniitsoq.

Figure 10. The primary block breaks along minute fractures.

Sample description and sample evaluation is in progress.

Date: 25/7.
Weather: Grey and drizzling.

Locality: Sisimiut (Appendix A map A)

Arrived early morning.

Used the day to buy supplements and book rooms for the trip to Narsarsuaq.

Date: 26/7.

Weather: Sunny and calm.

Locality: Sisimiut (Appendix A map A)

Peter Japsen, Johan Bonow, Knud Erik Klint and Frederik Kromann Jensen arrived at 1130 h. and we sailed to Inussuk.

Locality: 3, Inussuk (Appendix A map A)

Knud Erik and Frederik disembarked with their camp equipment.

The beach is red of garnet sand and 25 kg was sampled.

The source rock is the local garnetgneiss typical of the area.

There was no time for more measurements of the garnet placer, but on the return trip more data were collected.

Continued to the inner part of Nassuttooq at Seersinnilik. Arrived late in the evening.

Date: 27/7.

Weather: Sunny and calm.

Locality: 4, Seersinnilik (Appendix A map A)

Water depth: 3 m at high tide, because of an underwater threshold outside the bay.

Sample GPS position: 67°37'340N 51°47'257W.

The target rock is situated on the south side of Nassuttooq in the small bay Seersinnilik located by GEUS in 2001 (Kalvig et al. 2002) as a potential source for dimension stone (Figs. 11 and 12).

The rock is a flame-structured medium to corse-grained red, black and white migmatite. The minerals in the flame-structured migmatite are quartz, alkali feldspar, plagioclase and amphibole (Figs. 12, 13, 14 and 15).

The flame-structured migmatite is exposed from the eastern cap of the bay to the other side of the river at the shoreline. 50 m inland to the south along the river, there is a small outcrop of massive homogeneously pale red granite. Further to the south along the river the geology changes to more migmatitic and partly banded and flame structured migmatite. In some places the migmatitic grade is so high that patches of black, white and red minerals are too big (200 cm x 200 cm) for dimension stone.

The dominant vertical fracture direction is parallel to the river valley (320°) and perpendicular to the valley (50°). 3 km to the south along the river valley exfoliation structures, that indicate a sound and massive rock, is observed.

The general fracture density is 3-6 m, locally less or more.

Next to the river valley there are 1-3 m of sedimentary overburden.

The sample collection was done near the shoreline from the flame structured gneiss.

Because of the underwater threshold outside the bay we made a small exploration for alternative landing sights where machinery can be landed. There are a number of places near the bay and the topography is flat along the coast.

On the way out of the fjord we saw several localities with exfoliation structures on the south side of Nassuttooq in the Archean migmatite terrain. This indicates that there are very good possibilities for other places of interest for dimension stone prospecting.

Figure 11. The stream close to the sampling site. The stream has exposed the surface of the flame-structured migmatite/gneiss.

Figure 12. The sampling site near the shore.

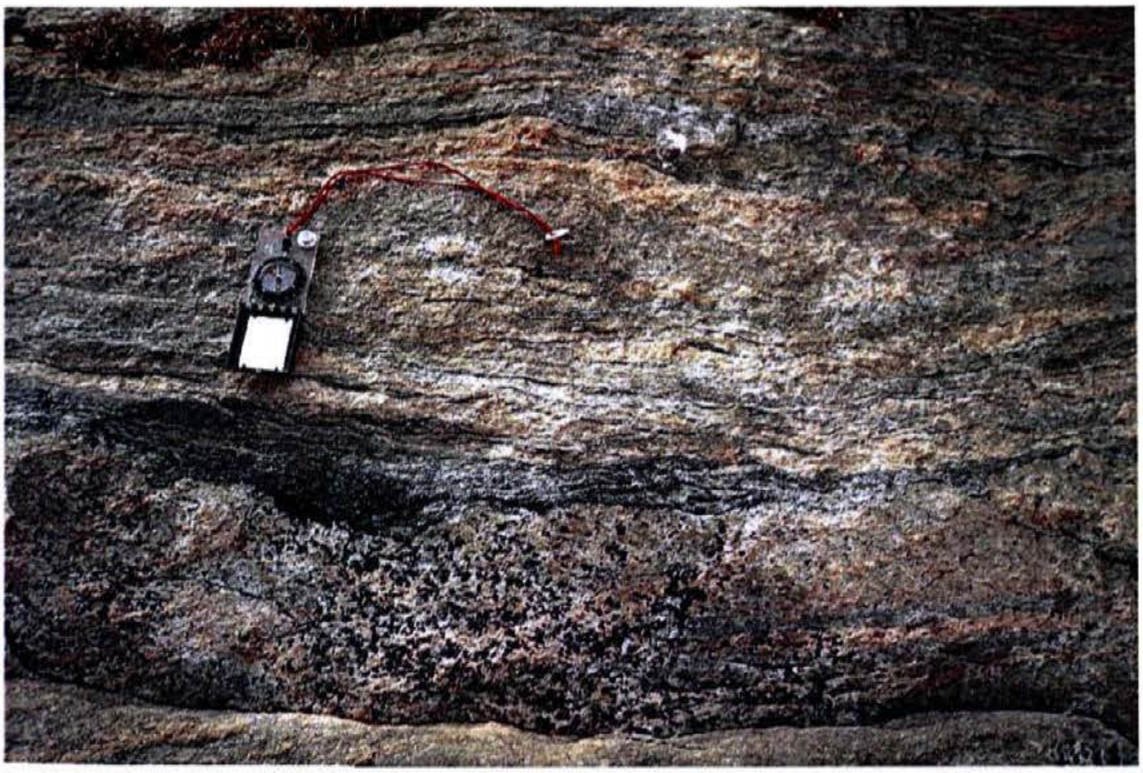


Figure 13. The flame-structured migmatite.

Figure 14. The flame-structured migmatite.

Figure 15. The flame-structured migmatite with a fresh sample next to the pencil.

Sample description and sample evaluation is in progress.

Date: 28/7.

Weather: Sunny and calm.

Locality: Tiggaat (Appendix A map A)

Peter Japsen and Johan disembarked and we continued to Inussuk.

Locality: 3, Inussuk (Appendix A map A)

At Inussuk we joined Knud Erik and Frederik to give them some advice in collecting samples for radiometric dating of younger deformation events.

While they were packing their equipment there was time to collct some data on the garnet deposit.

The garnet sand is only restricted to an area near the shore that has a volume of 60 x 20 x ca 2½ meters. No garnet sand is observed in the fossil beach ridges. From to profiles in the coast ridge the garnet concentrations are evaluated to be approximately 60% (Fig. 16). Further inland the grain size is coarser and the amount of gravel and fist sized rocks are increasing (Fig. 17).

Figure 16. One of the profiles in the coast ridge.

Figure 17. The beach with the garnet sand. Further inland the amount of gravel and fist sized rocks is increasing.

Sailed to the bay at Rifkol to anchor in lee.

Date: 29/7.

Weather: Rain before noon, sunny and calm afternoon.

Locality: 1, Uummannaq (Rifkol) (Appendix A map A)

Used the first part of the day to collect more dimension stone data on Uummannaq meanwhile Peter and Johan collected samples for fission track dating for their project.

The dimension stone data collected this day are added to the text under day 24^{th} of July.

Arrived in Aasiaat late in the evening.

Date: 30/7.

Weather: Sunny and calm.

Locality: Aasiaat.

We spent the day in the Seaman's Home in Aasiaat and sent the drilling equipment to Narsarsuaq.

Date: 31/7.

Weather: Sunny and calm.

Waiting day.

Locality: Aasiaat.

Spent the day looking at the surrounding geology and saw that the grey gneiss in places was a possible, medium class rock for production of aggregates.

We contacted the local engineer from the community and he guided us around to different localities were he wanted advice about the possibilities for mining aggregates (Fig. 18).

Figure 18. The aggregate quarry at Aasiaat.

Date: 1/8.

Travel day.

Aasiaat – Sisimiut.

Date: 2/8.

Travel day.

Sisimiut – Nuuk.

Used the afternoon to visit Råstofdirektoratet.

Date: 3/8.

Travel day.

Nuuk – Narsarsuaq.

The flight was redirected to Kangerlussuaq because of fog in Narsarsuaq.

We met Karsten Secher, Tapani Tukiainen and Sven Monrad Jensen, geologists from GEUS. They recommended that we had a look on the Illimaasaq intrusion if there was time allowed.

South Greenland

Date: 4/8.

Travel day.

Kangerlussuaq – Narsarsuaq.

Weather: Sunny and calm.

The flight to Narsarsuaq was cancelled until the afternoon. In the late afternoon we were on board the ship Johnstrup.

Sailed close to the shore along the Eriks Fjord Formation out of Tunulliarfik just to get an impression of the red and white sandstone.

Arrived in Narsaq for to pick up some spare parts for the boat. Continued to Qaqortoq with fog and low visibility.

Arrived in Qaqortoq late in the evening.

Date: 5/8.

Weather: Sunny and calm.

From Qaqortoq we sailed directly to Aappilattoq and arrived mid evening.

The local people told us that there was some ice in Ikerasassuaq (Prins Christian Sund) and the other side of Annikitsoq.

Date: 6/8.

Weather: Sunny and calm.

Locality: 5, Annikitsoq (east of Morujunnguaq) (Appendix A map C)

The first target area is a locality in the bay east of Morujunnguaq on Annikitsoq (Fig. 19) recommended by Gothenborg et al. (1994).

The bedrock in the area is a grey coarse-grained post-tectonic rapakivi granite with cm sized biotite crystals. With a quick reconnaissance we concluded that the locality was too broken up in two directions. It was also impossible to find a suitable landing site for a helicopter and difficult to land the small dinghy on shore. So we cancelled the sampling at the locality and chose to find an alternative locality.

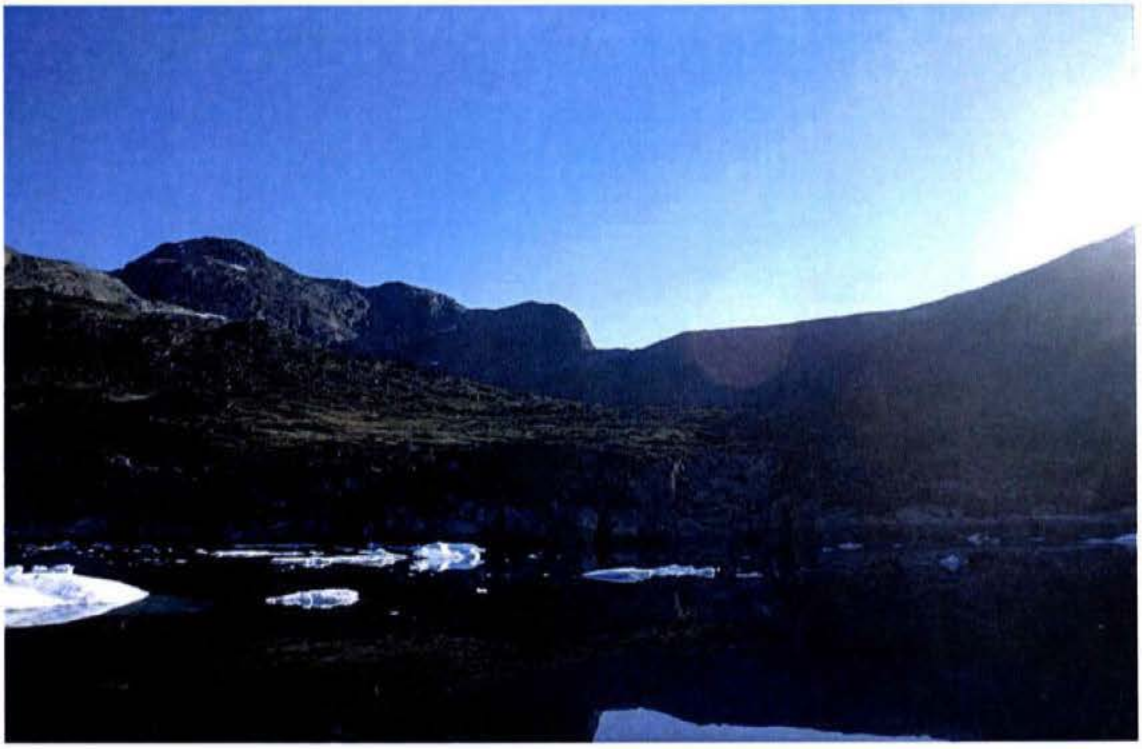


Figure 19. The locality at the bay east of Morujunnguaq on Annikitsoq. There was a suitable landing site for a helicopter.

Locality: 6, Annikitsoq (Qasigissat Nuua) (Appendix A map C)

Sample GPS position: 60°03'742N 44°06'283W.

Water depth: 17 m, 5 m from the coast.

The next locality we headed for was also by Gothenborg et al. (1994). On the way to the next locality the ice was getting increasingly dense.

The place is located on the opposit side of Annikitsoq at Qasigissat Nuua (Figs. 20 and 21). The granite here is a grey massive homogeneously coarse-grained biotite-rich rapakivi granite with feldspar crystals up to 7 cm in size, both with and without rapakivi texture. The vertical fracture density is 5-7 m orientated 140° and 50°. The rapakivi granite is open with a close pattern of microfractures. The surface colour is light greenish brown and the alteration colour of the feldspar is pink and green. The alteration depth is ca 40 cm.

2 samples were prepared with explosives and chisel. The biggest sample was left on the locality for later pickup by helicopter (Fig. 21). We brought the smaller sample with us as a backup if the helicopter transport failed.

Figure 20. Preparation of the smaller backup sample.

Figure 21. The large sample prepared for helicopter sling.

Sample description and sample evaluation is in progress.

After all the gear was brought back to Johnstrup we tried to sail northward up through Perutussut but had to return because of ice.

Instead we returned to a promising place at Morujunnguaq.

Localitet: 7, Annikitsoq (Morujunnguaq) (Appendix A map C)

Sample GPS position: 60°06'638N 44°15'194W.

Water depth: 17 meter outside the bay at the cap and there is 4 meter in the bay.

The bedrock at Morujunnguaq is the same biotit rich grey rapakivi granite as at Qasigissat Nuua. The only difference is that the vertical fracture density is between 6-20 m in the direction 286°N and 4-10 meters in the direction 10°N. There are pronounced exfoliation structures with 2½ m high benches. The rapakivi granite is very well exposed and the topography makes the area easily accessible (Fig. 22).

The locality at Morujunnguaq is the best place for mining the grey rapakivi, both because of the quality of the rapakivi granite and proximity to Aappilattoq.

Figure 22. The rapakivi granite is very well exposed and the fracture density is low at Morujunnguaq.

Sample description and sample evaluation is in progress.

Attempted to sail northwest around Annikitsoq to Ikerasassuaq (Prins Christian Sund), but after a few miles we had to give it up because of heavy ice and lack of time.

After a long night with fog and ice we arrived in Nanortalik.

Date: 7/8.

Weather: Sunny and calm.

Locality: 8, Tasiusaq.

GPS position: 60°11'709N 44°48'779W.

The rapakivi granite is the same grey type that we have seen at the other places but with a significant amount of xenoliths. The exposure in the area is too low to give an appropriate estimate of the fracture density, but some exposures have 4x5 m^2 surfaces free of fractures (Fig. 23).

Figure 23. One of the rare small exposures at Tasiusaq.

Date: 8/8.

Weather: Sunny and calm.

Locality: 9, Qunnermiut (Appendix A map C)

Sampel GPS position: 60°26'150N 45°14'943W.

Grey rapakivi granite like previous localities, but with significantly larger biotite (1-3 cm) crystals and the alteration depth is 50 cm or more. It was very difficult to collect a fresh sample (Fig. 24). In all outcrops there is observed xenoliths from centimetre to metre size.

The locality is totally unqualified for dimension stone production.

Figure 24. The rapakivi granite at Qunnermiut is very weathered.

Locality: 10, Illorpaat (Appendix A map B)

Sample GPS position: 60°28'060N 45°21'186W.

The rapakivi granite at the locality is of the same quality as at Qunnermiut and is totally unqualified for dimension stone production.

Arrived in Qaqortoq after midnight.

Date: 9/8.
Weather: Sunny and calm.

In Qaqortoq we talked with the skipper on Kisaq and he promised to take the generator to Tasiilaq and give it to Henrik Hansen (former member of the Sirius patrol) so that I could pick it up there later on.

Locality: 11, 1 km west of Tasiluk (Appendix A map B)

Sample GPS position: 60°41'097N 45°51'646W.

Rock type: Light aplitic granite.

100 kg of aplitic granite was sampled for further testing (Fig. 25).

The area is dominated by the light aplitic granite (Fig. 26) and there is not observed any intrusive rocks in the area.

Figure 25. Sampling the light aplitic granite.

Figur 26. The light aplitic granite.

Sample description and sample evaluation is in progress.

Locality: 12, South part of Arpatsivik island (Appendix A map B)

Sample GPS position: 60°45'056N 45°55'668W.

Rock type: Red-grey aplitic granite.

100 kg of aplitic granite is sampled for further testing (Fig. 27).

Figure 27. Red-grey aplitic granite at Arpatsivik.

Sample description and sample evaluation is in progress.

Locality: 13, Kangilleq.

Sample GPS position: 60°50'439N 45°52'612W.

The rock type on the beach is not aplitic as expected, but a medium to coarse-grained porphyritic granite with several kinds of cross cutting dykes. About 500 m inland, along a small stream, there is a red-grey aplitic granite (Fig. 28). In the aplitic granite there are purple fluorite crystals and an unknown blue-grey ore mineral. Both the ore mineral and the fluorite are related to fractures and the ore mineral is also observed as 5 mm large spots in the aplitic granite.

100 kg of aplitic granite is sampled for further testing.

Figure 28. The sampling site, of the red-grey aplitic granite with a blue-grey ore mineral and fluorite, at Kangilleq.

Sample description and sample evaluation is in progress.

Date: 10/8.
Weather: Rain and light wind.

Locality: 14, Peninsula east of Akununnaat (Munkebugten) (Appendix A map B)

Sample GPS position: 60°42'931N 46°10'625W.

Many mafic dykes and several medium grained granitic irregular dykes cut the grey aplitic granite in the area (Fig. 29). This scenario makes the place unsuitably for an aggregate mine. But because of the logistic in the area (near Qaqortoq) we sampled 100 kg of the grey aplitic granite.

Figure 29. The grey aplitic granite east of Akununnaat.

Sample description and sample evaluation is in progress.

Locality: 15, South part of Kingittoq (Appendix A map B)

Sample GPS position: 60°42'883N 46°24'427W.

The rock type at the locality is a medium grained red granite and not, as expected from the map studies, an aplitic granite (Fig. 30).

100 kg of medium grained red granite is sampled for further testing.

Figure 30. Medium grained red granite at Kingittoq.

Sample description and sample evaluation is in progress.

Locality: 16, Killavaat Alannguat (Kringlerne) **(**Augite syenite) (Appendix A map B)

The syenite that borders the Julianehåb batholith is not suitable for dimension stone production because of the high fracture density (max 2x3-m^2 surfaces without fractures) and the coarse grain size (Fig. 31).

Figure 31. The syenite that borders Julianehåb batholite.

Locality: 17, Killavaat Alannguat. (Kakortokite)

Sample GPS position: 60°52'108N 45°52'023W (dark type).
Sample GPS position: 60°52'061N 45°52'295W (light type).

The medium grained kakortokite is in places massive homogenous and sound. Exfoliating structures shows 2 m high benches and the fracture density is 4-6 m making up 6x4x2 m blocks with right angles (Figs. 32 and 33). There are two types of the medium grained kakortokite: a dark and a light, both types are sampled. The colour of the kakortokite is a mixture of red, black and bluish-white, the light type has a smaller content of dark minerals. The pronounced colours are an advantage for a possible dimension stone quarry. The dark minerals are aegirine and arfvedsonite; the red mineral is eudialyte, the bluish-grey mineral is nephline and the white laths are feldspar. There are several other exotic minerals in the kakortokite not mentioned here. The radioactivity from kakortokite is not higher than from normal granite. The Uranium content is 20.6 ppm and the thorium content of 59,4 ppm in the red part (eudialyte) of the kakortokite whereas a typical alkali granite has 44.1 ppm U and 123 ppm Th (Bailey et al. 2001).

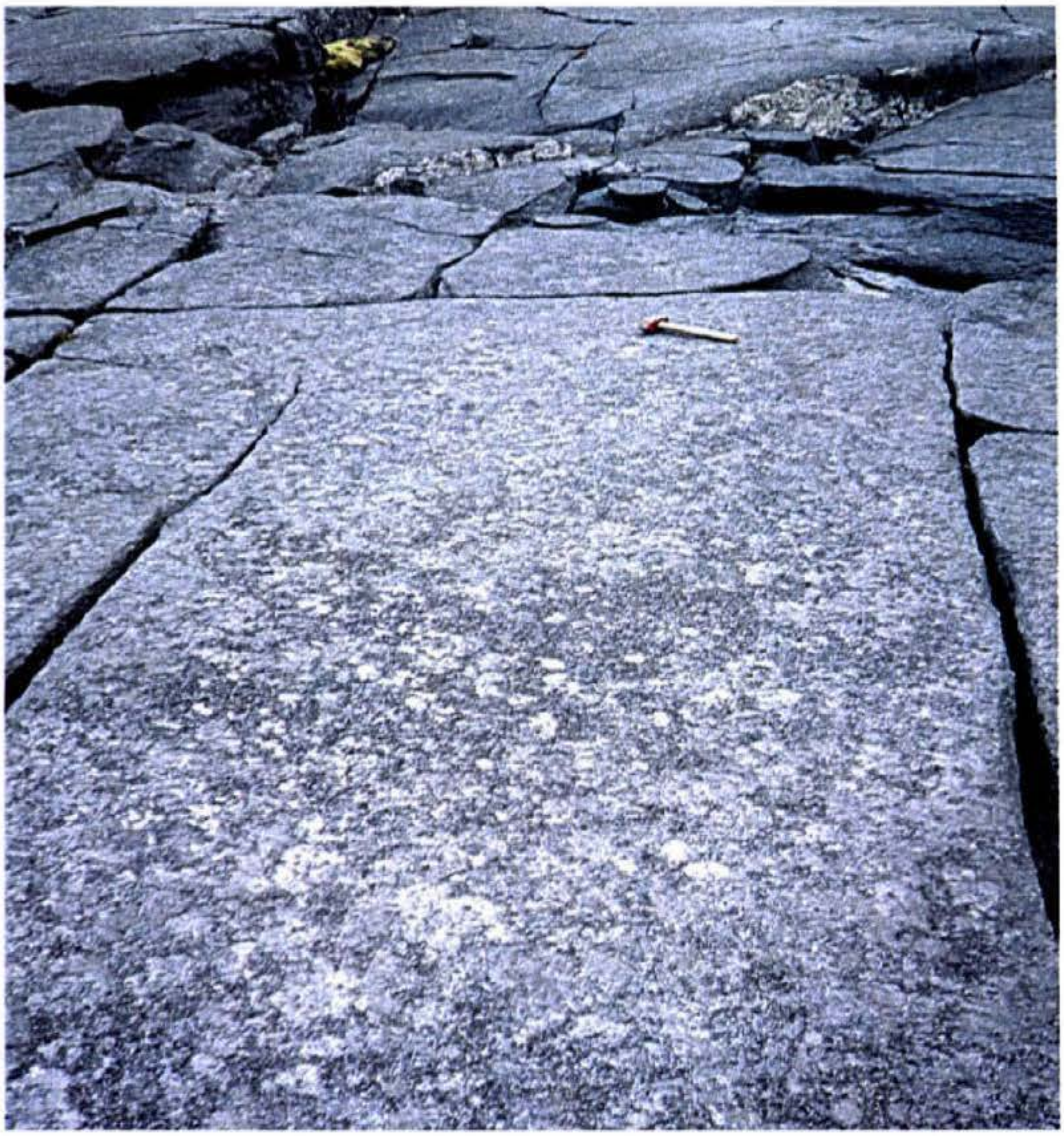


Figure 32. The medium grained dark kakortokite in large blocks with right angles.

Sample description and sample evaluation is in progress.

Date: 11/8.

Weather: Sunny and calm.

Locality: 18, Mouth of Kangerluarsuk (naujaite).

GPS position: 60°53.453"N 45°50.920"W.

The naujaite is coarse-grained and the minerals are mostly in red, black and white clusters (Fig. 33). The surface is very weathered and it was impossible to collect a big sample. On the surface the naujaite looks sound, but it is very open and breaks easily.

Figure 33. The coarse-grained naujaite with red, black and white minerals in clusters.

Locality: 19, Mouth of Kangerluarsuk (lujavrite).

Sample GPS position: 60°53.235"N 45°50.276"W.

The lujavrite is a dark green with black spots medium grained rock (figure 34). The rock is massive and the fracture density is in places 2-6 meters, but a cover of boulders made a fracture density estimate very difficult.

According to Bailey et al. 2001 the lujavrite is radioactive and this feature disqualified the rock as a possible dimension stone.

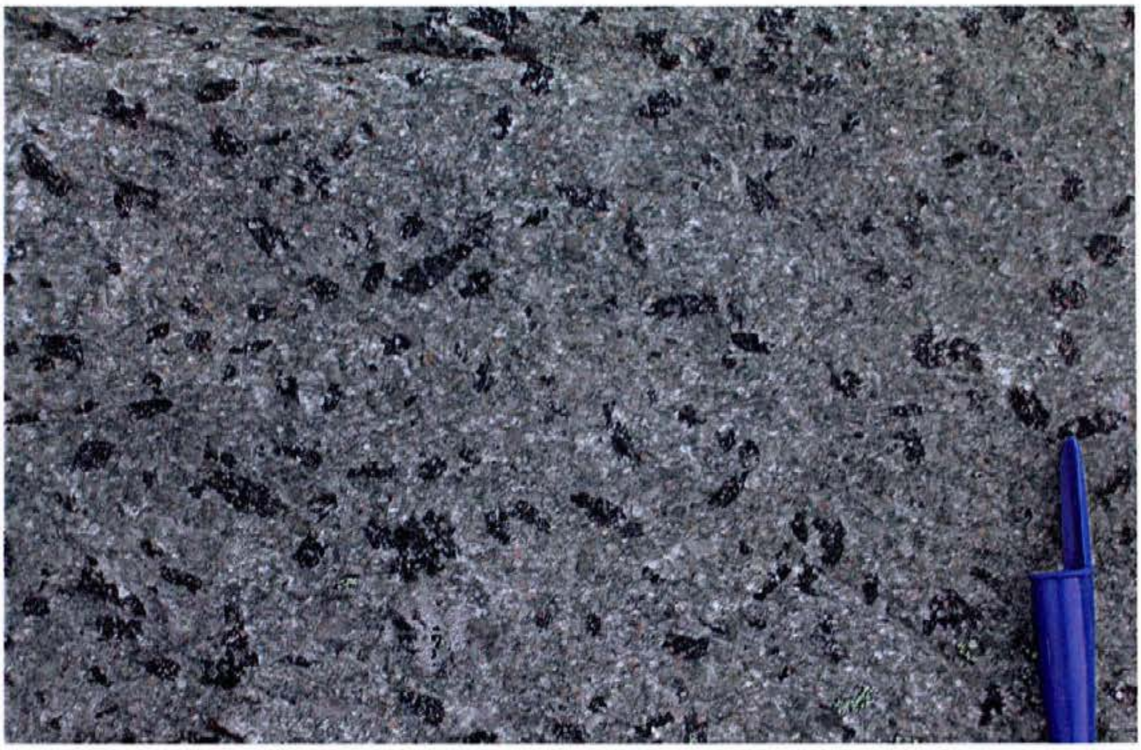


Figure 34. The dark green medium grained lujavrite with black spots.

Date: 12/8.

Weather: Sunny and calm.

Locality: 20, 15 km Southwest of Sillisit.

GPS position 61°03.583N 45°32.707N.

The target rock is the sandstone in Eriksfjord Formation.

At first look the red sandstone at the position looked sound from the distance (Fig. 35) but closer observation showed that it was very fractured and the layer of red sandstone disappears under 0.5 km overburden of flood basalts and conglomerates.

Figure 35. Large overburden and too high fracture density in the Erikfjord Formation.

Locality: 21, Sillisit (figure 36).

Sample GPS position 61°03'288N 45°32'901W (Sandstone with reduction spots).
Sample GPS position 61°03'947N 45°32'496W (Deep red with structures).

At Sillisit the access to the red sandstone called Igaliko sandstone is good because there is a network of dirt roads in the area (Fig. 37).

The red sandstone is well known for its white reduction spots (Figs. 36 and 38), but the reduction spots are only fund at one locality were it is related to the dyke that cuts the sandstone. At other localities were the red sandstone is cut by dykes the sandstone is totally white at the margins (Fig. 39).

The colour varies from light red to deep red and there are sedimentary structures in all the observed localities (Fig. 40). In some outcrops near the shore dark spots are evenly distributed in the red sandstone.

The sandstone forms beds that dip 5-15° to the west. Between the sandstone layers are layers of conglomerate (Fig. 41) and flood basalt.

The fracture density limits the block size to a maximum of 1x1x0,4m. Most of the sandstone is in beds controlled by the sedimentation. The thickness of the individual sandstone beds varies from 1 - 40 cm (Fig. 42) with dense vertical fractures.

The dip of the layers limits the amount of free material, because the overburden increases extremely if the mining direction is in the dip direction.

The best type of sandstone in the area is found 1.5 km northwest of the farmhouses and this sandstone is deep red with sedimentary structures (Fig. 43).

Figure 36. Sillisit with J.F. Johnstrup as a small red spot. The locality with the reduction spots is the red profile to the left near the shore.

Figure 37. A local road along a profile with red and pale-red sandstone.

Figure 38. The locality with the white reduction spots in the red sandstone.

Figure 39. Dyke that cuts the red sandstone with pronounced contact reduction of the sandstone.

Figure 40. Deep red sandstone with sedimentery structures.

Figure 41. Conglomerate bed.

Figure 42. Red sandstone near the shore. The sedimentary beds control the subhorisontal cleavage.

Figure 43. Deep red sandstone with sedimentary texture in relative large blocks 1.5 km from the shore.

Advantages: The sandstone can be polished. The colour is deep red. There are sedimentary structures in the sandstone. The rock type is rare on the dimension stone market. The logistics in the area is good.

Disadvantages: High fracture density. The overburden will be very thick due to the dipping layers. The best quality is 1,5 km from the shore. There is no large homogeneous volume documented. The sandstone is cut by a large number of dykes. Mining, cutting and polishing quarts is expensive.

Sample description and sample evaluation is in progress.

Some of the dykes in the area are reddish with randomly distributed 0.5-1 cm large, white plagioclase phenocrysts and a fine-grained matrix (Fig. 44). The dikes that cut the sandstone are commonly 3-5 meters wide and vertical. The fracture density in some of the dikes is low and they are very sound. It can be impossible to distingwish the reddish dykes from the red sandstone even from a close distance, because of the similar colour.

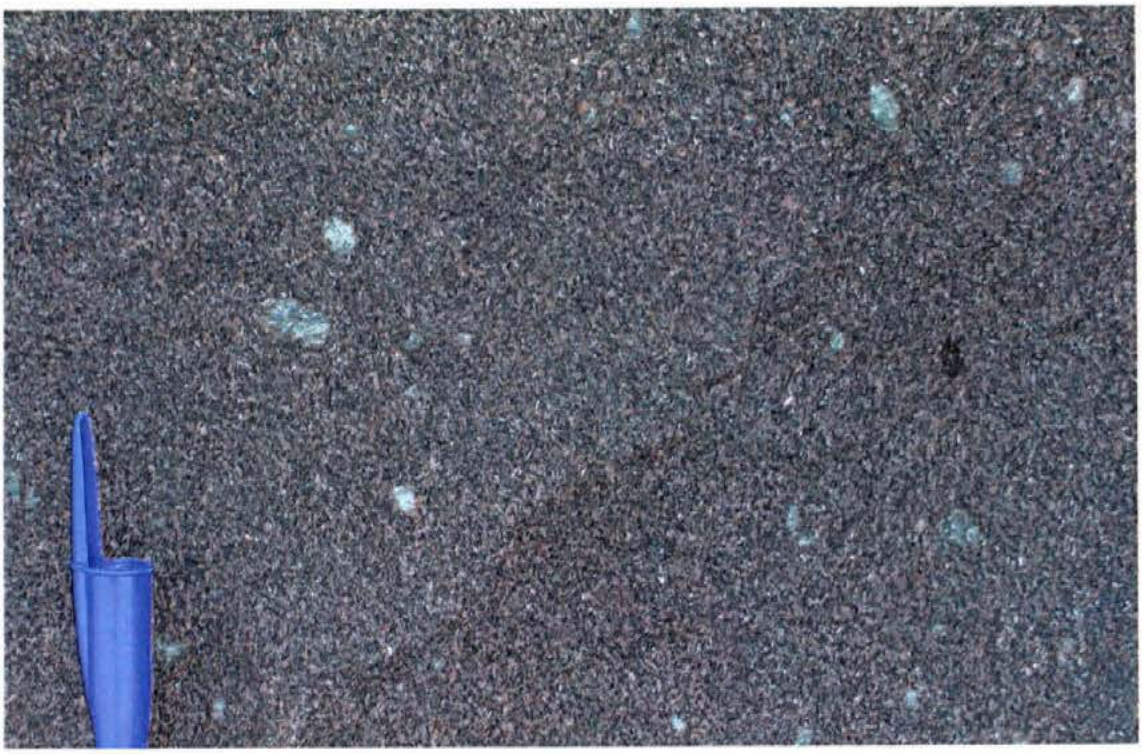


Figure 44. Reddish dyke with white plagioclase phenocrysts.

Date: 13/8.

Weather: Sunny and calm.

Continued work at Sillisit.

Observations and conclusion are summarised above.

Arrived in Narsarsuaq in the evening.

Date: 14/8.

Weather: Sunny and calm.

Travel day.

Paarvo Härmä returned to Helsinki and I headed for Tasiilaq with a stopover in Nuuk.

Narsarsuaq – Nuuk

Used the afternoon to visit Råstofdirektoratet and Greenland Resources A/S.

Date: 15/8.

Weather: Sunny and calm.

Travel day.

East Greenland

Arrived at Tasiilaq at noon.

Contacted Pertti Frandsen and Michael Frank who owns the boat that I had hired.
I picked up the generator from Henrik Hansen and brought it down to the boat together with the drilling equipment.

The explosives were not easy to find, but at last we found it in the local carpenter shop, and not in the secure depot for explosives. But the man in charge of selling explosives could not deliver before the next day.

Date: 16/8.

Weather: Sunny and calm.

Locality: 22, 1,5 km east of Tiniteqilaaq.

Sample GPS position: 65°52'747N 37°43'425W.

Water depth: 7 - 20 m from the shore. The cliffs dip steep into the water.

Started out in the afternoon heading for Tiniteqilaaq.

Arrived at the target area at the cap 1.5 km east of Tiniteqilaaq and started reconnaissance for a place to take a good sample (Fig. 45).

The rock type at the cap is pale pink, medium-grained, massive, homogeneously, sound, biotite alkali feldspar granite.

The dominating fractures follow the orientation of the massive benches around the cap. These fractures are interpreted as controlled by exfoliation and major fault systems.

Vertical fractures that cut the granite were observed at several places, but they are spaced with more than 4 metres (Fig. 46), and the main direction is between 45° and 52°.

The pronounced exfoliation structures show benches up to 6 meter high and fracture-free surfaces in the area are up to 60x60 m^2 (Figs. 47 and 48). The horizontal fractures are totally dominated by the exfoliation in the area and the spacing between varies 1 m at the top of the cap (50 m) up to 6.5 meters at sea level (Fig. 48).

The total area with the sound weakly pink granite is very large and continues to the east for more than 2 km. To the south the sound granite continues about 1 km to the other side of the bay. The sound pale pink granite continues also to the north, but it is cut by a major fault 500 meters from the sampling site (Fig. 49).

Figure 45. The cap 1,5 km east of Tiniteqilaaq.

Figure 46. The fracture density is generaly more than 4 meters (Kalvig et al. 2002).

Figure 47. Fracture-free surfaces with pronounced exfoliation structures (Kalvig et al. 2002).

Figure 48. High benches near the shore (Kalvig et al. 2002).

Figure 49. The sampling site.

Sample description and sample evaluation is in progress.

Date: 17/8.

Weather: Rainy and windy.

Arrived Tasiilaq early morning.

Used the afternoon to pack the equipment.

Date: 18/8.

Weather: Heavy rain.

Waiting day. The harbour office was closed.

Date: 19/8.

Weather: Heavy rain.

Sending the sample and equipment to Denmark. Changed my ticket because there was a chance to reach a flight so I could be in Denmark 20/8.

Tasiilaq – Kulusuk

Date: 20/8.

Weather: Grey with rain.

Because of a mistake in booking system, I had to stay in Kulusuk even though there was a seat free on the early flight from Kulusuk to Reykjavik.

Date: 21/8.

Weather: Grey with rain.

Travel day.

Kulusuk – Reykjavik.

Date: 22/8.

Weather: Grey with rain.

Travel day.

Reykjavik – Copenhagen.

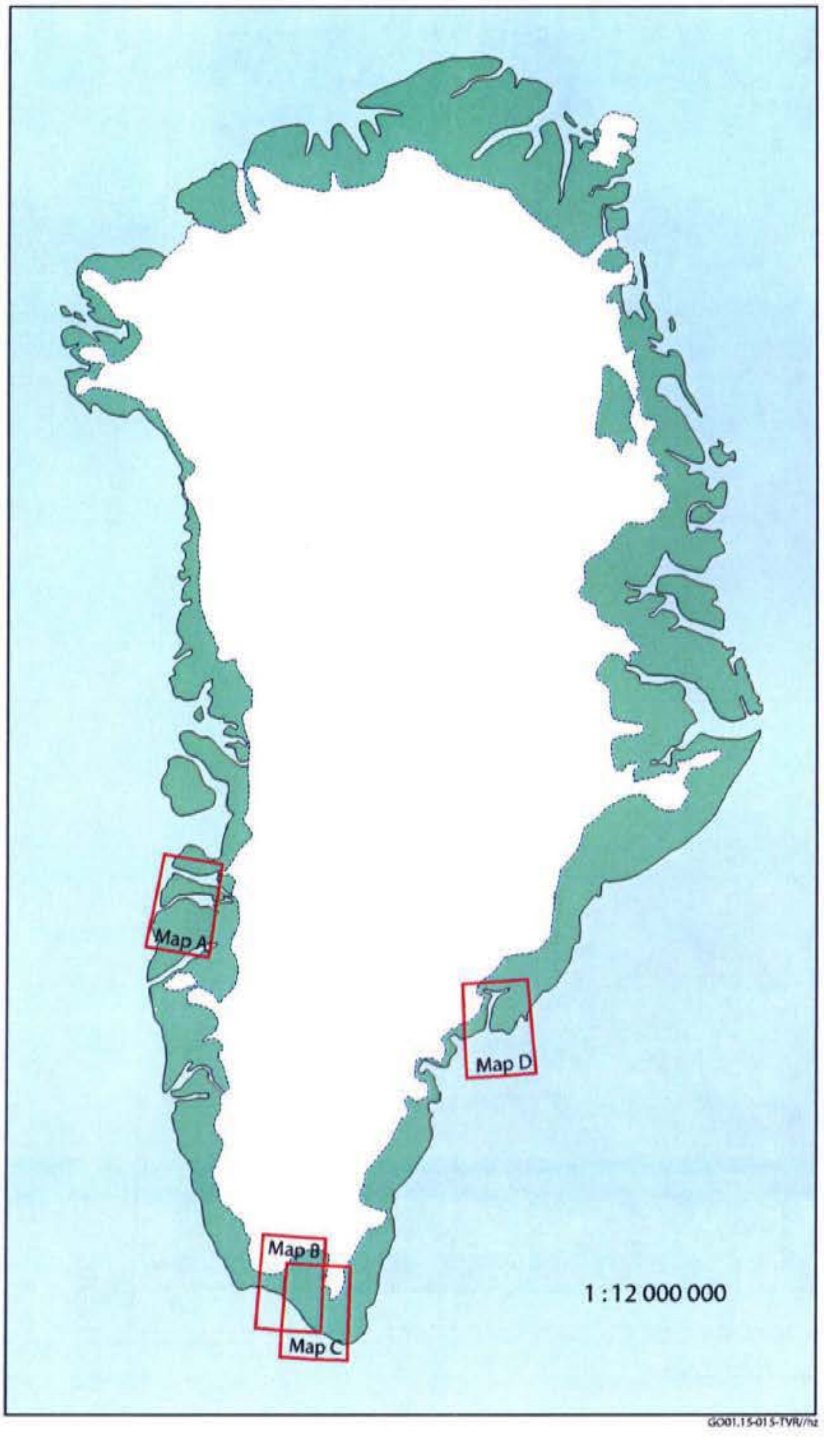
References

Bailey J.C., Gwozdz R., Rose-Hansen J. & Sørensen H. 2001:Geochemical overview of the Ilimaussaq alkaline complex, South Greenland. In: Sørensen, H. (ed.): The Ilimaussaq alkaline complex, South Greenland: Status of mineralogical research with new results. *Geology of Greenland Survey Bulletin* 190. 35-53.

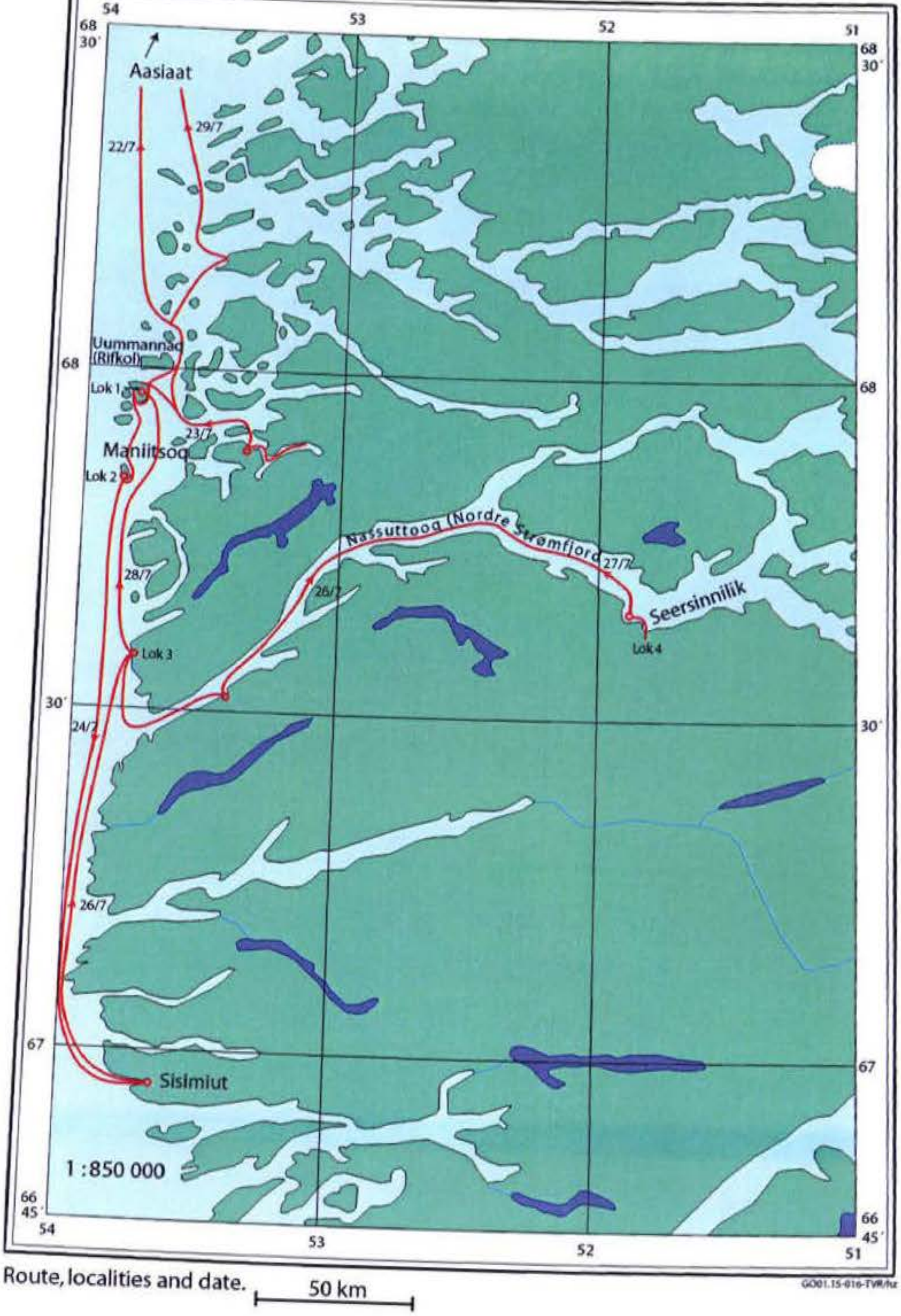
Gothenborg J., Garde A.A. and Bugnon C. 1994: Greenland ornamental stone resources. Open File Series. Grønlands Geologiske Undersøgelse 94/2, 143 pp.

Kalvig P., Knudsen C.N. and Rasmussen T.V. 2002: Potentialer for facadesten og skærver i Grønland. *Danmarks og Grønlands Geologiske Undersøgelse Rapport* 2002/11. 104 pp.

Appendix A. Index map of Greenland

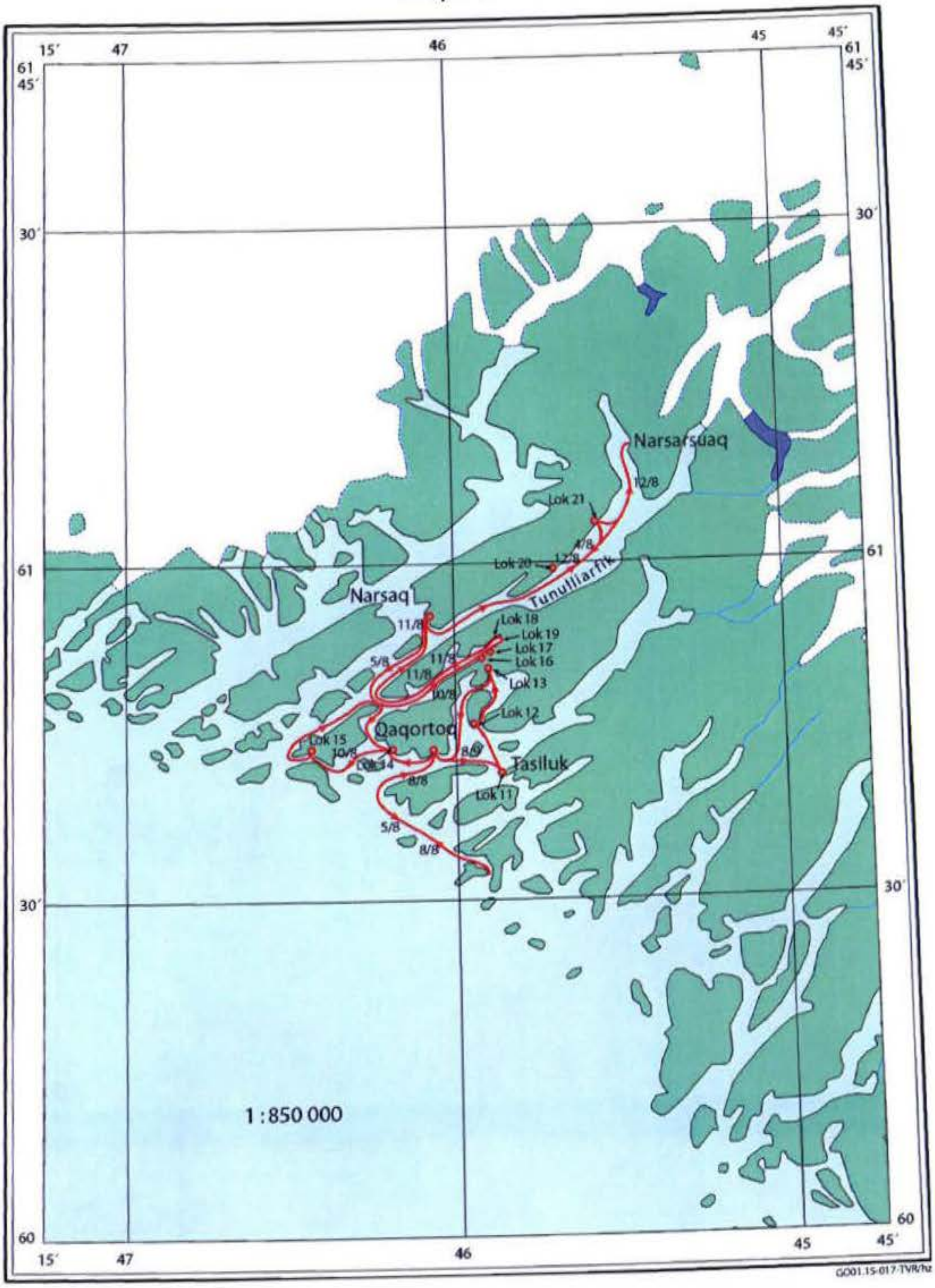


Map. A



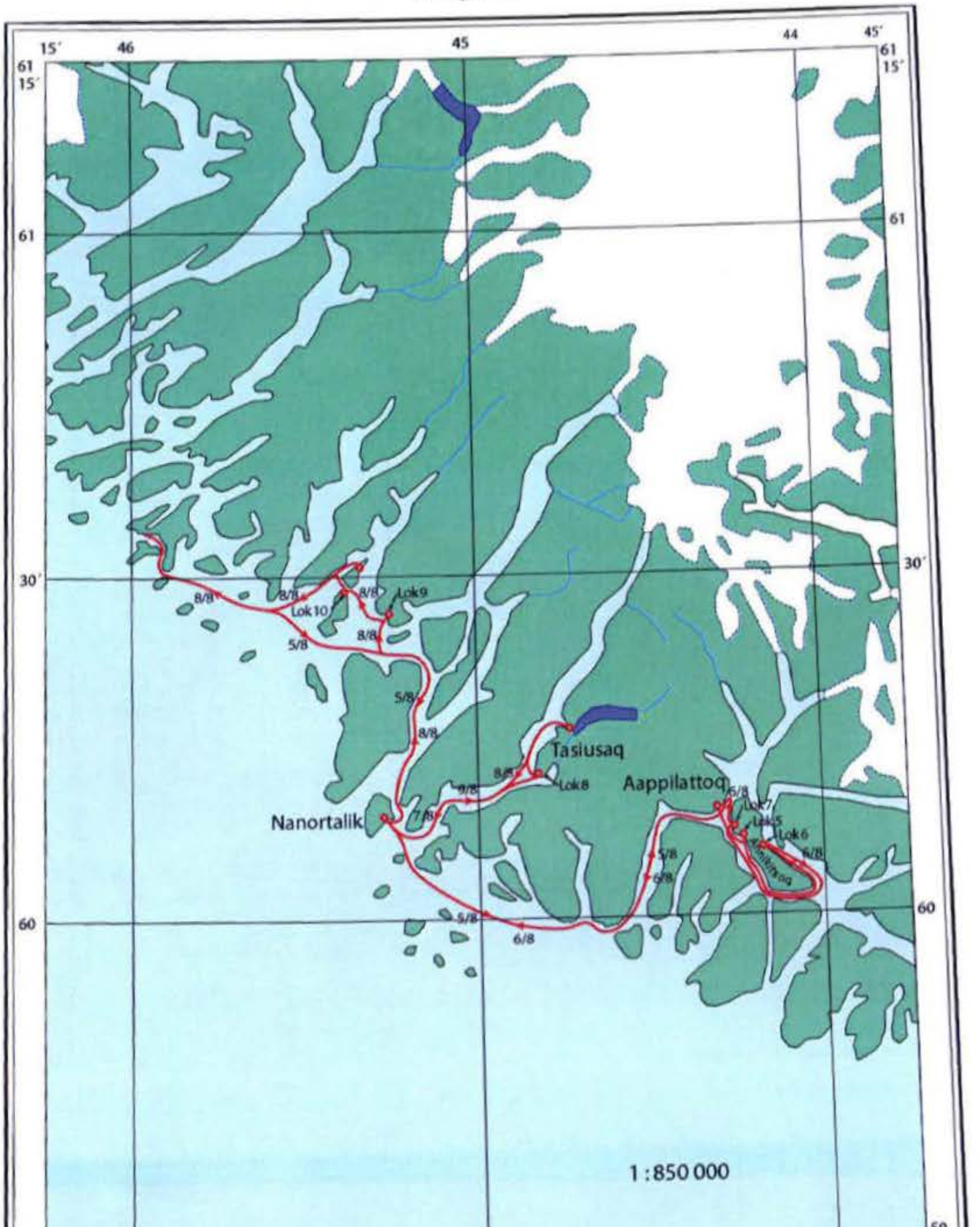
Route, localities and date. 50 km

Map. B



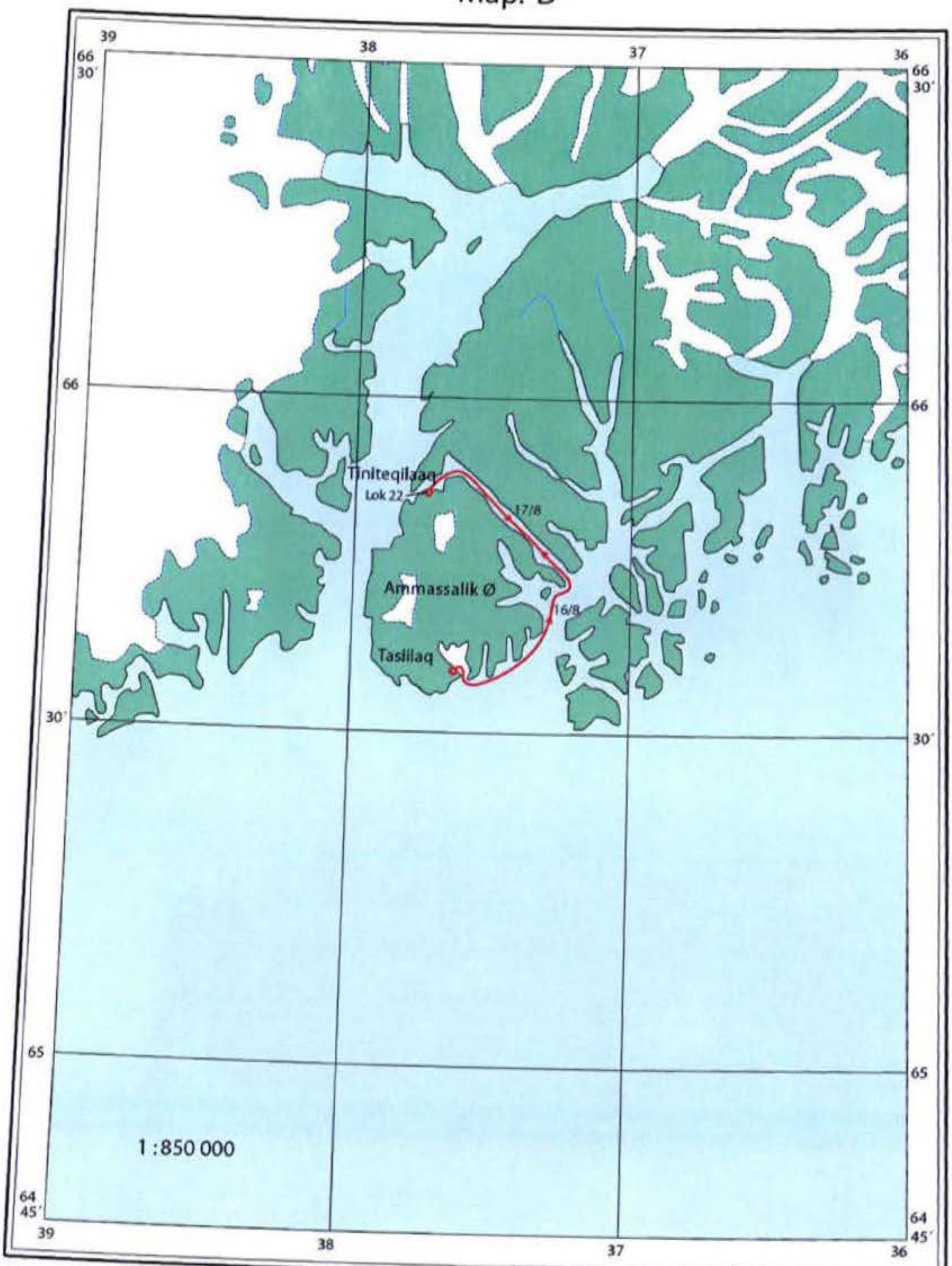
Routes, localities and date. 50 km

Map. C



Routes, localities and date. 50 km

Map. D



Routes, localities and date. 50 km

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