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Geothermal research in Greenland

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ABSTRACT

Surface manifestations of geothermal activity are rare in Greenland. They are mainly found in the basaltic areas at Scoresbysund and Disko. The highest temperature is found on the east coast, north and south of Scoresbysund, and the hottest spring is nearby Cap Tobin, 62°C. The hottest one in Disko is around 18°C. A limited investigations have been made into the possibilities of geothermal utilisation in Disko. Twelve small geothermal fields are known there. Most of the thermal springs are found in the basaltic lava pile but three of them are in Precambrian gneiss and one in Cretaceous sandstone. The regional permeability of the basaltic formation in south west Disko seems to be similar to the more permeable part of the Icelandic Neogene basalts such as in NW-Iceland where geothermal utilization is common. The permeability elsewhere in Disko is unknown. The warm springs are most likely connected to fissures or fissure swarms in the bedrock that allow the groundwater to penetrate deep down and form vertical convection systems as is the case in most Icelandic low temperature geothermal fields. Seismic activity is known in the Disko area and the earthquakes can form and maintain permeable fissures and fissure swarms. Changes are known to occur in the temperature and runoff in the warm springs after earthquakes. Nothing is known about the geothermal gradient in Disko.

The warm springs of Unartorssuaq (Engelskmandens havn) are the only ones located near to an inhabited area. They are ca. 2 km outside the town Qeqertarsuaq (Godhavn). They seem to be connected to fissures and faults found in the field and the fissures can be traced towards the town. Chemical analyses indicate that the temperature of the geothermal liquid in the depths might be 50-70°C. Boreholes are needed to investigate the geothermal gradient and the size and orientation of the geothermal system. Until drilling nothing can be stated about the possibilities of geothermal utilisation in Qeqertarsuaq.

1. INTRODUCTION

Geothermal springs with homeothermic source water temperature > 2°C (homeothermic springs) can be found all over Greenland but warm springs ≥ 10°C are very rare. They are found primarily in Disko Island, West Greenland and on the east coast at a number og locations north and south of Scoresbysund (Fig 1). There the warmest geothermal springs of Greenland, 55-62°C, are found. Outside these regions only two occurrences of geothermal (>10°C) springs are known, that is at Unartoq in South-Greenland and Ikasagtivaq on the southeast coast near Ammassalik. Disko Island and Scoresbysund are indicated by Tertiary basalt formations that are suggested to have been formed above the Iceland Mantle Plume during the drift of the N-American continental plate in the early Tertiary (Fig. 2) (Lawver and Müller 1994). The main geothermal sites in Greenland seem to be confined to the hot spot track and might therefore be related to Icelandic geothermal activity. This is also thermally indicated as the maximum temperature in Disko is 18°C, in the Scoresbysund area it is 62°C, in NW-Iceland 100°C and in inside the hot spot region in eastern central Iceland high temperature fields exist with erupting steam vents at >>100°C.

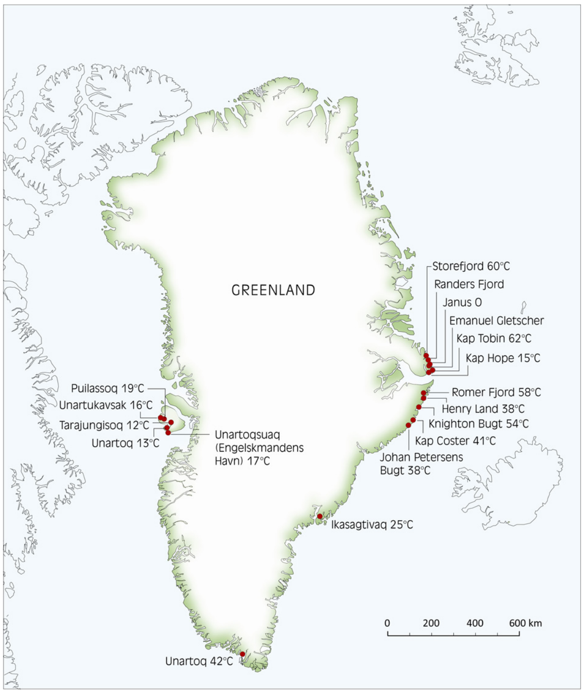

Figure 1: Geothermal springs in Greenland ≥ 10°C.

Geothermal exploration in Greenland has mainly centered on aimed at the influence of the warm springs on the flora and fauna (Kristensen 1987, 2000). The flora and fauna around the thermal springs are noted for the large element of southern species, which in many cases have their northern limits in these areas.

Only limited investigations have been made on possible utilisation for space heating or power production. In the summer 2005 such preliminary investigation in Disko Island was launched but has not yet been completed. Hjartarson and Ármannsson (2005) published preliminary results and this article is based on their report.

2. QEQERTARSUAK AND DISKO ISLAND

Disko Island is around 20.000 km^2. It belongs into the basaltic region of West Greenland. The geology is in some respects similar to the geology of Iceland, especially NW-Iceland. However the basaltic pile is considerably older or more than 60 Ma (Larsen et al. 1992) whereas the basaltic region of NW-Iceland is 14-16 Ma. The basalt in Disco rests on a much older basement of Cretaceous sandstone and Precambrian gneiss.

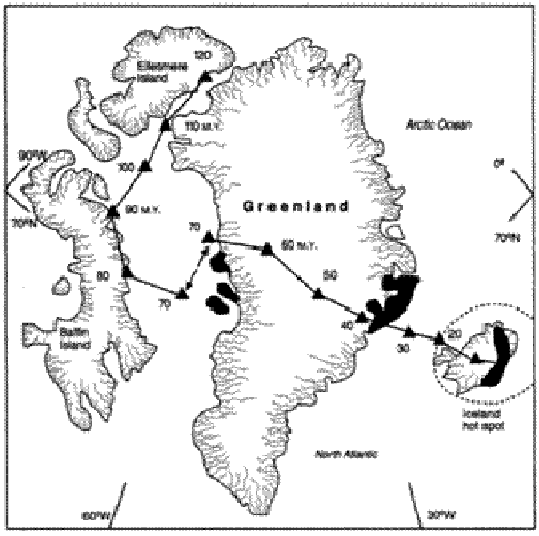

Figure 2: The track of the Iceland Mantle Plume (Adapted from Lawer and Müller 1994).

Geothermal activity is known in several places on the south coast of Disco, for example near Qeqertarsuaq and farther north such as in Diskofjord and in Akugdlit fjord (Mellemfjord). In all places the temperature is below 18°C and the water discharge is rather small. The source of the geothermal heat and its relation to the stratigraphy and tectonics are unknown but it seems reasonable to suggest that it is somehow connected to early Tertiary volcanism.

The population of Qeqertarsuaq (Godhavn) is about 1000 people. The town lies north of the Arctic Circle, 600 km north of Nuuk, near to the latitude 69. The main industries are fishing and hunting but tourism is increasing. The town gets its space heating and electricity from diesel generators. The University of Copenhagen has since 1906 run the Arctic Station near the town carrying out comprehensive natural research.

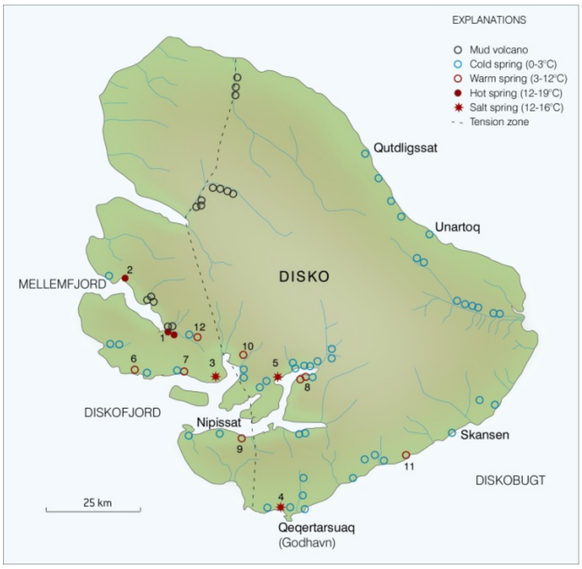

Figure 3: Geothermal springs, cold springs and various phenomena in Disko Island. 1) Puilassoq 2) Unartukavsak 3) Unartuarak 4) Unartorssuaq 5) Tarajungitsok 6) Qeqertarssuk 7) Kuanit 8) Angujartutit 9) Unartoq 10) Avdlaugissat 11) Qofat 12) Kildedalen (Partly adapted from Kristensen 1987).

3. THE INVESTIGATIONS OF 2005

The geothermal springs ≥ 10°C are confined to the south western part of Disko (Fig. 3). Twelve locations are known (Table 1), five of which were investigated in 2005. Disco Island belongs to the permafrost zone and the general rule is that all springs and minor streams freeze during the winter. An exception from this rule are the numerous homeothermic springs that are found both in the Precambrian gneiss, Cretaceous sandstone and in the Tertiary basalts. In these northern territories all springs with considerably constant annual temperature that are 3°C or more are called homeothermic springs or even thermal springs. In a way this is a natural definition because the mean annual air temperature is quite lower.

Around Qeqertarsuaq all major spring sites were investigated both the cold and warm ones. After that a trip was made to Diskofjord and Akugdlit. There only springs of more than 10°C were explored. Most of these places are extremely remote and far away from inhabited areas. Unartorsuaq (Engelskmandens Havn) near the town Qeqertarsuaq is the only exception.

Table 1. Geothermal sites on Disko

Site	*°C (max)*	*l/s*	*Bedrock*
Qofat			Sandstone
Uunartorsuaq	16.2	2-3	Gneiss
Unartoq	11.1	1-2	Basalt
Angujartutit	(3-12)		Basalt
Tarajungitsoq	11.5	2	Gneiss
Avdlaugissat	(3-6)		Gneiss
Unartuarak	14.5		Basalt
Kuanit	(3-12)		Basalt
Qeqertarssuk	(3-12)		Basalt
Puilassoq	17.6	2	Basalt
Kildedalen	14,5		Basalt
Unartukavsak	15.4	3-4	Basalt

3.1 Unartorssuaq

Unartorssuaq (Engelskmandens Havn) is a rocky inlet 1.8 km northwest of the Qeqertarsuaq harbour (Fig. 4). Around the town outcrops of Precambrian gneiss indicate a N-S trending ridge below the Tertiary basalt (Chalmers et. al 1999). The cliffs around Unartorssuaq are a part of this gneiss formation forming the mountain slope up to 200-250 m a.s.l. where the basaltic pile takes over.

A gravel shore is at the head of the inlet with a narrow vegetative zone below steep cliffs of gneiss. There two brooks flow into the sea. Warm springs are found on the shore. The water seeps to the surface in the vegetative zone in a few places and disappears again in the gravel of the beach. Kristensen (1987) mentions many springs in Unartorssuaq and declares four of them really warm:

A. Thermistor loc. 13.5-15.5°C
B. Tardigard loc. 13.2-14.0°C
C. Halacarid loc. 9-10.4°C
D. Bubble loc. 11.4-16.0°C

Figure 4: Unartorssuak. The geothermal springs appear on the gravel beach. Qeqertarsuaq is seen in the upper left at 2 km distance.

In the summer 2005 three of them were detected, probably A, B og D. The easternmost spring, probably the Bubble spring, is the smallest one. It is only a seepage forming a small bog. Maximum temperature is 14.8°C and the discharge about 0.1 l/s. Conductivity 821 µS.

The central spring issues below a large erratic rock at the head of the inlet. This is probably the Tardigard geothermal spring. Temperature 13.8°C, visible discharge 0.2 l/s. Conductivity 585 µS. When a hole was dug in the gravel downstream of the erratic rock more warm water appeared flowing towards the sea, at least 2 l/s.

The westernmost spring issues below an even larger erratic rock on the shore. It is called Thermistor Rock (Termistor-stenen). Here the warmest water has been detected, and in fact the second warmest spring in Disko. The water has a diffuse origin and flows all around the rock. Maximum temperature was 16.2°C and the visible discharge was estimated to be about 1 l/s but more flow could easily lurk in the gravelly shore. Conductivity 711 µS.

The conductivity of the warm water is 10 times higher than in the cold springs in the neighbourhood. The temperature of the geothermal springs is slightly variable from time to time. This is because of variable mixing with cold groundwater. Porsild (1920) observed 17°C in the springs of Unartorssuaq in the early 20th century. The discharge is also variable for the same reason. The groundwater level can also cause springs to appear and disappear from time to time. A low groundwater level might be the explanation why the Halacarit spring mentioned by Kristensen (1987) was not found in 2005.

A prominent deep and wide fissure with a WNW trend, cuts the cliffs inland off the bay, (Fig. 5). NE-SW fissures also occur and more diffuse N-S cracks can be seen. The main fissure can be traced towards and into the town but there it becomes indistinct (Fig. 9). It seems to be young and active, moderately eroded and at its bottom recently fallen boulders can be seen. Fissures like this one are common in the gneiss bedrock but most of them look much older with eroded brinks. This fissure might cause deep convection of the groundwater. Near the surface the geothermal water of the main fissure seems to be flowing horizontally along

Figure 5: Unartorssuak. The geothermal system is possibly related to the fissure cutting the cliffs and trending towards the town.

the N-S cracks and appear as warm springs at the shore. If the geothermal system is connected to this main fissure it might be prolonged towards the town. That would be reflected in elevated geothermal gradient, but that cannot be proved without drilling.

3.2 Homeothermic Springs in Unartorssuaq and Lyngmarken

Large homeothermic springs issue at the contact between the Precambriam gneiss and the basalt pile in the slope of the mountain right up from the shore of Unartorssuaq. The water temperature is about 3°C and the conductivity 40 µS. There is rich vegetation around the springs. A brook flows from the springs towards the shore. A little further west there is another brook related to springs in a small rock glacier. Together they form a large brook that cascades into the sea at Unartorssuaq. The runoff is 50-100 l/s.

The drinking water supply for Qeqertarsuaq is in a spring area 1 km to the southeast, in Lyngmarken at the same stratigraphic contact. Here a sedimentary layer with clay and lignite, several meters in thickness, is interbedded with the Precambrian gneiss and the overlying Tertiary basaltic pile. The temperature of the water is 1.4°C and the conductivity 32 µS. The discharge is at least 30 l/s. Greenland Spring Water ApS opened a new spring water plant in Qeqertarsuaq in August 2009 for international marketing of arctic tap water.

3.3 Unartoq in Disko Fjord

On the south coast of Disko fjord is a geothermal spring named Unartoq (Fig. 3). The name means hometherm in Greenlandic. The small village Kangerluk is on the shore across the coast. The bedrock is covered by till and soil but is probably basalt. The warm water issues from several small springs in a bog ca. 80 m from the shore. The springs are bubbling. Max. temp. 11.1°C and the discharge 1-2 l/s.

No conclusive faults or fissures can be seen that might explain the warm upwelling but geological maps show a fault in the mountain slope to the north trending towards the springs. A ridge of increased magnetism passing close by the springs was detected by magnetic measurements in the field (Fig. 6) The ridge most probably indicates a basaltic dyke. The site is 24 km north west of Qeqertarsuaq and seems to be too remote for geothermal utilization.

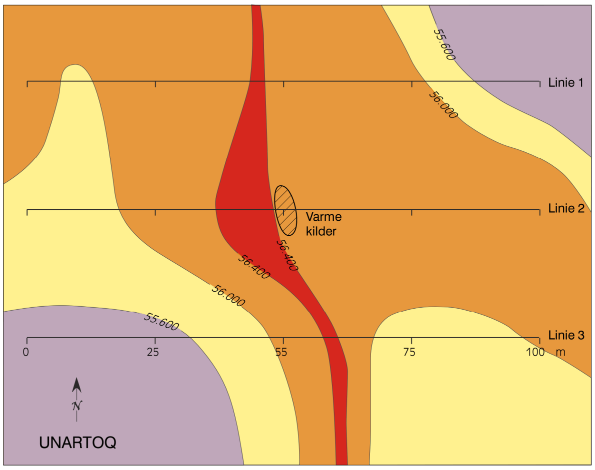

Figure 6: Magnetic map of Unartoq. A narrow ridge where the magnetic field is relatively high crosses the area near to the springs trending N – NNW. The unit of the isolines is nT.

3.4 Tarajungistoq

On the north coast of Disko fjord there is a small inlet called Eqalunnguit. Hyaloclastite breccia is exposed on the shore itself but up from the shore the bedrock is of Precambrian gneiss, a continuation of the gneiss ridge exposed at Qeqertarsuaq. The warm spring, Tarajungitsoq, is in a moor covering the gneiss, 100-200 m from the shore and 30-40 m a.s.l. (Fig. 7). The water has a bland salty taste and in Greenlandic Tarajungitsoq means exactly “salty taste”. Prominent white precipitates cover the stones and gravel in the brook flowing from the spring and the water is characterized by the precense of a thick gelatinous microbial mat. Maximum temperature 11.5°C and the discharge is estimated about 2 l/s. The chemical content, conductivity and radioactivity of the water was higher here than in other springs than were sampled during the investigation (Table 7).

Figure 7: Tarajungitsoq. The water is saturated by salt and more elements in solution that precipitate when it cools down and form white precipitates on stones in the brook.

3.5 Puilassoq

Puilassoq is the warmest geothermal spring area in Disko Island. The name simply means a spring. Heide-Jørgensen and Kristensen (1999) have described the area. It is at the head of the large fjord Akugdlit, ca. 200 m upstream from the estuary, 25 m a.s.l. (Fig. 3). The springs are bound to a small hillock 14 x 8 m^2 and up to 2 m in height (Fig. 8). A bog is all around. The hillock is covered by green grass so it is easily found. The water is rich in algae but no geothermal precipitates are found in it. Large basaltic boulders are exposed all around. There are several separate outflows, two larger than the others, the one in the north east and the other in thesouthwest part of the dome.

Table 2. Temperature, discharge and conductivity in Puilassoq 30.8.2005

	°C	l/s	µS
Northeast outflow	17,6	1	102,0
Southwest outflow	17,4	0,5	102,1
Small pool 500 m to the east	6,9	0,1	840

Ca.10 m north west of the hillock is a small outflow in the bog, 9.6°C and 500 m to the east there is a small pool, 6.9°C (Table 2). The temperature in the springs is slightly variable, the reported maximum is 18.8°C. Measurements during winter time give higher results than summer measurements (Heide-Jørgensen and Kristensen 1999).

The bedrock is not exposed near the spring area but according to geological maps it is basalt. In the mountain south of the area a prominent fault cuts the basaltic pile from mountaintop to shore. Its continuation in the lowland is hid by the overburden but it might cut the bedrock below Puilassoq affecting the geothermal system. A magnetic survey in 2005 however didn’t reveal any anomalies in the magnetic field in the area.

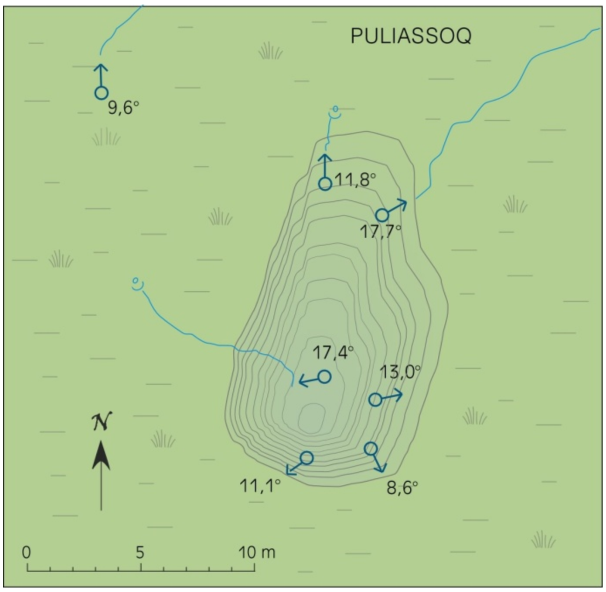

Figure 8: The hillock and geothermal springs in Puilassoq

In Kildedalen (the Spring Valley), 3 km west of Puilassoq several warm springs are found in a bog. There the maximum temperature is 14.5°C. This area was not investigated during the visit in 2005.

3.6 Unartukavsak

The Unartukavsak geothermal springs are on the north coast of outer Akugdlit fjord. The place can be detected from a far because the vegetation is richer and greener than elsewhere on the coast. The outflow is in a steep slope from the shore and up to 80 m a.s.l. The floe is artesian. Maximum temperature 15.4°C. Total discharge is estimated 3-4 l/s (see Table 3).

Table 3. Temperature, discharge and conductivity in Unartukavsak 30.8.2005

Locality	*°C*	*l/s*	*µS*
Springs at the shore	15,4	0,1	70,3
Spring line in the slope	13,2	0,2	72,0
Uppermost springs, artesian water	11,2-14,6	3	72,8-93,3

4 TEMPERATURE VARIATIONS IN THE WARM WATER

It has long been noticed that the temperature in the geothermal springs is slightly variable, higher in the winters than in the summers (Heide-Jørgensen og Kristensen 1999). This might seem to be contradictory, the winter frost should lower the water temperature. In fact it is not the air temperature that affects the fluctuations in the springs, rather the groundwater conditions. During the winter all precipitation falls as snow and the surface soil freezes, forming a solid layer down through the permafrost zone. Advection of groundwater to the geothermal convection stops and the temperature in the thermal springs increases.

The first information on geothermal activity in Greenland goes back to the ancient Greenland description of Ivar Bardarson written after his dwelling in the Norse settlement sometime around 1300 AD. He mentions warm springs (36-42°C) in the in small islets of the old Ravensfjord (Hrafnsfjörður), that is now known as the Island of Unartoq. He also describes their annual temperature fluctuations and their therapeutic properties. He writes: “In these islets there is a lot of warm water. In winter it is so hot that no one endures it but in summer it is suitable for bathing. There many people have got holistic treatment and good healing and remedy of illnesses.” (Halldórsson 1978, p. 135).

5 EARTHQUKES

Earthquakes are important for maintaining geothermal systems. They open up and fissures and cracks in the bedrock through which water can penetrate deep down into the crust. The warm water rises to the surface again because of its reduced density and a convection system has been formed along with geothermal springs. In and around Disko earthquakes are well known. On March 30th 2005 an earthquake 4.3 on the Richter-scale was detected with origin near Qeqertarsuaq (Fig. 9). Attendant changes in the temperature and discharge of springs have been reported along with earthquakes. A seismic station was operated in Qeqertarsuaq for years but has now been abandoned.

6 CHEMICAL ANALYSIS

Two cold springs and four geothermal springs were sampled for chemical analyses during the investigation in 2005 (Table 7). The samples are identified as Disko 1 to 6. Disko 1 is a cold spring in the slope above Unartorssuaq, Disko 2 is from a geothermal spring in Unartorssuaq, Disko 3 is from the saline geothermal spring in Tarajornitsoq. Disko 4 is from the geothermal spring in Unartoq. Disko 5 is from the warmest spring in Disko Island, Puilassoq and Disko 6 is from a cold spring in Orpinguit (Österlien) upstream from the Arctic Station in Qeqertarsuaq. The coordinates are shown in Table 5.

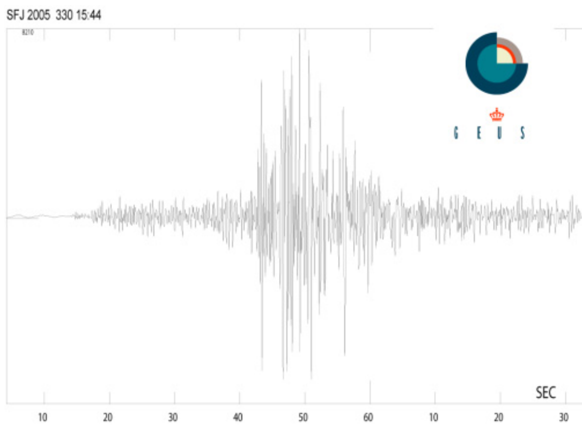

Figure 9: A seismograph from an earthquake near Disko in March 2005

The chemical content of the geothermal samples was slightly different in those originating in the gneiss and those basaltic bedrock. Chemical geotemperature for the water was calculated and besides the possibilities of mineral precipitation were estimated using the WATCH-program (Arnórsson et al. 1982, 1983a, Bjarnason 1994). The results are presented in Table 4 along with rock type in the field and measured temperatures.

Table 4. Chemical geothermometer temperatures (Fournier 1977, Fournier and Potter 1982, Arnórsson et al. 1983b) and calcite saturation in four warm springs in Disko.

Locality	*Measured temp. °C*	*Quarz temp. °C*	*Na/K temp. °C*	*Calcite-saturation, log(Q/K)*
Disko 2	13,8	50	70	0,355
Disko 3	11,5	68	52	-0,240
Disko 4	11,1	20	0	0,160
Disko 5	17,7	34	10	0,476

Several chemical geothermometers can be used but in Disko the quartz mineral thermometer is supposed to be the appropriate one (Hjartarson and Ármannsson 2005). In Iceland the chalcedony temperature is most often used in these calculations. That is because the bedrock is so young that chemical balance with quartz has not been reached. In the much older bedrock in Disko the quartz balance has on the other hand supposedly been approached. The calculations indicate that Unartorssuaq (Disko 2) and Tarajornitsoq (Disko 3) are the most promising sites. There, geothermal water with temperature between 50-70°C might be expected in boreholes.

7. RADIOACTIVITY

Anomalous radioactivity has been measured in some of the geothermal sites in Disko Island (Kristensen 1987). Using

Geiger-Muller and McPhar counters Hansen et al. (1988) reported results from three places:

1) In the brook flowing into the sea at Unartorssuaq no radioactivity was detected exceeding the background level, that was 55 CPS (gamma counts per second).

2) In the geothermal spring at the Thermistor Rock (Termistorstenen) the radioactivity was 200-450 CPS or 3-8 times higher than the background level (55 CPS).

3) In Tarajungitsoq the maximum results showed revealed 1400 CPS or 35 times the background level, that was 40 CPS.

Table 5. Sampling sites for chemical analyses

Sample	Locality	Coordinates
Disko 1	Unartorssuaq	N69.26544 W53.56798
Disko 2	Unartorssuaq	N69.25981 W53.56669
Disko 3	Tarajungitsoq	N69.55674 W53.60651
Disko 4	Unartoq	N69.43227 W53.89095
Disko 5	Puilassoq, warmest	N69.67172 W54.38391
Disko 6	Orpinguit (Österlien)	N69.25712 W53.51875

In the summer of 2005 four sites were sampled for analysis of the radioactivity using a liquid scintillation counter (see Theodórsson and Gudjonsson2003) at the University of Iceland. (Table 7). This is a Radon (Rn) radioactivity and the analyses agree the results of earlier measurements. The radioactivity of the samples from Disko is much higher than that of Icelandic samples. However the results were below all guideline limits for health standards. In Europe the maximum level in drinking water is 1000 Bq/l (EC Recommendation 2001/928/Euratom). The radioactivity of geothermal water in boreholes is suggested to be higher. Radon has a half-life of 3.8 days so the radioactivity decays rapidly.

Table 6. Radioactivity in water samples from Disko Island.

Locality	*Bedrock*	*Radioactivity [Bq/l]*
Unartorssuaq	Gneiss	140
Tarajungitsoq	Gneiss	705
Unartoq	Basalt	61
Puilassoq	Basalt	11

8. RESULTS

In Greenland geothermal surface manifestations are rare. They are mainly found in or near to the basaltic areas in Scoresbysund on the east coast and in Disko Island at the west coast. The highest temperature is foundnorth and south of Scoresbysund where the warmest spring is at Cap Tobin, 62°C. The warmest one in Disko is about 18°C. Limited investigations have been made into the possibilities of geothermal utilisation in Disko. Twelve small geothermal fields are known there , five of which are briefly described in the paper. Most of the thermal springs are found in the basaltic lava pile but three of them are in Precambrian gneiss and one in Cretaceous sandstone. The regional permeability of the basaltic formation in southwest Disko seems to be similar to the mort permeable part of the Icelandic Neogene basalts such as in NW-Iceland where geothermal utilization is economically important. The permeability elsewhere in Disko is unknown. The warm springs are most likely connected to fissures or fissure swarms in the bedrock that allowi the groundwater to penetrate deep down and form vertical convection systems as is the case in most Icelandic low temperature geothermal fields. Seismic activity is known in the Disko area and the earthquakes can form and maintain permeable fissures and fissure swarms. Changes are known to occur in the temperature and discharge of the warm springs after earthquakes. Nothing is known about the geothermal gradient in Disko.

Chemical analysis was carried out on samples from four of the geothermal sites. Using geothermometers the temperatures in the roots of the geothermal systems were calculated along with some practical characteristics of the warm water. It is concluded that Unartorssuaq and Tarajornitsoq are the most promising sites. There, geothermal water with temperature 50-70°C might be expected in boreholes.

The warm springs of Unartorssuaq are the only ones located near an inhabited area (Fig. 10). They are ca. 2 km outside the town Qeqertarsuaq (Godhavn). They seem to be connected to prominent fissures and faults found in the field which can be traced towards the town. If this is the case the geothermal system itself might also extend to the town. That cannot be proved without drilling. Boreholes are needed to investigate the geothermal gradient and the size and orientation of the geothermal system. Until drilling nothing more can be stated about the possibilities of geothermal utilisation in Qeqertarsuaq.

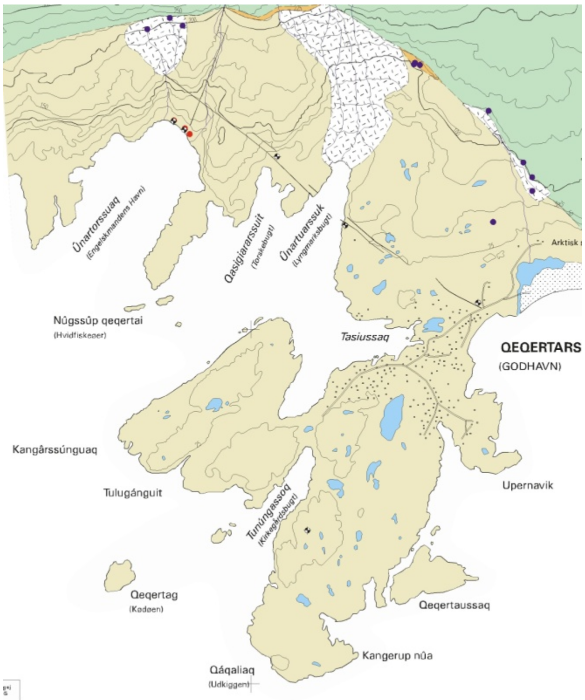

Figure 10: Map of Qeqertarsuaq. Cold spring = blue dot. Warm spring = red dot. Recommended drilling site = crossed circle. Light brown = Pre-cambrian gneiss. Orange = sedimentary layers. Green = basalt. Black lines = fissures.

Table 7. Results of chemical analysis. (Mineral concentration in mg/l; isotopes of hydrogen and oxygen in ‰ SMOW)

Staður		**Disko 1**	**Disko 2**	**Disko 3**	**Disko 4**	**Disko 5**	**Disko 6**
Staðarnúmer		K-792	H-11111	H-11112	H-11113	H-11114	K-793
Dags.		28.8.2005	28.8.2005	30.8.2005	30.8.2005	31.8.2005	3.9.2005
Sýni nr.		20050229	20050230	20050231	20050232	20050233	20050234
Hiti	(°C)	3,0	13,8	11,5	11,1	17,7	0,9
Efni							
Sýrustig	pH	9,84 / 20,0	8,16 / 21,0	7,24 / 18,4	10,06 / 18,8	10,16 / 20,0	8,36 / 17,2
Karbónat	CO_2 (t)	31,1	55,2	42,1	42,6	47,5	62,7
Brennist.vetni	H_2S	<0,03	<0,03	<0,03	<0,03	0,47	<0,03
Leiðni	Leiðni	38,7	585	1308	76,2	102	36,1
Uppleyst efni	TDS	37	420	1020	58	84	55
Kísill	SiO_2	11,1	14,4	22,6	13,3	23,9	11,3
Bór	B	<0,03	0,10	0,29	<0,03	0,04	<0,03
Flúoríð	F	0,03	1,5	2,75	0,03	0,04	0,03
Klóríð	Cl	3,24	146	387	6,3	5,4	3,99
Súlfat	SO_4	1,24	89,3	220	1,85	1,47	1,53
Kalsíum	Ca	2,08	47,3	76,2	1,15	1,92	6,38
Kalíum	K	0,05	1,58	3,49	0,07	0,10	0,08
Magnesíum	Mg	0,022	0,48	0,22	0,013	0,012	0,48
Natríum	Na	10,5	83,8	261	18,6	20,1	8,85
Ál	Al	0,0475	0,00558	0,00305	0,0631	0,0553	0,0233
Arsen	As	0,000448	<0,00005	<0,00005	0,00109	0,000717	0,000406
Baríum	Ba	0,000124	0,00743	0,0133	0,000112	0,00007	0,000246
Kadmíum	Cd	0,000022	0,000017	0,000018	0,000008	0,000051	0,000018
Kóbalt	Co	0,000269	0,00001	<0,000005	<0,000005	<0,000005	0,000253
Króm	Cr	0,00409	0,000164	0,000819	0,000237	0,000025	0,0497
Kopar	Cu	0,00119	0,0011	0,000339	0,000192	0,00018	0,00229
Járn	Fe	0,0221	0,0029	0,0028	0,0071	0,0028	0,22
Kvikasilfur	Hg	<0,000002	0,000009	0,000011	<0,000002	0,000009	<0,000002
Mangan	Mn	0,00143	0,000235	0,00153	0,000084	0,00008	0,00144
Mólýbden	Mo	0,000244	0,00583	0,00702	0,000255	0,000709	0,00575
Nikkel	Ni	0,0133	0,000138	0,00025	0,000079	0,000078	0,0119
Fosfór	P	0,0219	0,00438	0,00128	0,0162	0,00656	0,0257
Blý	Pb	0,00036	0,000028	0,000049	0,000012	0,00002	0,000185
Strontíum	Sr	<0,002	0,734	1,61	<0,002	<0,002	<0,002
Sínk	Zn	0,0222	0,00178	0,00234	0,000264	0,000856	0,0226
Samsætur							
Vetni	δD	-118,3	-119,3	-130,4	-112,4	-118,0	-106,7
Súrefni	$\delta^{18}O$	-16,49	-16,43	-17,46	-15,65	-16,34	-14,65

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