DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2004/20

Mineral resources of the Precambrian shield of central West Greenland (66° to 70°15'N)

Part 2. Mineral occurrences

Henrik Stendal, Bo Møller Nielsen, Karsten Secher and Agnete Steenfelt

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF THE ENVIRONMENT

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Abstract

This report forms part of an assessment of the mineral resource potential of central West Greenland conducted by the Geological Survey of Denmark and Greenland 2000–2003. It presents the principles applied in classifying and describing 160 compiled mineral occurrences from the region as well as an evaluation of the mineral resource potential.

The assessed region is underlain by an Archaean basement of tonalitic orthogneisses with intercalated supracrustal belts representing both continental and volcanic arc environments. The basement has been variably reworked during the Palaeoproterozoic Nagssugtoqidian collisional orogen and has been intruded by minor volumes of arc-related magmas in the core zone of the orogen

There are no mines in the region, and previous production has been limited to graphite. Many mineral showings have been recorded by commercial companies and the Survey during exploration since the 1960s, but none have so far become economically feasible. Most of the known occurrences are located in supracrustal belts and comprise banded iron-formation, semi-massive to massive sulphides, together with syn- and epigenetic gold and copper. Pyrochlore and diamonds are found within a 0.6 Ga old carbonatite-kimberlite province and some pegmatites are rich in monazite.

Based on the abundance, spatial distribution, size, grade, age and genesis of the mineral occurrences it is concluded that the following types of mineral occurrences have a potential for becoming economically feasible:

- Syn- and epigenetic gold in Archaean supracrustal rocks
- Graphite in Palaeoproterozoic supracrustal rocks
- Speciality metals in carbonatite
- Diamonds in kimberlitic dykes

Contents

Introduction

In 2003, the Geological Survey of Denmark and Greenland (GEUS) completed a four-year project aimed at assessing the mineral potential of the Precambrian part of West Greenland between latitudes 66º and 70º15'N. The project involved compilation of existing geo-scientific data, new geological mapping, field examinations of known and potential mineral occurrences, new chemical and isotope analyses, and data interpretation. The data compilation, available on a DVD (Schjøth & Steenfelt 2004), comprises regional, systematically acquired data sets presented in a Geographical Information System (ArcView). The present report concerns the compilation of mineral occurrences.

Exploration by commercial companies and government institutions has resulted in the identification of 160 mineral occurrences within the region. The reported information on the occurrences is stored at GEUS, in archived company reports and in a GEUS database (Greenmin). The work presented here comprises registration, classification and description of the mineral occurrences together with an assessment of the mineral resource potential based on their geological setting, economic significance and genesis.

Physiography and infrastructure

The land area between the Inland Ice and the sea varies in width from *c.* 50 km in the north to c 170 km in the southern part. Topographically, the region reflects a glacial morphology with a coastal zone characterised by numerous islands, peninsulas and skerries, and with long fjords dissecting the landscape (Fig. 1). The Jakobshavn Isfjord is the most impressive, being the outlet for the fastest moving glacier on the Earth (up to 30 m a day). Consequently, a large number of icebergs is constantly delivered to the fjord. The Aasiaat to Kangaatsiaq area is mostly lowland below 500 m in elevation, while the remaining inland comprises highlands with elevations generally between 200 and 1500 m and occurrences of local perennial ice caps at high altitude. Mountain peaks at the margin of the large Sukkertoppen Iskappe reach 2000 m.

The climate is arctic and the vegetation is commonly low and sparse except in sheltered valleys where scrubs may attain 1–2 metres of height. The rock exposure is generally good, except for scree, glaciofluvial deposits in valleys, and till and boulder fields along margin of the Inland Ice.

The region hosts six towns and eight villages, which is a high population density by Greenlandic standard. It also comprises the main entry site for air traffic, the international Kangerlussuaq airport. Each town has an air terminal for fixed-wing aircrafts and helicopters. During the summer time, the towns are also served regularly by cargo and passenger sea-going vessels.

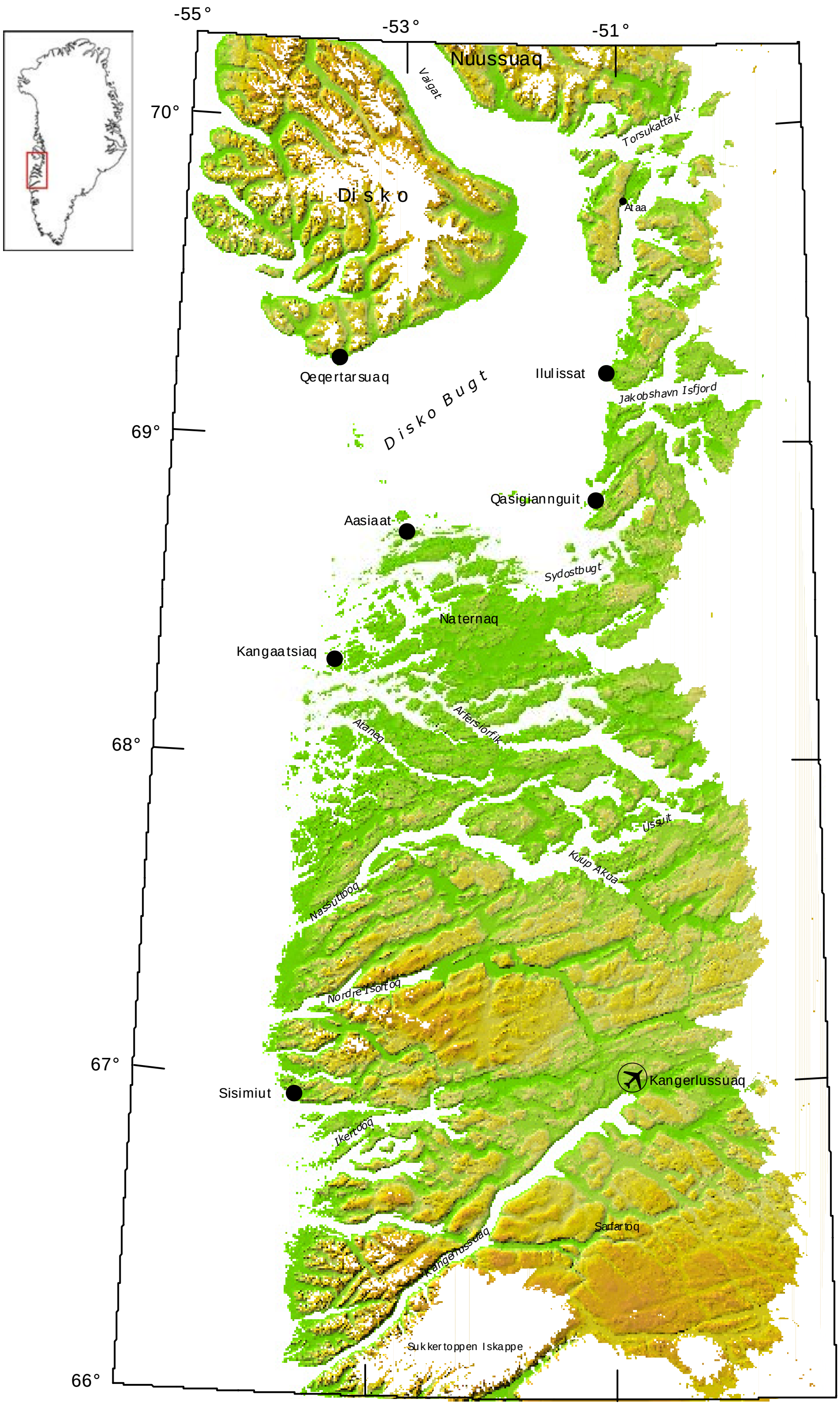

Figure 1. *Digital elevation model of central West Greenland.*

Geology and main mineral occurrences

The study region largely consists of Archaean and Palaeoproterozoic orthogneisses and supracrustal rocks (Fig. 2).

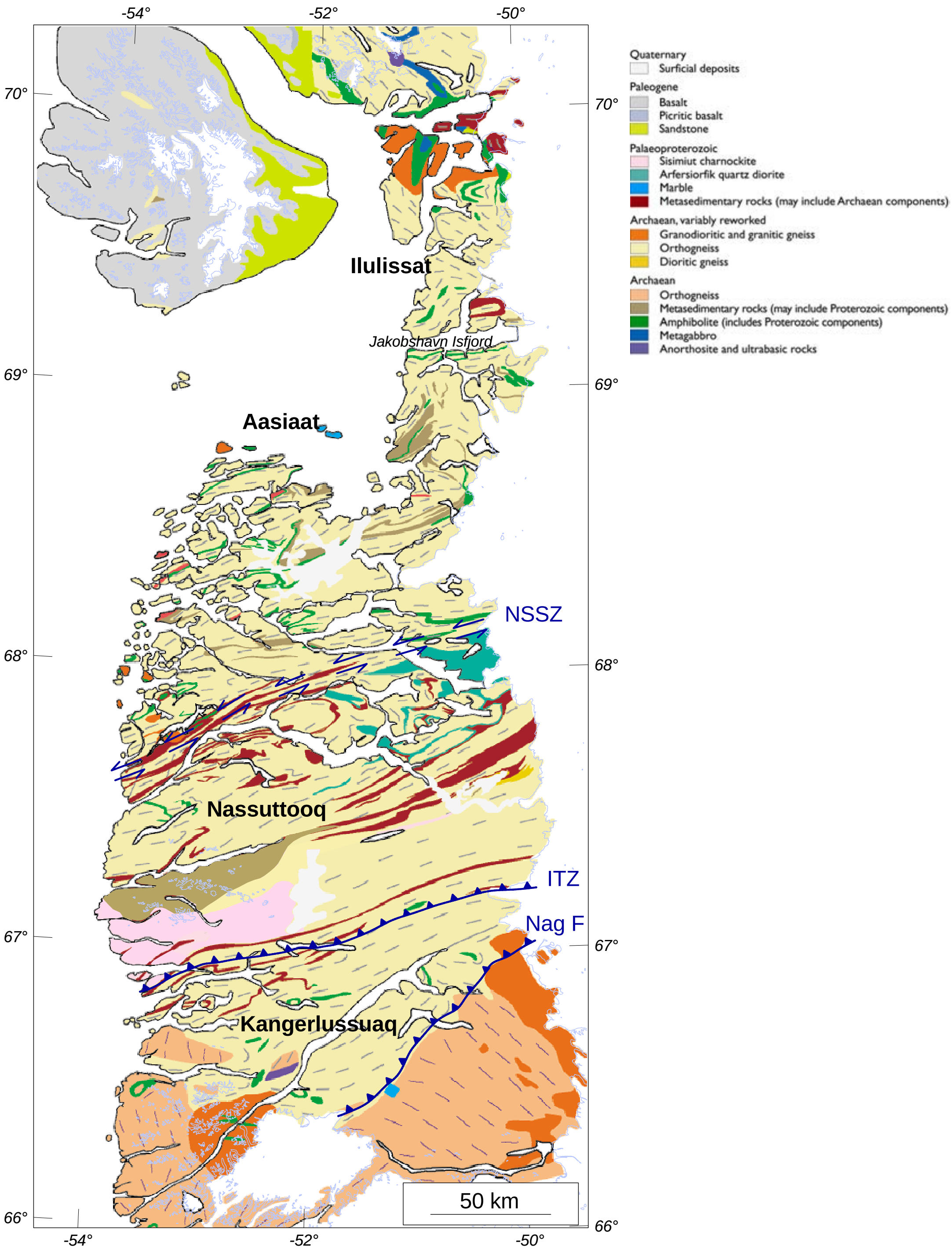

Figure 2. *Main features of the geology of central West Greenland compiled by Adam A. Garde, GEUS, with names of the four sections used in the geological descriptions below. The map is based on Escher & Pulvertaft (1995), but has been considerably modified in the Aasiaat and Nassuttooq areas according to recent geological mapping by GEUS.*

Most of the Archaean crust in the region was formed around 2800 Ma probably by accretion of tonalitic magma complexes formed at constructive continental margins (Kalsbeek & Taylor 1999; Connelly & Mengel 2000). Remnants of older continents comprise mid-Archaean (*c.* 3000 Ma) rock complexes in southern Nuussuaq and a small occurrence of early Archaean orthogneiss (*c.* 3600 Ma) in the south-eastern corner of the region. The Archaean basement together with Palaeoproterozoic cover rocks has been variably affected by the Palaeoproterozoic Nagssugtoqidian orogeny lasting from *c.* 2000 to 1750 Ma (van Gool *et al.* 2002b). The orogen comprises dykes intruded during initial rifting, volcanic rocks formed during subduction, bodies of mantle peridotite emplaced tectonically during collision, and post-collisional granites and pegmatites.

Much later, the Archaean continent south of the Nagssugtoqidian orogen was the focus of recurrent alkaline and carbonatitic magmatism resulting in numerous lamprophyre and carbonatitic dykes, in addition to the major Sarfartoq carbonatite complex (*c.* 0.6 Ga of age; Larsen & Rex 1992).

In the following description of the geology, the assessment region has been divided into four segments from north to south: Ilulissat area, Aasiaat area, Nassuttooq area, Kangerlussuaq area (Fig. 2).

Ilulissat area

Many aspects of the geology of the northern part of the Ilulissat area (often referred to as the Disko Bugt region) have been described in Kalsbeek (1999) and by Stendal & Schønwandt (2003). The area largely consists of late Archaean orthogneisses, intercalated with units of strongly deformed Archaean supracrustal rocks (Fig. 3). The metamorphic grade varies from amphibolite to greenschist facies. A large Archaean anorthosite-gabbro complex occurs at Nuussuaq. The supracrustal rocks at Itilli are massive, fine-grained amphibolite intruded by a 3030 Ma quartz diorite (Thrane & Connelly 2002). Small shear zones in the amphibolite hold epigenetic gold. The diorite seems to be associated with the anorthosite-gabbro complex and the setting is possibly an oceanic island arc. The supracrustal belts around Torssukattak, the Saqqaq, Itilliarsuk and Oqaatsut belts includes mafic metavolcanic rocks, but they have a high proportion of metasediments and are interpreted to represent a continental rift or margin setting (Garde & Steenfelt 1999). The three belts contain occurrences of volcanic-associated massive sulphides and both syngenetic exhalative (Saqqaq) and epigenetic shear zone-hosted gold. Banded iron-formation occurs in the Itilliarsuk and Oqaatsut belt. One radiometric age of *c.* 2851 Ma has been obtained from an acid volcanic rock within the Itilliarsuk belt (Kristine Thrane, GEUS, pers. comm. 2003).

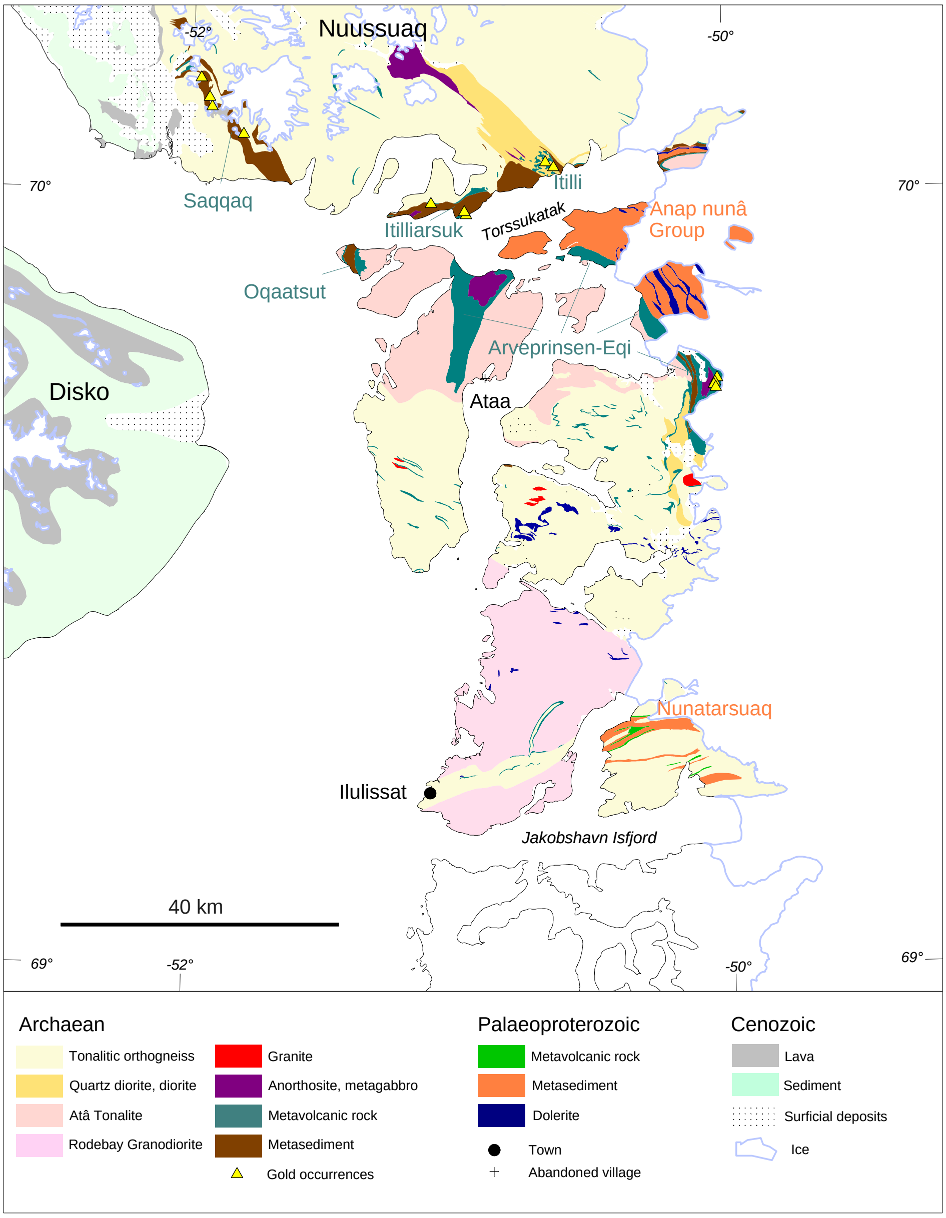

Figure 3. *Geology of the Ilulissat area with names of supracrustal belts (Archaean in green, Palaeoproterozoic in orange) and gold occurrences. Modified slightly from Garde (1994).*

South of Torssukatak, an arcuate belt of mafic metavolcanic rocks with minor acid volcanic rocks and intermittent metasedimentary layers, the Arveprinsen-Eqi belt, is intruded by a sill complex and by a tonalitic to granitic body, the 2800 Ma old Atâ tonalite. Acid volcanic rocks in this belt also indicated an age *c.* 2800 Ma. This granite-greenstone assemblage has been interpreted to represent a volcanic arc. The volcanic rocks host occurrences of auriferous volcanic-associated massive sulphides, minor banded iron-formation and epigenetic gold associated with both carbonate alteration of mafic rocks and zones of faulting or shearing.

The orthogneisses south of Ataa are polyphase grey biotite orthogneisses of tonalitic to granodioritic composition. The few ages obtained suggest that the orthogneiss precursors were formed around 2830 to 2800 Ma, and they are believed to represent accretions of intrusive complexes formed in volcanic arc environments. One orthogneiss unit, the Rodebay granodiorite (Garde & Steenfelt 1999) having almost the same age (2785 Ma, J. Connelly pers. comm. 2004), is distinguished from the other gneisses by a pronounced feldspar porphyritic texture. Minor granitic intrusions provide evidence for crustal heating at around 2750 Ma.

Palaeoproterozoic platform type sedimentary sequences (sandstone, marble and pelite of the Anap Nunaa Group) rest unconformably on metavolcanic rocks of the Archaean basement. Dolerite and lamprophyre dykes and sills intrude both Palaeoproterozoic sediments and Archaean basement.

The age of the supracrustal belt at Nunatarsuaq is uncertain, but is considered Palaeoproterozoic on the basis of isotope data (K. Thrane, pers. comm. 2004). It is dominated by psammitic and pelitic metasediments, but the succession also includes subordinate marble and mafic metavolcanic rocks. The setting of the supracrustal sequence was probably a continental basin or platform.

Aasiaat area

This area (Fig. 4), lying within the northern Nagssugtoqidian orogen in the terminology of Marker *et al.* (1995), has recently been mapped and investigated by GEUS (van Gool *et al.* 2002a). Three geological maps at 1:100 000 scale are being prepared for publication. The Archaean amphibolite facies orthogneisses are similar in appearance and age to those in the Ilulissat area, but this crustal section has undergone Palaeoproterozoic crustal heating resulting in widespread granite and pegmatite veining. Pegmatite intrusion ages suggest several heating events in the period from 1820 to 1760 Ma associated with crustal shortening (Connelly *et al.* 2000).

The supracrustal enclaves around Tasiusaq comprise mafic metavolcanic units tentatively regarded as formed in a volcanic arc environment. Other supracrustal enclaves, the Kangilinaaq, Ikamiut and Naternaq, comprise thick sequences of metasediments including marble, in addition to mafic metavolcanic rocks, and such assemblages suggest platformal or intracontinental basin settings. There is conflicting isotope and field evidence regarding the age of these supracrustal enclaves (Østergaard *et al.* 2002). It is possible that both Archaean and Palaeoproterozoic deposits are present, like in the northern Disko Bugt area where lower metamorphic grade and less deformation allows the recognition of an unconformity between Archaean and Palaeoproterozoic strata. Iron-formations, especially sulphide facies, are common in the supracrustal rocks of this area.

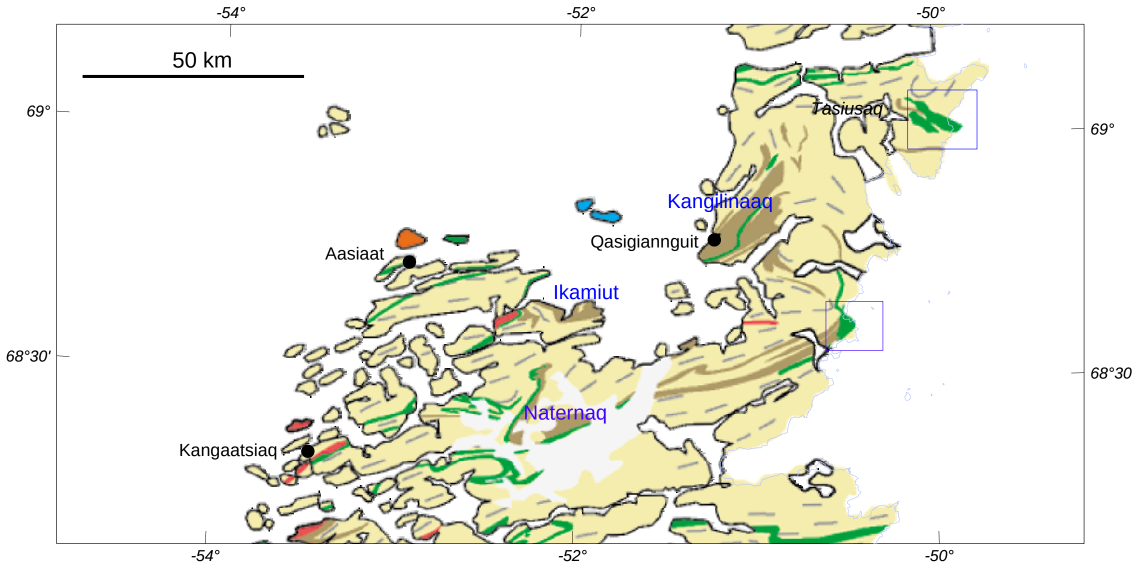

Figure 4. *Main features of the geology of the Aasiaat area. (enlargement of Fig. 2) with names of main supracrustal belts in blue. The framed areas are recently discovered occurrences of mafic supracrustal rocks (Piazolo & Knudsen 2004). This map section is mainly based on results of mapping at 1:100 000 scale by GEUS 2001–2003. Lithology in legend of Fig. 2.*

The Kangilinaaq belt comprises pelitic and quartzo-feldspatic paragneisses, amphibolite, dark biotite schist and local horizons of marble/calc-silicate. Ultramafic bodies are located in the central part of the sequence. The Ikamiut belt is dominated by sliceous metasediments. The Naternaq supracrustal belt is the largest belt in this region. Amphibolite, quartzo-felspathic metasediments, and garnet-bearing biotite schist dominate the Naternaq supracrustal belt, which also contains quartzitic rocks, marble/calc-silicate rocks, in addition to horizons of carbonate and oxide facies banded iron-formation and chert-rich layers. The latter are interpreted as of volcanic exhalative origin. The massive sulphide occurrence at Naternaq is the most prominent mineral occurrence within the Aasiaat area (Stendal *et al.* 2002).

Nassuttooq area

This area contains the core of the Nagssugtoqidian orogen, the collision zone comprising remnants of ocean floor and volcanic arc formations (van Gool *et al.* 2002b). The core zone is defined as the area between the Nordre Strømfjord shear zone and the Ikertôq thrust zone (Figs 2 and 5). The presently exposed rocks have experienced a considerable uplift as evidenced by the granulite facies metamorphic grade prevailing in most of the Nassuttooq area.

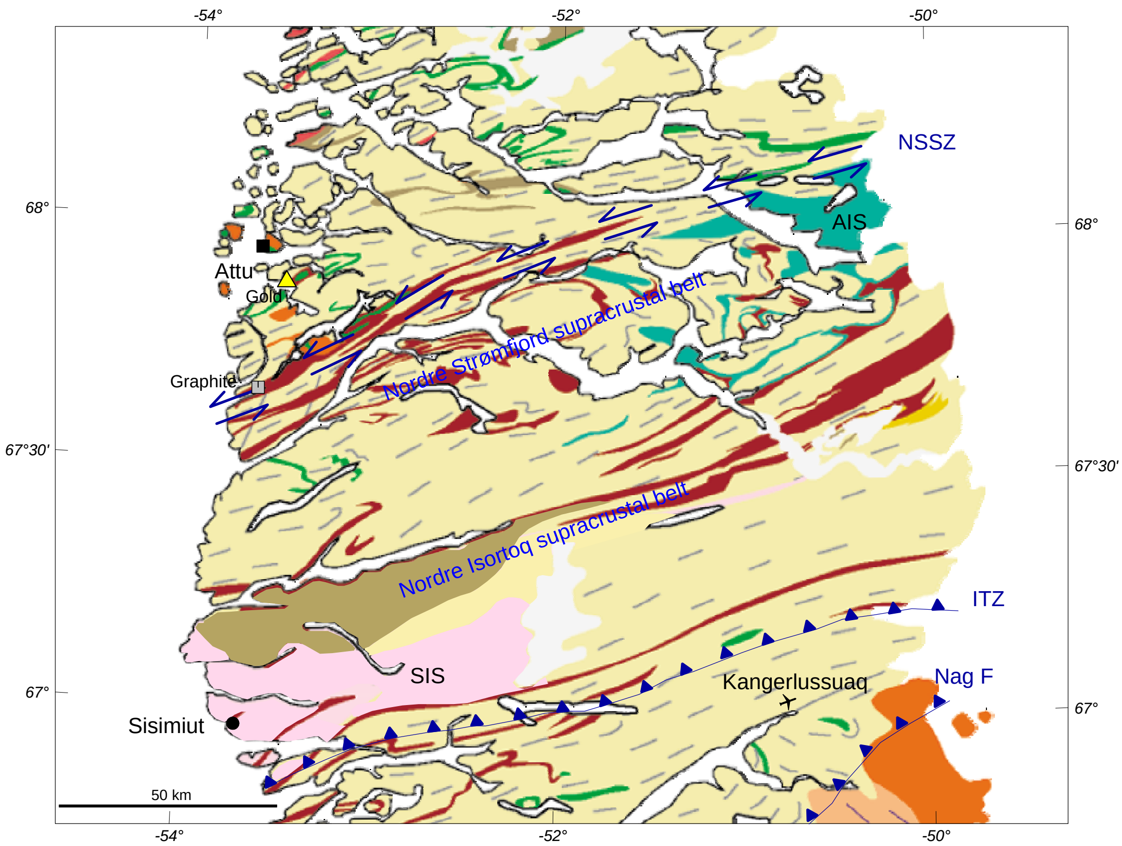

Figure 5. *Main features of the geology of the Nassuttooq area (enlargement of Fig. 2) with names of supracrustal belts in blue and location of main gold and graphite occurrences. The map section is based on Olesen (1984) and recent geological mapping by GEUS. AIS: Arfersiorfik intrusive suite. SIS: Sisimiut intrusive suite. NSSZ: Nordre Strømfjord shear zone. ITZ: Ikertôq thrust belt. Nag F: Nagssugtoqidian front. Lithology in legend of Fig. 2.*

The Nagssugtoqidian orogen is proposed to be a result of a full Wilson cycle involving the collision of two Archean cratons after the opening and closure of a minor oceanic basin. The present understanding of the orogen is illustrated in Fig. 6.

The Archaean basement in the northwestern part of the Nassuttooq area, NW of the Nordre Strømfjord shear zone, comprises a large layered ultramafic to mafic metaigneous complex (not shown on the map, Fig. 5) and a number of charnockitic and granitic orthogneisses. The protholith rock types for the mafic complex include gabbro, gabbro-norite, pyroxenites, and hornblendites. Granulite facies orthogneisses in the same area (near Attu, Fig. 5) host a recently discovered gold-bearing shear zone (Stendal *et al.* 2002).

Palaeoproterozoic intrusive and extrusive rocks resulting from the subduction(s) stages comprise two suites, the Arfersiorfik and Sisimiut suites (Kalsbeek *et al.* 1987; Kalsbeek & Nutman 1996). The former is dominated by quartz dioritic intrusive bodies and sheets, while the latter (also referred to as the Sismiut charnockite suite) is more variable in composition and comprises gabbros, quartz diorites, monzodiorites, tonalites, granodiorites and monzonites.

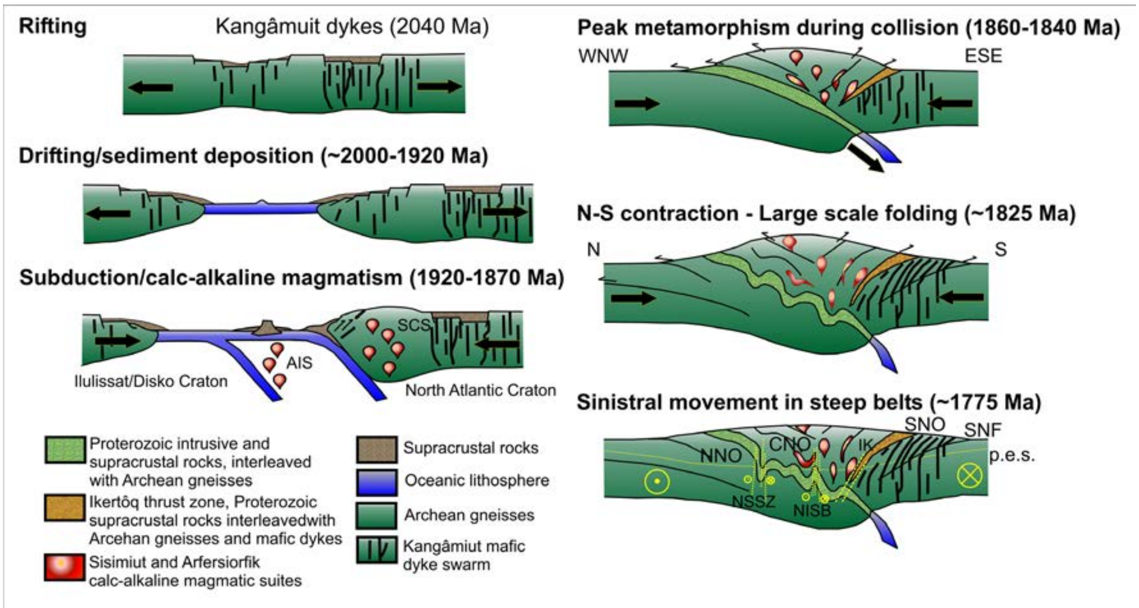

Figure 6. *Schematic model for the evolution of the Nagssugtoqidian orogen, slightly modified from van Gool et al. (2002b). AIS: Arfersiorfik intrusive suite. SCS: Sisimiut charnockite suite. NSSZ: Nordre Strømfjord shear zone. NISB: Nordre Isortoq steep belt from van Gool et al. 2002.*

Supracrustal rocks are common within the Nassuttooq area, where they occur as strongly deformed and metamorphosed ENE trending bands. Metasediments including subordinate marble predominate in the supracrustal bands. Collectively, the supracrustal enclaves in the northern Nassuttooq area are termed Nordre Strømfjord supracrustals. Isotope data for detrital zircons have confirmed that several of these are Palaeoproterozoic and deposited during the subduction stage(s) of the orogenic evolution (1930 to 1870 Ma; van Gool *et al.* 2002b). Owing to the intense deformation, it has not been possible to relate individual supracrustal units to a depositional environment, but the lithologies and mineral occurrences suggest that both platform and arc/back-arc type deposits are represented.

The Nordre Isortoq supracrustal belt comprises metasediments and metavolcanic strata that are occasionally rich in sulphides. Available isotope data suggest that a proportion of the rocks are Archaean, and that Palaeoproterozoic sediments are also present (Connelly & Mengel 2000; Marker *et al.* 2004).

A prominent shear zone, the Nordre Strømfjord Shear Zone (Bak *et al.* 1975), is a late feature in relation to the collisional deformation. It has developed in a ductile environment at *c.* 1774 Ma according to interpretation of isotope data (Connelly *et al.* 2000). Supracrustal sequences within the shear zone contain a large number of massive sulphide occurrences and abundant graphite. Two, particularly rich, graphite occurrences have been mined.

The Ikertôq thrust zone (Korstgård *et al.* 1987; van Gool *et al.* 2002b) constitutes the southern boundary of the core zone. The thrust zone is defined as a 5–10 km wide belt with penetrative, straight gneissic fabric and isoclinal folding and imbrication (van Gool *et al.*

2002b). Lithologically, the thrust zone contains Archaean orthogneisses interleaved with Palaeoproterozoic sheets of pelitic and psammitic paragneisses. All structures are transposed into planes with moderate to steep NNW dips. The Ikertôq thrust zone forms a prominent metamorphic and tectonic boundary. It has been suggested that the boundary represents an intense, ductile, south-directed thrust that has accommodated considerable crustal shortening and uplift of the central part of the orogen.

Kangerlussuaq area

The Archaean continent south of the Ikertôq thrust zone mainly consists of tonalitic to granitic orthogneisses in granulite facies or retrogressed from granulite facies. Remnants of a *c.* 3600 Ma old continent have been identified in the southeastern corner of the area by (Rosing *et al.* 2001). The remaining orthogneiss complexes have given ages in the interval 2870 to 2780 Ma (Kalsbeek & Nutman 1996; Connelly & Mengel 2000). A conspicuous Palaeoproterozoic dolerite dyke swarm, the Kangâmiut dykes, intruded the basement at *c.* 2040 Ma (Nutman *et al.* 1999). The deformation of the dyke swarm defines the Nagssugtoqidian front, which marks the southern limit of Nagssugtoqidian penetrative deformation (Escher *et al.* 1970).

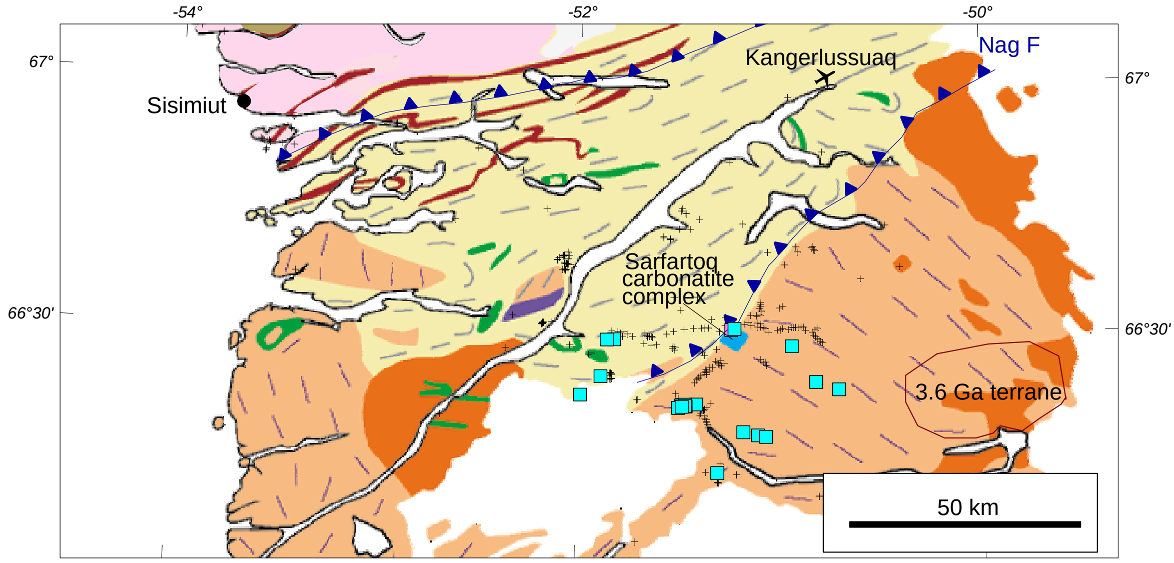

Figure 7. *Main geological features of the Kangerlussuaq area (enlarged from Fig. 2) with location of the Sarfartoq carbonatite complex (blue) hosting a Nb-Ta occurrence (purple square), known kimberlite occurrences (black crosses) and known diamond bearing kimberlite dykes (green squares). The extent of the 3.6 Ga old terrane (Rosing et al. 2001) is not well established and the outline shown here roughly embraces dated samples. Nag F: Nagssugtoqidian front.*

The Kangerlussuaq area hosts an important alkaline province comprising the 600 Ma old Sarfartoq carbonatite complex (Secher & Larsen 1980) together with a swarm of contemporaneous dykes described as kimberlites and lamproites (Larsen 1991). An older generation (*c.* 1200 Ma) of lamproites are clustered near Sisimiut. Diamonds are found in several of the kimberlite dykes (Jensen *et al.* 2003), and the carbonatite hosts a large pyrochlore deposit (Secher 1986).

Previous exploration

Exploration and prospecting within the area has been carried out since the beginning of the 20th century (Ball 1922). Graphite attracted economic interest as one of the first commodities in West Greenland. The activity increased around 1900 and in 1914–1916 it went as far as to primitive exploitation on a pilot scale at two sites (Eqalussuit and Utoqqaat) by Grønlandsk Minedrifts A/S. The activity was based on a licence granted in 1904 and later extended to 1933.

In the period from 1920–1950 there was no exploration activity in the area. In the late 1940s initial geological reconnaissance was carried out by the Geological Survey of Greenland, just established in 1946 (Ramberg 1949). From the beginning of the 1960s a modern phase of exploration was initiated by Kryolitselskabet Øresund A/S, and continued by other companies, as described below. The Survey undertook in 1975–76 an airborne radiometric (gamma-ray spectrometry) mapping programme in central West Greenland (Secher 1976). Airborne geophysical mapping programmes, mainly magnetic field, have been conducted 1992–1999 (Rasmussen & van Gool 2000), and geochemical mapping 1986–1993 (Steenfelt 2001).

In the Ilulissat (Disko Bugt) area, regional mineral exploration has been carried out by Cominco Ltd. in the 1960s (Paton 1968), Kryolitselskabet Øresund A/S in 1980–1982 (Gothenborg & Keto 1986), Platinova Resources Ltd/Rayrock-Yellowknife Resources Inc. in 1988 (Blackwell 1989). Following a gold discovery made by the Geological Survey of Greenland at Eqi in 1988, this area was further explored by Platinova Resources Ltd./Faxe Kalk A/S in 1989–91 (Knudsen & Nielsen 1992) and by the Survey (Stendal *et al.* 1999). NunaMinerals A/S has explored the area in the 1990’s, especially targets at Saqqaq, Itilliarsuk, and Eqi (NunaMinerals 2000). Many small mineral occurrences have been recorded in supracrustal rocks of Archaean and Palaeoproterozoic age elsewhere in the Disko Bugt area. Results of Survey exploration in the Ilulissat area are reviewed by Stendal & Schønwandt (2003).

In the area south of Ilulissat, exploration companies have been active since the early 1960s. Kryolitselskabet Øresund A/S prospected with the objective of locating rust zones for further investigation (Keto 1963; Vaasjoki 1964; Kurki 1965a, b; Vaasjoki 1965; Gothenborg 1980; Gothenborg & Keto 1980). A major discovery during a campaign in 1962–64 by Kryolitselskabet Øresund A/S was the massive sulphide occurrences at Naternaq (Lersletten), and further investigations in the following years were concentrated on the most extensively mineralised southern part of the Naternaq supracrustal belt (Vaasjoki 1964, 1965). In 1990–1993, Nunaoil A/S (now NunaMinerals A/S) prospected at Naternaq with ground geophysical VLF and magnetic surveys, and undertook a regional sediment sampling programme. Kryolitselskabet Øresund A/S also reported small occurrences of semi-massive sulphide at Qasigiannguit peninsula during their reconnaissance exploration in 1962 (Keto 1963). These occurrences was further investigated by Kryolitselskabet Øresund A/S in 1964, but were then abandoned due to small tonnage and low base metal grades (Kurki 1965c). The supracrustal rocks at Qasigiannguit peninsula were re-investigated for gold by

Nunaoil in 1996 (Petersen 1997), but no interesting results were found. Stendal *et al.* (2002) summarises exploration activities by GEUS in 2001.

During the geological mapping of the Agto map sheet (1:100 000) between 1965 and 1978 (Olesen 1984) discontinuous stratiform massive iron sulphide mineralisation was found in amphibolite/schist. Nunaoil A/S prospected in the same map sheet area during the early 1990s (Geyti & Pedersen 1991; Gowen 1992; Grahl-Madsen 1993). Their investigations included a regional heavy mineral concentrate and stream sediment survey that was subsequently followed-up in anomalous areas (Grahl-Madsen 1994; Sieborg 1992). Their targets were base and noble metal deposits in volcanic exhalative settings. Later, in the 1990s, RTZ Mining and Exploration Ltd. (Coppard 1995) and Inco Ltd. (Car 1997) prospected for Ni-Cu and Platinum Group Metals inspired by the spectacular discoveries from Voisey's Bay, Labrador (e.g. Li & Naldrett 1999).

Exploration of the Sarfartoq carbonatite complex used airborne gamma-ray spectrometry (Secher 1976) and follow-up on ground from 1977–80. The first showing of niobium mineralisation, discovered in 1978, demonstrated a high-grade, low tonnage type of pyrochlore deposit (Secher 1986).

The pyrochlore potential within the Sarfartoq complex has been drilled and evaluated by two companies: In 1989 Hecla Mining Company carried out drilling at the occurrence 'Sarfartoq 1' (Druecker 1990a, b). New Millenium Resources N.L continued exploration in the carbonatite area (Barnes 1999) and the company is holding a licence at the time of writing.

Kimberlitic rocks have been targeted for commercial diamond exploration since the mid-1990s. However, the first micro-diamonds were recorded already in 1973 in stream sediment samples from the valley of Sarfartoq. Since the mid-1990s, exploration companies have reported *in situ* micro and macrodiamonds in kimberlitic dykes and sills from several localities within the area (reviewed by Jensen *et al.* 2003). Survey research as well as company exploration is ongoing.

Description of mineral occurrences

A total of 160 mineral occurrences are known within the assessment region. They have been registered and classified as described in the following. A mineral occurrence in the context of this report denotes a concentration of ore minerals and includes industrial minerals, diamondiferous kimberlitic dykes and gemstones.

Principles applied in classification and description

Each mineral occurrence has been given a unique identification number (id. no.). Closely situated occurrences of the same type have been grouped and one within each group has been chosen as representative, termed 'type locality'. Each of the 53 selected type localities is described using a standardised form, in which the occurrences are categorised according to commodity, economical significance and occurrence type, and their geological setting, mineralogy etc. are described as explained in the following. The headings and their contents are inspired by standardised descriptions of mineral deposits by Eckstrand *et al.* (1996) and Lefebure & Ray (1995). All descriptions of mineral occurrences are given in the Appendix.

Type locality id. no.
The id. no. of the representative occurrence within a group of similar occurrences.

Type locality for id. nos.
The id. nos for all occurrences belonging to the group.

Locality Name and **Area**
'Locality Name' and 'Area' are self-explanatory.

Genetic relation
Short characterisation of the mineral occurrence in genetic terms, e.g. 'gold in exhalites in volcanic rocks'.

GSC deposit type
This post refers to a classification into mineral deposit types used by the Geological Survey of Canada (GSC) for Canadian mineral deposits (Eckstrand *et al.* 1996), which is adopted here and slightly modified to accommodate Greenlandic mineral occurrences. Classifying geological phenomena always implies a degree of simplification and the use of these categories should be regarded as a general way of referring Greenlandic mineral occurrences to well-known mineral deposits. The main categories of the Canadian classification are listed in Table 1, together with those subcategories that are used to classify mineral occurrences within the assessed region. Mineral deposit types applicable to occurrences reported on in the present report are marked in blue. A short characterisation of each of these is given in the next section.

Category	Mineral occurrence types (Canadian mineral deposit types)
1.0	Placer uranium, gold
1.2	Placer (Placer Au, Pt)
2.0	Stratiform phosphate
3.0	Stratiform iron
3.2	Algoma-type iron-formation
4.0	Residually enriched deposits
5.0	Evaporites
6.0	Exhalative base metal sulphides
6.3	Volcanic-associated massive sulphide base metals
6.4	Volcanic-associated massive sulphide gold
7.0	Unconformity-associated uranium
8.0	Stratabound clastic-hosted uranium, lead, copper
9.0	Volcanic redbed copper
10.0	Mississippi Valley-type lead-zinc

11.0	Ultramafic-hosted asbestos
12.0	Volcanic-associated uranium
13.0	Vein uranium
14.0	Arsenide vein silver, uranium
15.0	Lode gold
15.2	Quartz carbonate vein gold
15.3	Iron-formation-hosted stratabound gold
16.0	Clastic metasediment-hosted vein silver-lead-zinc
17.0	Vein copper and hydrothermal alteration (Vein copper)
18.0	Vein-stockwork tin, tungsten
19.0	Porphyry copper, gold, molybdenum, tungsten, tin, silver
20.0	Skarn deposit
21.0	Granitic pegmatites
22.0	Kiruna/Olympic Dam-type iron, copper, uranium, gold, silver
23.0	Peralkaline rock-associated rare metals
24.0	Carbonatite-associated deposits
25.0	Diamond (Primary diamond deposits)
25.1	Kimberlite-hosted diamond
26.0	Mafic intrusion (Mafic intrusion-hosted titanium-ore)
27.0	Magmatic nickel-copper-platinum group elements
27.2	Magmatic platinum group elements
28.0	Mafic/ultramafic rocks and related minerals (Mafic/ultramafic-hosted chromite

Table 1. *Main categories and selected sub-categories of Canadian mineral deposits types (Eckstrand et al. 1996) used to classify mineral occurrences within the assessed region. The blue classes are used in this report. Where categories are modified, the original names are given in parentheses.*

Commodity group

Main commodity of the mineral occurrence according to the table below.

Commodity group	Geochemical elements/minerals
Precious metals	Au, Ag, PGE
Base metals	Cu, Pb, Zn, Sn
Light metals	Al, Mg, Ti, Li
Iron and ferroalloys	Fe, Mn, Cr, Ni, Co, Mo, W, V
Speciality metals	REE, Y, Zr, Li, Be, As, Bi, Sb, Cd, Ga, Hg, Nb, Ta,
Fissionable metals	U, Th
Industrial minerals	Graphite, phosphate, cryolite, sillimanite/kyanite, diopside, garnet
Gemstones	Diamond, cordierite (dichroite), ruby

Table 2. *Classification of commodity groups.*

Commodities (minor)

Main commodities of the occurrence with possible minor commodities indicated in parentheses.

Economic significance

The economic significance of each mineral occurrence is estimated using a ranking from 1 to 4 of decreasing significance.

0. **Mineral deposit** - denotes an operating mine, abandoned mine or a mineral occurrence that is believed to have a high potential for becoming economically feasible, but which is presently uneconomic.

1. **Mineral prospect** - denotes a mineral occurrence, which has been drilled or investigated in some details and is believed to have a moderate or small potential for becoming economically feasible.

2. **Mineral showing** - denotes a mineral occurrence, which has a significant concentration of ore minerals, but is believed to have no economic feasibility on its own.

3. **Mineral indication** - denotes a mineral occurrence of minor extent, with only a small concentration of ore minerals, or an occurrence for which information is currently limited.

Geological characteristics

This section contains the verbal description of mineral occurrences and is subdivided using several sub-headings.

Description of occurrence – a general descriptive text on the appearance, location, general geology etc., often copied or modified from previous reports.

Geotectonic setting – the plate-tectonic setting of the mineral occurrence and its host rock. In many cases, the suggested setting is based on limited evidence and should be regarded as preliminary.

Depositional environment/geological setting – a text that describes the relationships between the mineral occurrence and its host rocks, the depositional environment and structure of supracrustal host rocks, intrusive relationships and structure of magmatic host rocks.

Age of mineralisation – absolute ages based on geochronology if available or ages relative to host rock or structure, else chronological eons, eras or periods or unknown.

Host/Associated rock types – host rock lithology.

Deposit form – size and shape (dimensions) of mineral occurrence or mineral bearing strata/formations.

Texture/Structure – common textural features of ore minerals and the textural relationships to host/associated rocks.

Ore mineralogy (principal and *subordinate*) – the principal ore mineral is listed first. Less abundant ore minerals follow in *italics*.

Gangue mineralogy (principal and *subordinate*) – list of principal and *subordinate* gangue minerals.

Alteration – description of any alteration apart from weathering.

Weathering – description of any distinct weathering products associated with the mineral occurrence.

Ore controls – a description of the factors governing the emplacement or deposition of the ore minerals.

Genetic models – Documented genetic models are rarely available for the mineral occurrences included in this report. The text under this heading expresses the compiler's present view or best estimate.

Analytical data
Most important available geochemical and geophysical data documenting the significance and commodities of the occurrence.

Exploration
Main exploration and exploitation activities and any available data for tonnage and grade of the mineral occurrence.

Photos, figures and maps
Photos and central figures or maps are included.

References
References listed are limited to those concerning the described mineral occurrence. Literature on the general geological setting and evolution is given in the 'References' at the end of the main report text.

Compiler and date
The initials of the compiler and the time (dd-mm-yyyy) of the compilation.

Main features of applied GSC mineral deposit types

The characteristic features of the GSC mineral deposit types applied to mineral occurrences of this report are presented here. The text is quoted from Eckstrand *et al.* (1996), but literature references given in descriptions of individual deposit types are omitted here. Some of the Canadian categories have been modified to accommodate Greenlandic mineral occurrences, see Table 1, but the original names are retained here.

1.0 Placer

1.2: Placer deposits are accumulations of heavy minerals concentrated by sedimentation processes involving gravity, water, wind, or ice. Placer deposits consist of resistant minerals to weathering such as gold, ilmenite, cassiterite, diamond, zircon, monazite, and rutile.

3.0 Stratiform iron

3.2: Algoma-type iron-formations consist primarily of microscopic alternating layers and beds of chert or quartz, and iron-rich minerals, magnetite, hematite, pyrite, pyrrhotite, iron carbonates, and iron silicates. They are composed of a variety of interbedded oxide, carbonate, sulphide, and silicate lithofacies rich in copper, zinc, lead, tin, and gold. Algoma-type iron-formations were deposited with volcanic rocks and greywacke, turbidite, and pelitic sediments in volcanic arc and spreading ridge tectonic settings.

6.0 Exhalative base metal sulphides

6.3: Volcanic-associated massive sulphide occurrences occur in terrains dominated by volcanic rocks and hosted by volcanic or sedimentary strata. The sedimentary strata are an integral part of the volcanic complex.

6.4: Archaean and Palaeoproterozoic *volcanic-associated massive sulphide gold*. Auriferous volcanic-associated sulphide deposits are either (1) copper-gold, (2) pyritic gold or (3) polymetallic sulphide deposits.

15.0 Lode gold

15.2: Quartz-carbonate vein gold occurrences consist of simple to complex quartz-carbonate vein systems associated with brittle-ductile shear zones and folds in deformed and metamorphosed volcanic, sedimentary, and granitoid rocks. The gold occurs in veins or as disseminations in the adjacent carbonate altered host rocks.

15.3: Archaean iron-formation-hosted stratabound gold is found in greenstone belts. Gold occurrences hosted by iron-formations are characterised by (1) close association between native gold and iron sulphide minerals; (2) the presence of gold-bearing quartz veins and/or shear zones; (3) structural complexity of the host terranes; and (4) paucity of lead and zinc in the ores.

17.0 Vein copper

Archaean and/or Palaeoproterozoic vein copper ± gold include various vein-type deposits in which copper is the dominant metal. The occurrences are structurally controlled and occur in faults, fault systems, and vein breccia zones.

20.0 Skarn deposits

Skarn deposits are abundant and variable in the geological environment. Skarn copper deposits are a skarn type, which can be mineable. In Canada, 5% of the copper production comes from skarn copper deposit. Two types of skarn copper occur, one associated with porphyry copper deposits and one not associated with porphyry copper deposits.

21.0 Granitic pegmatites

Granitic pegmatites are host for speciality minerals such as tantalum, niobium, tin, lithium, caesium, yttrium, and rare earth element. Feldspar, pure quartz and mica might also have economic significance.

24.0 Carbonatite-associated deposits

Carbonatite-associated deposits include a variety of mineral deposits that occur both within and in close spatial association with carbonatite and related alkalic silicate rocks. Carbonatite-associated deposits contain worldwide a variety of minerals including the majority of niobium reserves. Other possible mineable minerals are apatite, magnetite, baddeleyite, zircon and rare earth elements bearing minerals.

25.0 Primary diamond deposits

Diamonds are extracted from kimberlites and from lamproites. The subdivision into two groups on the basis of their host rocks, kimberlite and lamproite, is used in Canada. Concerning the diamond occurrences in Greenland the kimberlite-hosted type is presently the only recorded type.

26.0 Mafic intrusions

The classification of mafic rocks is in the GSC classification restricted to host iron-titanium. In this context the authors have extended the meaning to include other minerals such as the industrial mineral anorthosite. The mafic intrusion includes massive and layered intrusive complexes with rocks such as gabbro, leucogabbro, norite and anorthosite.

27.0 Magmatic nickel-copper-platinum group elements

A broad group of deposits containing nickel-copper-platinum group elements (PGE) occur as sulphide segregations associated with a variety of mafic and ultramafic magmatic rocks.

28.0 Mafic/ultramafic rocks and related minerals

The classification of *mafic/ultramafic rocks* is in the GSC classification is restricted to host chromite. In this context, the authors have extended the meaning to include other minerals than chromite, e.g. magnesite. The most common host rocks are gabbro, peridotite, and dunite.

Mineral resource potential

Favourable geological environments

Volcanic arc and back-arc settings are considered favourable environments for base metal concentrations within syngenetic volcanic-associated massive sulphides, graphite, banded iron-formations (Algoma type), as well as for syn- and epigenetic gold mineralisation. Such settings are represented by Archaean supracrustal belts in the Ilulissat and Aasiaat areas, and by the Palaoproterozoic Nordre Strømfjord supracrustal belt. The distribution of known occurrences of volcanic-associated massive sulphides reflects the position of the belt (Fig. 8).

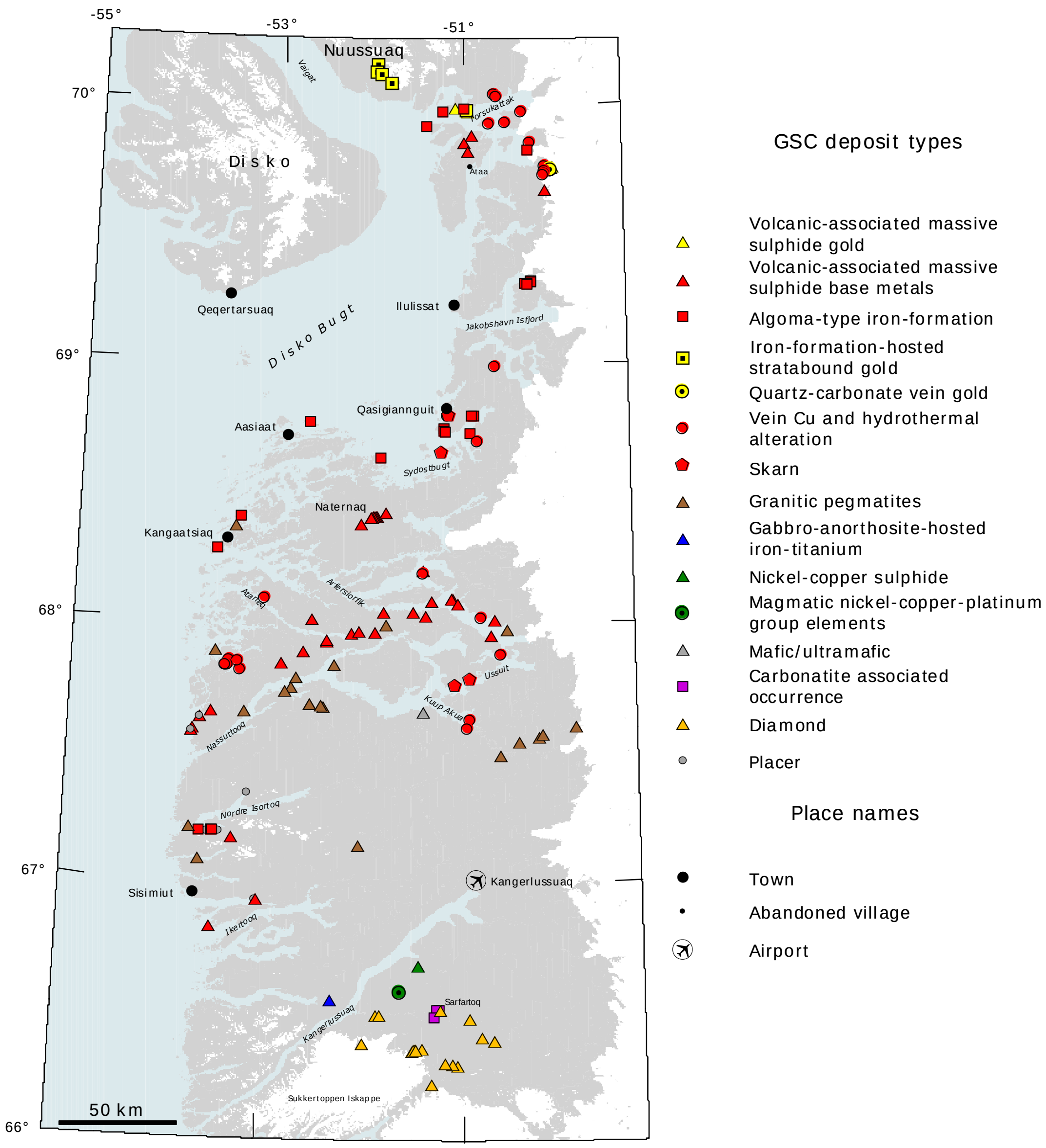

Figure 8. *Mineral occurrences of central West Greenland with symbols reflecting categories of GSC mineral deposit types.*

The known occurrences have insufficient grades or tonnage to be economically significant. It may be speculated that the known occurrences represent the distal facies of a large Besshi-type mineralising system and that the proximal facies is still to be discovered. On the other hand, several factors appear to lower the potential for large deposits of massive base metal sulphides in the supracrustal belts. Age data for massive sulphides (Barrie & Hannington 1999) suggest that the most prolific periods for the formation of such deposits are the intervals 2750 to 2700 Ma and 1900 to 1800 Ma, and both the Archaean and Palaeoproterozoic occurrences in central West Greenland (c. 2800 and c. 1950 Ma, respectively) are outside these age ranges. The supracrustal belts in central West Greenland are much smaller than greenstone belts hosting major massive sulphide deposits (e.g. Abitibi) and the successions are thinner. Finally, the metamorphic grade in most parts of the assessed region is amphibolite facies or higher, in contrast to the greenschist facies conditions prevailing in most rock complexes hosting major volcanic-associated base metal sulphide deposit. Overall, the supracrustal belts in central West Greenland appear less favourable environments for the formation of economically viable massive sulphide deposits.

However, the potential for finding small high grade gold deposits in the volcanic arc-related rocks still persist. The recent finding of two new occurrences of Archaean supracrustal rocks of possible volcanic arc setting in the Aasiaat area (Piazolo & Knudsen 2004), framed in Fig. 4, provides new opportunities for exploration.

Areas north of the central core zone of the Nagssugtoqidian orogen, northern Aasiaat and Ilulissat areas have not been severely affected by metamorphism and are preserved at an upper crustal level. The environment is favourable for vein-type mineralisation (gold, copper) caused by hydrothermal circulation in shear and fault zones.

South of the Nagssugtoqidian orogen, the penetration of a thick lithosphere by a kimberlitic dyke swarm has created favourable conditions for diamond deposits (Larsen & Rønsbo 1993). The absence of kimberlite pipes and the old age (*c.* 600 Ma) and deep erosion level of the dykes seems to reduce the potential for economic deposits. On the other hand, the documented occurrence of diamonds hosted by several dykes, and the abundance of kimberlite indicator minerals recorded in surface as well as in dyke samples increases the prospectivity of the kimberlite swarm.

Results of the ranking of economic significance

According to the ranking of the economic significance of the 160 known mineral occurrences, two are believed to have a potential for becoming economically feasible, although they are presently regarded as uneconomic:

- The pyrochlore mineralisation in the Sarfartoq carbonatite complex (niobium-tantalum) in the Kangerlussuaq area (#115).

- The graphite occurrence at Eqalussuit (#99). Graphite is the only commodity within the region that has been exploited for a short period, and the quality and concentration of graphite is still interesting.

Nine mineral occurrences are ranked as having a moderate to small potential for becoming economically feasible:

- Gold occurrences in the Ilulissat area (type localities #3,9,24 and 26).

- The Archaean banded iron-formation (iron) occurrence in the Ilulissat area (#159).

- Occurrences of base metal mineralisation in volcanic-associated sulphides in the Ilulissat area (type localities #7 and 15).

- The Qaqortorssuaq anorthosite complex (aluminium) in the Kangerlussuaq area (#119).

- Apatite in the Sarfartoq carbonatite complex (phosphorus), Kangerlussuaq area (#116).

Among the 149 remaining mineral occurrences that are regarded as mineral showings with no economic feasibility or as small concentrations of ore minerals, the nineteen diamond bearing kimberlites in the Kangerlussuaq area should be given special attention. Only micro- and a few macrodiamonds have been recovered, so far. Hence on their own, these occurrences are not economically feasible, but positive results of current and future exploration may increase the economic significance considerably.

Summary descriptions of significant mineral occurrences

This section contains summary information on mineral occurrences ranked 1 and 2 in economic significance and sorted by commodity. More detailed information and references to literature and exploration reports by commercial companies may be found in the individual mineral occurrence descriptions of the appendix.

Gold

The most prospective gold occurrences are all hosted in Archaean rocks. Two are stratabound and were probably formed during deposition of the host sediments and lavas, but the remaining were emplaced later in crosscutting veins, alteration zones, breccias and shear zones. Brief descriptions of the occurrences are given here together with locality id. nos. (#).

Saqqaq (#1-4). The supracrustals comprise felsic metasedimentary rocks with subordinate mafic and ultramafic metavolcanic units. The sequence may represent deposition in a continental rift or at an active continental margin. The age is not known, but believed to be Archaean. Gold occurs in a 1 to 2 m thick garnet-quartz horizon situated at the boundary between ultramafic lavas and mica schist. The horizon has been interpreted as a syngenetic exhalative chert (Garde *et al.* 1999), or alternatively a silicified shear zone (NunaMinerals 2000). The auriferous metachert layer contains a few percent of disseminated sulphides. Gold values are in the range of 1–16 ppm over 1–2 m and the auriferous bed can be followed for at least 4 km. In addition to gold, the mineralised layer also has high concentrations of As (average 404 ppm), Ni (average 652 ppm) and Cr (average 1403 ppm).

Eqi (#22, 24, 26). The metamorphosed mafic and felsic volcanic rocks are considered part of a 2.8 Ga old volcanic island arc. Three types of gold mineralisation are found (Stendal *et al.* 1999). Syngenetic gold occurs in up to 20 cm thick lenses of semi-massive pyrite situated in a 50–200 m wide zone between rhyolitic lava and sericite-rich sediment. Composite grab samples of massive pyrite have yielded up to 0.2% Cu and 1 ppm Au. Hydrothermal activity associated with the volcanism at Eqi resulted in pervasive carbonate alteration along N–S trending zones. The carbonatised rocks consist of ankerite, chlorite, green fuchsitic mica and disseminated pyrite. Chip samples of carbonate alteration have given up to 2.3 ppm Au over 2.5 m, while grab samples of quartz-veined rocks have yielded between 5 ppb (microgram per ton) and 60 ppm Au. The third kind of gold mineralisation is hosted by a 10 m wide and 100 m long breccia zone is clearly epigenetic and is Palaeoproterozoic in age. The breccia is situated immediately west of a major N–S trending thrust separating the greenschist facies volcanic rocks to the east from amphibolite facies sedimentary rocks to the west. The breccia includes pyrrhotite, pyrite and chalcopyrite and minor amounts of sphalerite and arsenopyrite. The main zone yielded up to 1.7 ppm Au over 1 m, and the best section of 12 short drill holes assayed 1.3% Cu and 12 ppm Au over 3.2 m.

The setting, lithologies and types of hydrothermal alteration and mineralisation in the Eqi-Arveprinsen supracrustal belt are reminiscent of gold producing greenstone belts elsewhere, e.g. the Dome Mine, Timmins area (Moritz & Crocket 1991; Hodgson 1993) in the Canadian Abitibi belt. However, the much smaller size of the greenstone occurrences in the Ilulissat area limits the potential for large gold deposits. The potential remains, however, for small high-grade occurrences.

Itilliarsuk (#9). The metasediment-dominated supracrustal sequence along the south coast of Nuussuaq hosts large, rusty-weathering iron-formations in the form of both magnetite-rich bands and semi-massive sulphide. Mica schist with disseminated pyrrhotite and pyrite attains a thickness of about 150 m. NunaMinerals (2000) have identified several sites with epigenetic gold mineralisation in sulphide-rich schists, quartz veins, and shear zones. The best target is a shear zone that hosts a quartz-sericite rock yielding 9 ppm of Au over 1.7 m. The mineralised structure can be traced 500 m along strike. The *Itilliarsuk* gold occurrences are hosted by iron-formations of both oxide and sulphide facies, a setting that has certain similarities with the Homestake and Lupin deposits (see Kerswill 1996).

Attu (#70). This gold occurrence is the only place outside the Ataa area where gold concentrations above 1 ppm have so far been recorded (Stendal *et al.* 2002). The recently discovered occurrence has been ranked 3, because limited investigations have been carried out. However, the mineralisation provides evidence that gold has been available in this part of the region, and that it has been mobilised and deposited in connection with shearing. Therefore, it opens up a new field for exploration. Samples of silicified mylonite assayed 2 to 8 ppm Au. The samples are derived from a prominent mylonite zone through granulite facies orthogneiss that contains pegmatite veining, silicification, magnetite and sulphide mineralisation. The zone is 100–330 m wide, strikes 75° and dips 60–70º W, and has a strike length of several kilometres.

Speciality metals

The Sarfartoq carbonatite complex (Secher 1986) is ellipsoidal at the surface and covers about 90 km^2, of which 10 km^2 are intrusive carbonatites (Secher & Larsen 1980). The carbonatite complex lies within a province of carbonatitic and kimberlitic dykes in the southern part of the survey area that continues southwards to 65° N (Larsen & Rex 1992). The mineral resources have been estimated at 1000 mill. t with 3.5% P_2O_5 and a minimum of 100 000 t with 15% Nb_2O_5 and 0.18% Ta_2O_5, and an additional potential for rare earth elements (REE) is outlined.

The core of the complex comprises two compositional phases. The outer, early-crystallised core is Mg-rich (rauhaugite) with a CaO/MgO ratio of 1.8-2.8, whereas the inner core is sövitic in composition with CaO/MgO ratio from 2.8 to 8.2. Apatite is enriched in the rauhaugite zone and its content decreases inwards.

The pyrochlore mineralisation is associated with a hydrothermal phase terminating the magmatic evolution. Several stages of pyrochlore deposition have taken place in veins and shear zones within a fenitised zone surrounding the complex. The type of pyrochlore occurrence is unique with no known counterpart worldwide. Whereas the carbonatite complex has a geochemical, spatial and chronological evolution similar to other carbonatite complexes, the conditions for pyrochlore deposition must have been unusually favourable to render the extremely rich mineralisation.

Enrichment of REE in veins and shear zones within the fenite is also associated with the late magmatic to hydrothermal phase. The REE veins are high in intermediate REE, Eu in particular, relative to light REE (La-Sm). Similar veins associated with carbonatites in the United States and elsewhere have the same characteristics.

Diamonds

The alkaline province has been the target for location of kimberlitic rocks based on numerous reports of diamond-favourable indicator minerals from till sampling, finds of kimberlitic dykes, and recovery of both micro and macro diamonds from kimberlitic rocks. The alkaline rocks were indeed intruded along the Archaean border zone during continental rifting following the opening of the Iapetus sea at the dawn of the Cambrian (Larsen & Rex 1992). The approximately 600 diamonds recorded to date in Greenland are from just two locations, both located in the unreworked Archaean craton. All in situ diamond occurrences fall within areas outlined by the diamond-favourable indicator minerals from till and stream sediment samples.

Industrial minerals

Graphite is abundant in sulphide-rich supracrustal rocks of the Nordre Strømfjord supracrustal belts and is particularly enriched in the coastal parts of the belts, where they are hosted by pelitic metasediments (#99). The largest resource has been calculated to contain 5.3 million t of flake graphite ore having an average content of 9.5% carbon (Pedersen 1992). The graphite is considered to represent metamorphosed bituminous and sulphide rich strata deposited in a volcanic arc or back-arc environment associated with Nagssugtoqidian subduction.

Iron

The banded iron-formation at Itilliarsuk (#159) is approximately 200 m thick and consists of alternating bands of magnetite-chert and quartz-mica schist. The resource is estimated to contain 150–200 000 million t of ore grading 20% iron (Gothenborg & Morthorst 1981).

Base metals

Many occurrences have been recorded of disseminated to semi-massive to massive sulphides hosted in supracrustal sequences comprising rocks of both volcanic and sedimentary origin. In this report, they are referred to the occurrence type volcanic-associated massive sulphides. Most of such occurrences are of limited extent and are not enriched in base metals. However, two occurrences within the Archaean supracrustal belts in the Ataa area have attracted an interest from commercial exploration companies, and they have been subject to extensive sampling and drilling.

The occurrence at Itilliarsuk (#7) has a very conspicuous gossan developed on top of an about 150 m thick sequence of mica schist with disseminated pyrrhotite and pyrite. Minor lenses of massive to semi-massive sulphides occur centrally in the sequence as documented by drill-core intersections with up to 30 % combined pyrrhotite and pyrite. Analyses of material recovered during a percussion drilling campaign in the late 1990s have returned maximum values of 500 ppm Cu, 1000 ppm Pb and 600 ppm Zn (Gothenborg & Morthorst 1981).

Two lenses of massive sulphide, up to 0.5 m wide and two to three metres long in outcrop, at Arveprinsen Ejland (#15) represent the most massive of several occurrences of semi-massive sulphide within the Arveprinsen-Eqi supracrustal belt (Stendal & Schønwandt 2003). The lenses are hosted by an isoclinally folded thin raft of metasediments enclosed by metagabbro of a sill complex. Assays of chip samples from the lens in the upper limb have given 3.7% Cu, 0.6% Pb, 1% Zn and 0.6 ppm Au over 1.5 m, and samples from the lower limb 0.7% Cu, 0.2% Pb, 3.1% Zn and 0.08 ppm Au over 1.5 m.

None of the occurrences in the Aasiaat and Nassuttooq have been ranked more than 3, but it should be mentioned that the occurrences at Naternaq (# 52–62 + 158) and Ataneq (# 71–75), have received some attention because of their size. High assay values for Cu (2.7%) and Zn (3.75%) at Naternaq were obtained in the 1960s, but they have never been reproduced. Later assays by another company and by GEUS do not exceed 0.15% Cu and 0.3% Zn. Concentration data for the Ataneq occurrences acquired by GEUS (Madsen 2003) are equally low.

Main mineralisation events

Available geochronological data permit an outline of some main events of mineralisation within the assessment region, but large uncertainties still exist concerning the chronology of many epigenetic types of mineralisation. Also, there is conflicting evidence regarding the age of the Naternaq and Nordre Isortoq supracrustal belts, which may indicate that the belts contain both Archaean and Palaeoproterozoic components.

The major crust-forming event in the region takes place around 2800 Ma with the accretion of tonalitic to granodioritic magmatic complexes together with supracrustal rocks generated in subduction-related volcanic arc systems. This event was also responsible for the formation of the most important mineral occurrences known in the region, the massive sulphides, banded iron-formations and gold occurrences, all of volcanogenic origin.

Crustal heating resulting in widespread granite veining and migmatisation around 2750–2700 Ma may have generated hydrothermal circulation and vein-type mineralisation, although no specific mineral occurrence have been related to this event.

The Nagssugtoqidian orogeny starting some 700 million years later involved the formation of widespread volcanic-associated massive to semi-massive sulphides and associated graphite during the subduction stage 1930–1870 Ma. In the same period, deformation was initiated in the Rinkian fold belt in the northern continent. Pb-isotope data suggest that sulphides deposited in fault and shear zones hosted in Palaeoproterozoic supracrustal rocks in the Ataa area have an age of *c.* 1900 Ma, and that shear zone hosted gold bearing sulphides within Archaean sulphide lenses have the same age. (Stendal 1998) suggests that many epigenetic gold and copper occurrences within the Ataa area were formed at this time. However, it has not been resolved if the hydrothermal activity in the low-metamorphic sediments is related to the continental movements. Another possibility is that prominent dolerite dykes and sills that intruded into the Palaeoproterozoic continental sediments could have driven the hydrothermal fluid circulation.

The period of Nagssugtoqidian continent collision, 1860–1840 Ma, is not associated with any known mineralisation. However, crustal heating following the collision created at least two generations of pegmatites in the period 1820 to 1760 Ma, many of which are enriched in allanite and monazite, and a few have copper and gold bearing minerals. Monazite bearring pegmatites have been dated at *c.* 1800 Ma (R. Frei, pers. comm. 2004). The pegmatites are confined to the Aasiaat and northern Nassuttooq area. Lamproites and ultramafic lamprophyres intruded the basement in the Ilulissat area at *c.* 1750 Ma, but no mineralisation has been referred to this age.

A pervasive albitisation has taken place in the Ilulissat area, where it affected Palaeoproterozoic sediments of the Anap nunâ Group and a few sites within the Archaean basement. The timing of this event is somewhat uncertain, but according to Rb-Sr isotope data from albitised siltstones, Kalsbeek estimated that the albitisation occurred hundreds of million years after the deposition of the sediments, possibly in the interval 1700–1600 Ma. The albitisation can not be tied to any other known metamorphic or tectonic event. Although very limited mineralisation involving economically interesting metals is known to be associated with the albitisation, such kind of hydrothermal alteration is potentially important for gold mineralisation (Ettner *et al.* 1993).

Brittle deformation in shear zones within the Nassuttooq area, like the gold mineralised one at Attu, must have developed contemporaneous with or after the uplift of the Nagssugtoqidian core zone, which terminated at around 1670 Ma (rutile closing temperature and K-Ar data, Willigers 1999; Connelly *et al.* 2000).

The formation of carbonatite-related Nb-Ta mineralisation and diamondiferous kimberlites took place around 600 Ma. The intrusion of the alkaline rocks has been related to rifting associated with the opening of the Iapetus Ocean (Larsen *et al.* 1983; Larsen & Rex 1992).

Conclusion

The mineral resource potential of central West Greenland has been evaluated based on the abundance, spatial distribution, size, grade, age and genesis of the 160 known mineral occurrences. It is concluded that the following types of mineral occurrences have a potential for becoming economically feasible:

- Syn- and epigenetic gold in Archaean supracrustal rocks in the northeastern Disko Bugt.
- Graphite within supracrustal rocks in the Nassuttooq–Sisimiut region.
- Speciality metals in the Sarfartoq carbonatite complex.
- Diamonds in kimberlitic rocks in the Kangerlussuaq area.

Both Archaean and Palaeoproterozoic volcanic-associated massive sulphide occurrences are abundant in the region. However, none of the presently known occurrences is of economic interest.

Acknowledgements

This report contains contributions from several researchers from the GEUS departments of Economic Geology and Geological Mapping, all of whom are acknowledged for their work. Technical staff at GEUS and external contractors are acknowledged for their valuable contribution during the field work in 2001 and 2002. Else Moberg and Mette Svane Jørgensen, both GEUS, are thanked for assistance in preparing some of the figures. Village people in Greenland are thanked for their hospitality and interest in our work. A special thank goes to Karl Markussen, Attu, for showing us the new gold location south of Attu.

The report is a contribution to the second performance contract (2000–2003) between the Geological Survey of Denmark and Greenland (GEUS) and the Ministry of the Environment.

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Appendix – Mineral occurrence

Contents of appendix:

Maps with location of mineral occurrences

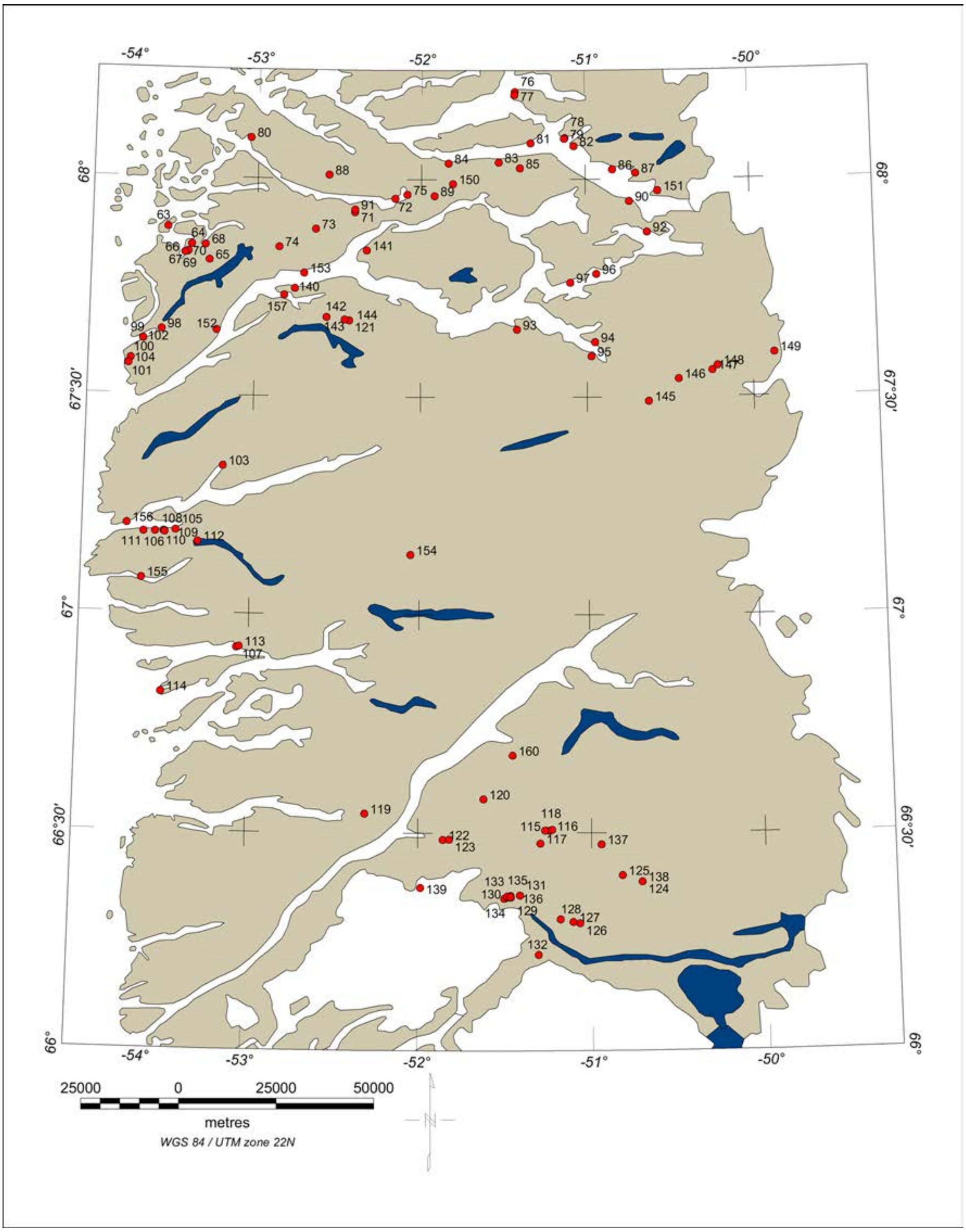

Figure 9. *Location of mineral occurrences in the region from 66°N to 68°15'N. Numbers refer to the unique id. nos. of the mineral occurrences.*

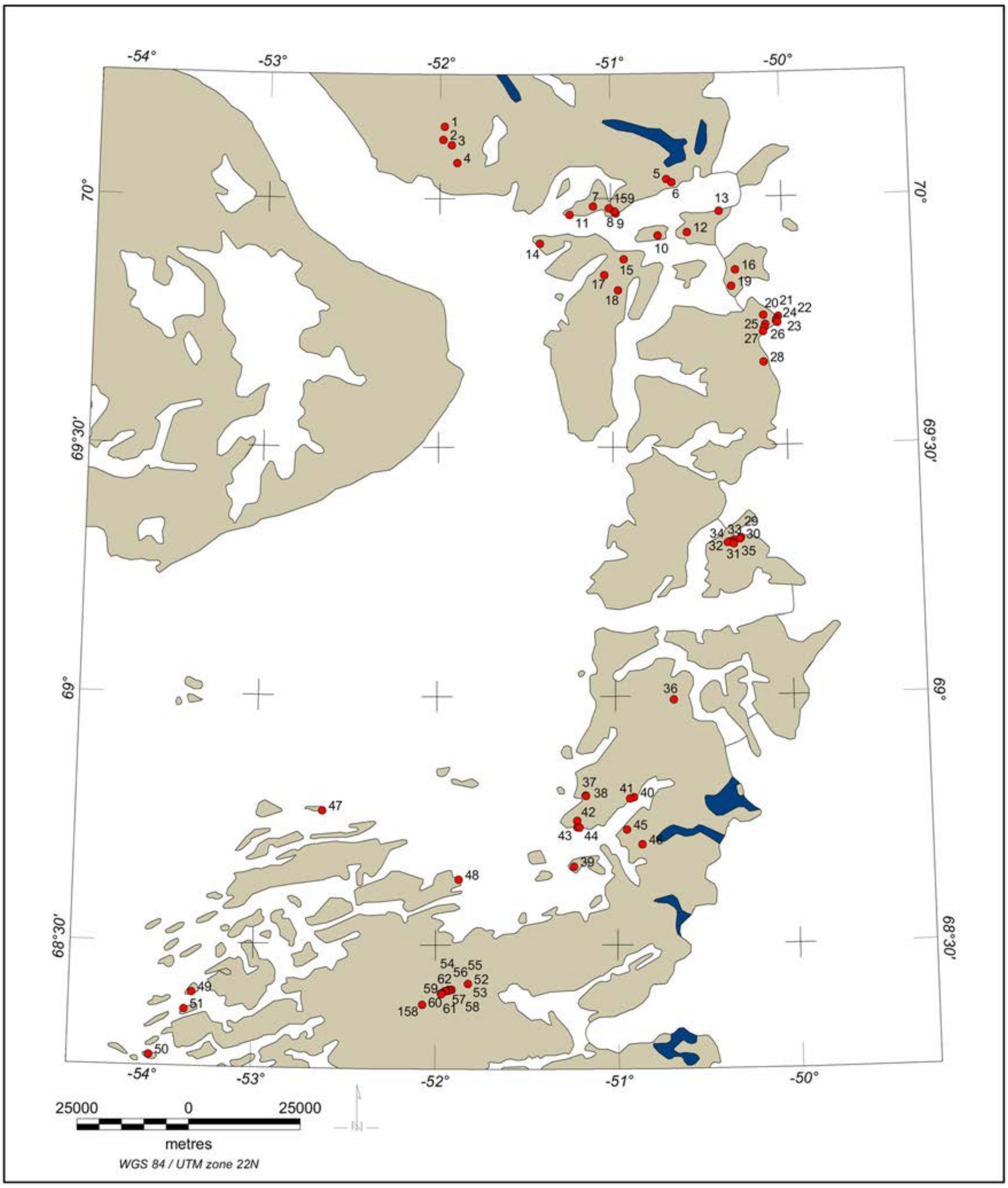

Figure 10. *Location of mineral occurrences in the region from 68°15'N to 70°15'N. Numbers refer to the unique id. nos. of the mineral occurrences.*

Overview-table of mineral occurrences

Type id. no	Associated id. no	Loc. name	Economic significance	Commodity group	Main commodity	Sub commodity	GSC deposit type
3	1, 2, 3, 4	Saqqaq	**2**	Precious metals	Gold	Nickel and copper	Iron-formation-hosted stratabound gold
5	5, 6	Itilli	3	Precious metals	Copper	Gold, cobalt	Vein Cu and hydrothermal alteration
7	7, 8	Itilliarsuk 1	**2**	Base metals	Copper, lead and zinc	Gold	Volcanic-associated massive sulphide gold
9	9	Itilliarsuk 2	**2**	Precious metals	Gold		Iron-formation-hosted stratabound gold
10	10	Qeqertakassak	4	Base metals	Copper	Cobalt and gold	Vein Cu and hydrothermal alteration
11	11	Naajaat Qaqqaat	4	Iron and iron alloys	Iron		Algoma-type iron-formation
12	12	Anap Nunaa 1	3	Base metals	Copper	Gold	Vein Cu and hydrothermal alteration
13	13	Anap Nunaa 2	3	Base metals	Copper		Vein Cu and hydrothermal alteration
14	14	Oqaatsut	4	Iron and iron alloys	Iron		Algoma-type iron-formation
15	15	Anderson showing	**2**	Base metals	Copper and zinc	Gold	Volcanic-associated massive sulphide base metals
16	16	Qapiarfiit	3	Base metals	Copper	Cobalt and gold	Vein Cu and hydrothermal alteration
17	17,18	Amazone prospect	3	Base metals	Copper and lead		Volcanic-associated massive sulphide base metals
19	19	Qingaarssuaq	4	Iron and iron alloys	Iron		Algoma-type iron-formation
22	21, 22	Eqi 1	3	Precious metals	Gold	Copper	Volcanic-associated massive sulphide gold
24	23, 24	Eqi 2	**2**	Precious metals	Gold		Quartz-carbonate vein gold
26	20, 25, 26, 27	Eqi West	**2**	Precious metals	Gold	Copper and bismuth	Vein Cu and hydrothermal alteration
28	28	Manittsoq	3	Base metals	Zinc and lead		Volcanic-associated massive sulphide base metals
33	29, 30, 31, 32, 33, 34, 35	Nunatarsuaq	4	Base metals	Copper and zinc		Algoma-type iron-formation
36	36	Tasiussuaq	4	Base metals	Copper		Vein Cu and hydrothermal alteration
37	37	Paradisbugt 1	4	Base metals	Copper		Vein Cu and hydrothermal alteration
38	38	Paradisbugt 2	4	Base metals	Copper	Iron	Skarn
39	39	Akulliq	4	Industrial minerals	Soapstone		Skarn
45	40, 41, 42, 43, 44, 45	Kangersuneq 1	4	Base metals	Copper and zinc		Algoma-type iron-formation
46	46	Kangersuneq 2	4	Base metals	Copper		Vein Cu and hydrothermal alteration
47	47	Aassiaat	4	Base metals	Copper and zinc		Algoma-type iron-formation
48	48	Ikamiut	4	Base metals	Copper and zinc		Algoma-type iron-formation
50	49, 50	Kangaatsiaq 1	4	Base metals	Copper and zinc		Algoma-type iron-formation
51	51	Kangaatsiaq 2	4	Precious metals	Gold	Copper and cobalt	Granitic pegmatites

Type id. no	Associated id. no	Name	Economic significance	Commodity group	Main commodity	Sub commodity	GSC deposit type
58	52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62 158	Naternaq	3	Base metals	Copper and zinc	Gold	Volcanic-associated massive sulphide base metals
63	63	Attu 1	4	Speciality metals	Rare Earth Elements	Thorium	Granitic pegmatites
64	64, 65	Attu 2	4	Base metals	Copper		Vein Cu and hydro-thermal alteration
70	66, 67, 68, 69, 70	Attu 3	3	Precious metals	Gold	Copper	Vein Cu and hydro-thermal alteration
71	71, 72, 73, 74, 75	Ataneq	3	Base metals	Copper and zinc		Volcanic-associated massive sulphide base metals
84	76, 78, 79, 80, 81, 82, 83, 84, 85, 87, 88, 89, 90, 91	Arfersiorfik 1	3	Base metals	Copper and zinc		Volcanic-associated massive sulphide base metals
86	77, 86	Arfersiorfik 2	4	Base metals	Copper		Vein Cu and hydro-thermal alteration
93	93	Kuup Akua	3	Light metals	Magnesium		Mafic/ultramafic
94	92, 94, 95	Ussuit 1	4	Base metals	Copper		Vein Cu and hydro-thermal alteration
96	96, 97	Ussuit 2	4	Industrial minerals	Diopside		Skarn
99	98, 99	Eqalussuit	**1**	Industrial minerals	Graphite		Volcanic-associated massive sulphide base metals
101	100, 101	Inussuk	4	Base metals	Copper and zinc		Volcanic-associated massive sulphide base metals
106	102, 103, 104, 105, 106, 107	Isortuarsuk	3	Industrial minerals	Garnet sand		Placer
108	108, 109, 110, 111	Nordre Isortoq	4	Base metals	Copper		Algoma-type iron-formation
113	112, 113, 114	Utoqqaat	3	Industrial minerals	Graphite		Volcanic-associated massive sulphide base metals
115	115	Sarfartoq	**1**	Speciality metals	Niobium	Tantalum, Uranium	Carbonatite associ-ated occurrence
116	116	Sarfartoq	**2**	Industrial minerals	Phosphorous		Carbonatite associ-ated occurrence
117	117	Sarfartoq	3	Speciality metals	Rare Earth Elements		Carbonatite associ-ated occurrence
119	119	Qaqortorssuaq	**2**	Light metals	Aluminium	Feldspar	Gabbro-anorthosite-hosted iron-titanium
120	120	Kangâmiut dykes	4	Base metals	Copper		Magmatic nickel-copper-platinum group elements
136	118, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139	Kangerlussuaq	3	Gemstones	Diamond		Diamond
140	140	Nassuttooq 1	4	Gemstones	Cordierite		Granitic pegmatites

Type id. no	Associated id. no	Name	Economical significance	Commodity group	Main commodity	Sub commodity	GSC deposit type
144	121, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157	Nassuttooq 2	3	Speciality metals	Rare Earth Elements		Granitic pegmatites
159	159	Itilliarsuk	**2**	Iron and iron alloys	Iron		Algoma-type iron-formation
160	160	Kakilisattoq	3	Base metals	Copper	Nickel, platinum and palladium	Nickel-copper sulphide

Table 3. *Overview of the mineral occurrences described in the Appendix. For the convenience of the reader, the column-headings are given in the top of the table at each new page covered by the table.*

Saqqaq (gold) Type id. no. 3

Type locality id. no.: 3

Type locality for id. nos.: 1, 2, 3, 4

Locality name: Saqqaq

Area: Nuussuaq

Genetic relation: Gold in exhalites in volcanic rocks

GSC deposit type: 15.3 – Iron-formation-hosted stratabound gold

Commodity group: Precious metals

Commodities (minor): Gold (nickel, copper)

Economic significance: 2

Geological characteristics:

Description of occurrence: An auriferous metachert horizon occurs between a mafic/ultramafic metavolcanic sequence and overlying metasedimentary rocks (Garde *et al.* 1999; Thomassen & Tukiainen 1992).The Saqqaq supracrustal rocks occur in a NW-SE striking belt (5 x 29 km), which is enclosed in the Archaean Nuussuaq gneisses. The exposed thickness of the supracrustal rocks is approximately 0.5 km.

Geotectonic setting: The geotectonic setting of the Archaean supracrustal rocks of the area represents a possibly continental margin or back environment.

Depositional environment/Geological setting: The structural lower part of the sequence comprises 150 m of a mafic to ultramafic unit, which in the uppermost part includes a 3–4 m thick auriferous sulphide-bearing cherty quartzite. This unit is followed by c. 100-m thick mica-garnet schist, which is overlain by several hundred metres succession of interlayered amphibolite and metasediments. A granitoid sill (100 m) has intruded the upper part of the supracrustal rocks. The boundary relationships to the surrounding orthogneisses are not known nor is the direction of younging.

Age of mineralisation: The syngenetic mineralisation is Archaean.

Host/Associated rock types: Mafic- to ultramafic rocks.

Deposit form: The gold mineralisation is the stratiform type of exhalative origin as interpreted by Thomassen and Tukianinen (1992) and Garde *et al.* (1999). However, NunaMinerals A/S is of the opinion that the gold is related to shear zones. NunaMinerals (2000) described the auriferous metachert horizon as the low angle ‘Saqqaq shear zone’.

Texture/Structure: Disseminated fine-grained sulphides. Grains of native gold up to 20 µm occur both as inclusions in arsenopyrite and as single isolated grains (Garde *et al.* 1999).

Ore mineralogy (principal and *subordinate*): The auriferous metachert layer contains a few percent of disseminated iron sulphides with accessory amounts of arsenopyrite and chalcopyrite.

Gangue mineralogy (principal and *subordinate*): Quartz.

Alteration: Chloritization.

Weathering:

Ore controls: Syngenetic mineralisation associated with mafic/ultramafic rocks.

Genetic models: The deposit is formed by exhalation with gold associated to the sulphide minerals.

Analytical data:

Gold values in the range of 1 ppm over 2m can be followed for 4 km, but may be traced for a substantially longer distance (Nunaminerals 2000). Within the continuously mineralised zone, at least three potential gold zones were identified yielding 8.2 ppm over 2 m, 15.9 ppm over 1 m, and 12.2 ppm over 2 m respectively (Nunaminerals 2000). The auriferous metachert layer is also anomalous in As (average 404 ppm), Ni (average 652 ppm) and Cr (average 1403 ppm). Other sulphide-bearing horizons within the mafic/ultramafic unit have proven to be slightly enriched in copper (Thomassen & Tukiainen 1992).

Exploration:

The Saqqaq supracrustal rocks were investigated by GGU during the Disko Bugt Project 1988–1992 (Thomassen & Tukiainen 1992). In 1992 Platinova A/S investigated the supracrustal belt (Atkinson & Rutherford 1992). During the late 90s Nunaoil A/S and Nuna Minerals A/S did exploration and drilling on the deposit (Bliss 1997; Heilmann 1998; Heilmann 1999; Heilmann 2001; Petersen 1997).

Photos, figures and maps:

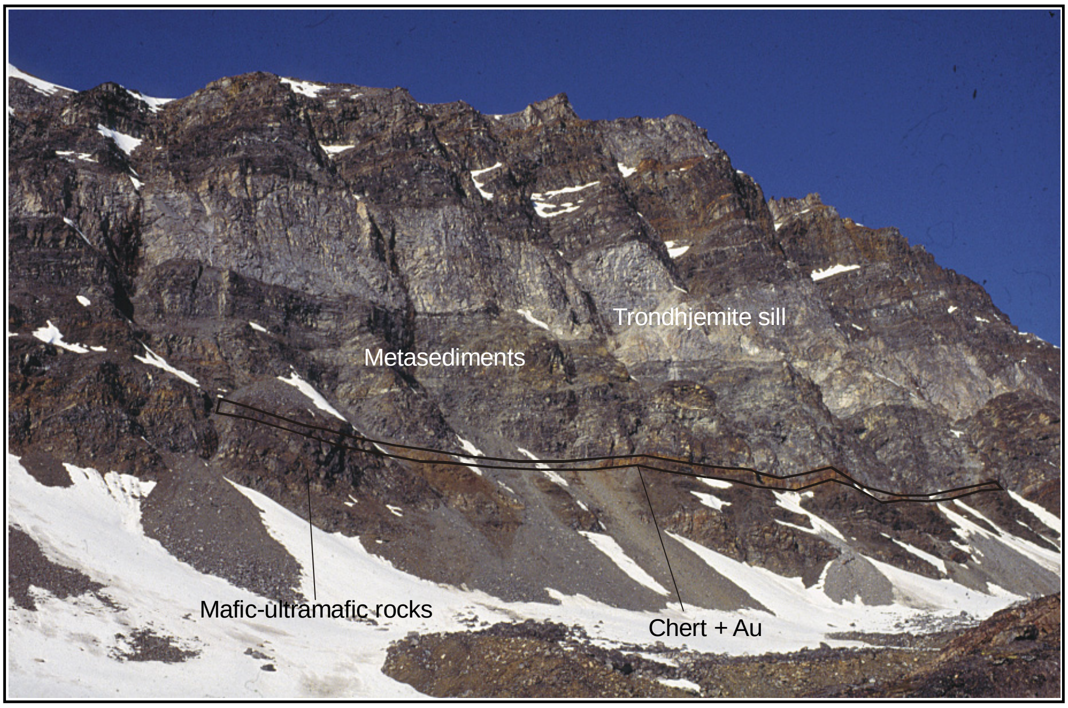

Figure 11. *A section of the Saqqaq supracrustal rocks with rusty metachert.*

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Garde, A.A., Thomassen, B., Tukiainen, T. & Steenfelt, A. 1999: A gold-bearing volcanic-exhalative horizon in the Archaean(?) Saqqaq supracrustal rocks, Nuussuaq, West Greenland. Geology of Greenland Survey Bulletin **181**, 119–128.

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Thomassen, B. & Tukiainen, T. 1992: Gold mineralisation in Precambrian supracrustal rocks of southern Nuussuaq, central West Greenland: 1991 results. Open File Series Grønlands geologiske Undesøgelse **92/3**, 31 pp.

Compiler and date (dd-mm-yyyy):

HST 03-12-2003

Itilli (copper) Type id. no. 5

Type locality id. no.: 5

Type locality for id. nos.: 5, 6

Locality name: Itilli

Area: Nuussuaq

Genetic relation: Gold in veins and shears

GSC deposit type: 17.0 – Vein copper and hydrothermal alteration

Commodity group: Precious metals

Commodities (minor): Copper (gold, cobalt)

Economic significance: 3

Geological characteristics:

Description of occurrence: Syn- and epigenetic sulphide mineralisation, low-grade copper-gold- (cobalt) occurs widespread in the southern part of an amphibolite unit. The syngenetic mineralisation is mainly found in the northern part of the area as semi-massive to massive lenses up to 2 m wide and 10 m long. The sulphide lenses are hosted in various rocks such as amphibolites, schists and paragneisses. Disseminated sulphides hosted in amphibolites occur in close relation to minor shear zones about one metre. Locally these shear zones host quartz lenses (5–10 cm wide and 1 m long) parallel to the fabric of the shear zone and often surrounded by a halo of hydrothermal alteration.

Geotectonic setting: The geotectonic setting of the Archaean amphibolite rocks is suggested to be a part of an earlier arc system than the Eqi–Arveprinsen Ejland supracrustal rocks to the south.

Depositional environment/Geological setting: Epigenetic mineralisation is widespread in the area in shear-fault zones. The occurrences are small with pyrite and copper as the main constituents, but locally also As, Ni, Co and Au are found. This type of widespread epigenetic copper mineralisation occurs in the southern part of Itilli in an amphibolite unit.

Age of mineralisation: It is not possible to see whether these shear- and breccia-zones are of Archaean or Palaeoproterozoic in age.

Host/Associated rock types: The supracrustal rocks at Itilli comprise of an ultramafic unit up to 200 m thick and towards NE a unit dominated by biotite-garnet schist with subordinate amphibolite. The latter unit is at least 350 m thick. The relative stratigraphic position of these units is uncertain but it is suggested that the northeastern unit forms the lower part of the supracrustal succession and the southwestern amphibolite unit the upper part. The amphibolite unit consists of massive to fine-grained amphibolites interlayered with biotite-garnet and quartz-mica schists. The amphibolite unit is intruded by a quartz-diorite (3030 Ma, K. Thrane, GEUS, pers. com). In the northern part these rocks form an amphibolite-diorite agmatite.

Deposit form: Quartz veins and shears in amphibolite.

Texture/Structure: Some of the massive sulphide lenses have a texture indicating that they have been recrystallized. Veinlets and disseminated sulphides including chalcopyrite occur both in the quartz lenses and the sheared amphibolite (Stendal and Schønwandt 2003).

Ore mineralogy (principal and *subordinate*): Pyrite, pyrrhotite and chalcopyrite.

Gangue mineralogy (principal and *subordinate*): Quartz.

Alteration: Silicification.

Weathering: Malachite staining is common.

Ore controls: Epigenetic mineralisation in quartz veins and shear zones.

Genetic models: The deposit is part of a volcanic-associated massive sulphide system with gold associated to the sulphide minerals especially in shear zones and quartz veins where the sulphide minerals are recrystallized.

Analytical data:
Generally the sulphide lenses are low in precious and base metals but single grab samples assayed up to 0.6% Cu and 840 ppm Ni (Blackwell 1989). The mineralised area covers 300x400 m. This area is drill tested by the Kryolitselskabet Øresund A/S in 1982 with 20 short holes totalling 933 m. The best intersection returned 0.8% Cu over 3.49 m (Gothenborg & Morthorst 1982).

Exploration:
The supracrustal rocks at Itilli were investigated by GGU during the Disko Bugt Project 1988–1992. Kryolitselskabet Øresund A/S initiated exploration in the Itilli area (Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982).

Photos, figures and maps:

References:
Gothenborg, J. & Morthorst, J. 1981: Report on the ore exploration in Atâ area, Jakobshavn, 1980, 80 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).

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Stendal, H. & Schønwandt, H.K. 2003: Precambrian supracrustal rocks and mineral occurrences, Northeast Disko Bugt. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2003/24, 57 pp.

Compiler and date (dd-mm-yyyy):

HST 03-12-2003

Itilliarsuk 1 (copper) Type id. no. 7

Type locality id. no.: 7

Type locality for id. nos.: 7, 8

Locality name: Itilliarsuk (1)

Area: Nuussuaq

Genetic relation: Massive sulphides (volcanic-associated massive sul phide)

Commodity group: Base metals

GSC deposit type: 6.4 – Volcanic-associated massive sulphide gold

Commodities (minor): Copper, lead, zinc (gold)

Economic significance: 2

Geological characteristics:

Description of occurrence: Sulphide mineralised layers are found within the thickest succession of supracrustal rocks north of Torsukattak in the Itilliarsuk area. The supracrustal sequence is at least 2.5 km thick. The contact between the supracrustal rocks and the underlying gneisses is strongly tectonised and a basal unconformity has not been located. The sedimentary pile is intruded by gabbroic sills and thin felsic dykes. The lower 400 m of the succession consist of amphibolite with sheared lenses of ultramafic rocks.

Geotectonic setting: The geotectonic setting of the Archaean supracrustal rocks of the area represents an environment with more metasediments intercalated in the volcanic sequences at an active continental margin.

Depositional environment/Geological setting: Sub-marine volcanic environment.

Age of mineralisation: The age is of the mineralisation is uncertain but syngenetic with the Archaean host rocks.

Host/Associated rock types: The host rocks are acid and mafic volcanic rocks. Within and on the top of this succession a polymict conglomerate with felsic and mafic clasts occurs. The felsic clasts resemble the underlying gneisses indicating that the supracrustal succession rest unconformably on the Nuussuaq gneiss. The amphibolite succession is overlain by a more than 2 km thick sequence of siliciclastic rocks dominated by mica-garnet schists. Locally the siliciclastic succession is interlayered with up to 100-m thick amphibolite and metagabbro, and in the middle part very thin BIF horizons occur. Several hundred metres of felsic volcanic rocks conclude the supracrustal succession. Lower amphibolite facies metamorphism and at least two phases of deformation have affected all rocks.

Deposit form: Stratiform beds in sericitic schist and mafic rocks. The sulphide mineralisation at Itilliarsuk has a thickness of about 150 m of mica schist with disseminated pyrrhotite and pyrite. In the middle part of the metalliferous sediments several minor lenses of massive to semi-massive pyrrhotite occur spatially related to thin amphibolite layers.

Texture/Structure: Disseminated to semi-massive pyrrhotite.

Ore mineralogy (principal and *subordinate*): Investigated drill-core samples show the sulphides pyrrhotite (up to 30 vol.%) and minor *pyrite*. One part of the sulphide-rich schist is associated with gold bearing quartz veins with As-Sb sulphosalts.

Gangue mineralogy (principal and *subordinate*): Quartz.

Alteration: Sericitisation and silicification.

Weathering: The sulphide-rich rocks are yellow-orange (rust) weathering sulphide-rich mica schist and dark-grey massive sulphide rock, the latter weathering to a brownish gossan ('Rust zone').

Ore controls: Syngenetic semi-massive ores stratiformly layered in sericite schist.

Genetic models: The deposit is considered to be a volcanic-associated massive sulphide deposit with gold associated sulphide minerals.

Analytical data:

The 'Rust zone' is shown to be lean in both base and precious metals. Analyses of 175 powder samples collected by percussion drill (up to 50 cm deep) yielded maximum values of 500 ppm Cu, 1000 ppm Pb and 600 ppm Zn (Gothenborg & Morthorst 1981). Chip sampling over 5 m of the central part of the 'Rust zone' returned only 7–8 ppb Au. A 25-cm thick quartz vein cutting mica schist yielded up to 300 ppb Au.

Exploration:

Kryolitselskabet Øresund A/S initiated exploration in the Itilliarsuk area (Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). During the late 90s Nunaoil A/S and Nuna Minerals A/S did exploration and drilling on the deposit (Heilmann 1998; Petersen 1997). NunaMinerals A/S has continued some exploration in the area (Nunaminerals 2000).

Photos, figures and maps:

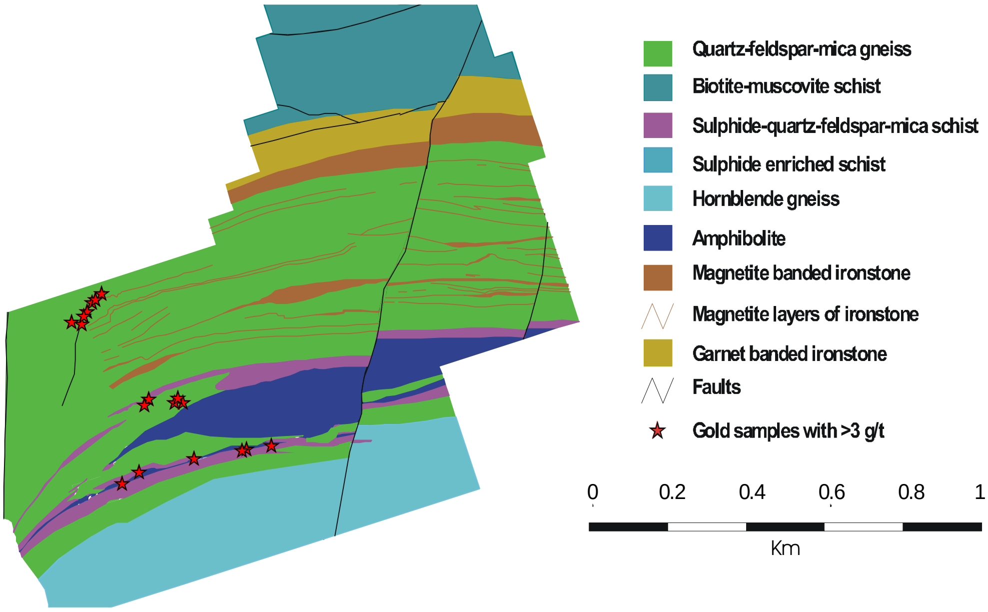

Figure 12. *Geological map of Itilliarsuk - modified from Nunaminerals (2000).*

References:

Gothenborg, J. & Morthorst, J. 1981: Report on the ore exploration in Atâ area, Jakobshavn, 1980, 80 pp, Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).

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HST 03-12-2003

Itilliarsuk 2 (gold) Type id. no. 9

Type locality id. no.: 9

Type locality for id. nos.: 9

Locality name: Itilliarsuk (2)

Area: Nuussuaq

Genetic relation: Gold in shear zones

GSC deposit type: 15.3 – Iron-formation-hosted stratabound gold

Commodity group: Precious metals

Commodities (minor): Gold

Economic significance: 2

Geological characteristics:

Description of occurrence: Gold mineralisation is observed in shear zones within supracrustal rocks. The supracrustal sequence is at least 2.5 km thick. The contact between the supracrustal rocks and the underlying gneisses is strongly tectonised and a basal unconformity has not been identified. The sedimentary pile is intruded by gabbroic sills and thin felsic dykes. The lower 400 m of the succession consist of amphibolite with sheared lenses of ultramafic rocks. New investigations by NunaMinerals (2000) have revealed good gold targets in sulphide-rich schists, quartz veins, and shear zones.

Geotectonic setting: The geotectonic setting of the Archaean supracrustal rocks of the represents an active continental margin.

Depositional environment/Geological setting: The metalliferous mica schist with disseminated pyrrhotite and pyrite make up about 150 m of the sedimentary sequence. In the middle part of sediments several minor lenses of massive to semi-massive pyrrhotite occur spatially related to thin amphibolite layers. The gold targets are in the sulphide-rich schists, quartz veins, and shear zones. The best target is a shear zone that hosts quartz-sericite rock.

Age of mineralisation: The age is of the mineralisation is uncertain but epigenetic in relation to the Archaean host rocks. The age could be from Archaean to Palaeoproterozoic.

Host/Associated rock types: The amphibolite succession is overlain by a more than 2 km thick sequence of siliciclastic rocks dominated by mica-garnet schists. Locally the siliciclastic succession is interlayered with up to 100-m thick amphibolite and metagabbro, and in the middle part very thin BIF horizons occur. Several hundred metres of felsic volcanic rocks conclude the supracrustal succession. Lower amphibolite facies metamorphism and at least two phases of deformation have affected all rocks

Deposit form: Veins in shear zones in sericite schist and mafic rocks.

Texture/Structure: Disseminated.

Ore mineralogy (principal and *subordinate*): The sulphide-rich schist is associated with gold bearing quartz veins with As-Sb sulphosalts.

Gangue mineralogy (principal and *subordinate*): Quartz.

Alteration: Sericitisation and silicification.

Weathering: The sulphide-rich rocks are yellow-orange (rust) weathering sulphide-rich mica schist and dark-grey massive sulphide rock, the latter weathering to a brownish gossan ('Rust zone').

Ore controls: Semi-massive ores stratiform layered in sericite schist.

Genetic models: The deposit is part of a volcanic-associated massive sulphide system with gold associated to the sulphide minerals.

Analytical data:

The shear zone hosted gold yields 9 ppm over 1,7 m and a strike length of 125 m. The mineralised structure can be traced 500 m along strike. Core drilling reaches the mineralisation 80 m down dip and returned 0.82 ppm gold over 3.1 m (Nunaminerals 2000).

Exploration:

Kryolitselskabet Øresund A/S initiated exploration in the Itilliarsuk area (Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). Later exploration was done by Platinova Resources Ltd. and Yellowknife Resources (Blackwell 1989). During the late 90s Nunaoil A/S and Nuna Minerals A/S did exploration and drilling on the deposit (Heilmann 1998; Petersen 1997; NunaMinerals 2000).

Photos, figures and maps:

See map under type locality id. no. 7.

References:

Blackwell, J. 1989: Report of 1988 field season, Disko Bay project, 18 pp. Unpublished internal report. Platinova Resources Ltd. and Yellowknife Resources, Toronto, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20312).

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hagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).
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Compiler and date (dd-mm-yyyy):

HST 03-12-2003

<u>Qeqertakassak (copper)   Type id. no. 10</u>

Type locality id. no.:	10
Type locality for id. nos.:	10
Locality name:	Qeqertakassak
Area:	Disko Bugt
Genetic relation:	Veins and shears
Commodity group:	Base metal
GSC deposit type:	17 – Vein copper and hydrothermal alteration
Commodities (minor):	Copper (cobalt, gold)
Economic significance:	4

<u>Geological characteristics:</u>

Description of occurrence: Disseminations of pyrite in albitite and in veins and shear zones. Albitisation is extensively developed on Qeqertakassak, Anap Nunaa and Qapiarfiit. Some of the quartzo-feldspatic rocks have been partially or completely altered to massive, very fine-grained, pinkish yellow albitites (Kalsbeek 1992; Ryan & Escher 1999).

Geotectonic setting: Palaeoproterozoic basin or shelf settings.

Depositional environment/Geological setting: Palaeoproterozoic deformation and metamorphism dominate most of the region. Open folds overprint flat-lying ductile shears with north- or north-westward movement of the hanging wall (Escher & Pidgeon 1976; Grocott & Davies 1999).

Age of mineralisation: The albitisation post-dates the regional Proterozoic deformation. Locally the albitisation seems to have penetrated laterally from fractures hosting carbonate veins.

Host/Associated rock types: Siliciclastic rocks.

Deposit form: Disseminations.

Texture/Structure: Disseminations of pyrite in albitite and in vein and shears.

Ore mineralogy (principal and *subordinate*): Pyrite, *pyrrhotite, chalcopyrite gersdorffite and cobaltite.*

Gangue mineralogy (principal and *subordinate*): Albite, quartz and *carbonate*.

Alteration: The most pronounced hydrothermal alteration found in is at a regional pervasive albitisation, which has mainly affected the lower part of the Palaeoproterozoic siliciclastic sequence (Kalsbeek 1992). The only sulphide mineral related to the albitisation seems to be accessory disseminated pyrite and a few up to 10 m wide silicified fracture zones cut across the Palaeoproterozoic sediments e.g. Anap Nunaa.

Weathering: No distinct weathering except for malachite staining.

Ore controls: Albite alteration and vein and shear.

Genetic models: Hydrothermal alteration in connection with veining and shearing.

Analytical data:

The fault-zones host quartz-carbonate veins with minor pyrite dissemination yielding up to 510 ppm Cu (Thomsen 1991). Chip sampling of pyrite-bearing rocks yielded up to 220 ppm Co and 18 ppb Au (Thomsen 1991). Kryolitselskabet (Gothenborg 1980; Gothenborg & Morthorst 1981) obtained Cu up to 2.5%, Co up to 0.2%, As up to 0.2% and Au 0.3 ppm.

Exploration:

Kryolitselskabet Øresund A/S has carried out the first exploration Maniitsoq area (Gothenborg 1980; Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). GGU carried out reconnaissance in the area in the late 1980s. Contemporaneously exploration was done by Platinova Resources Ltd. and Yellowknife Resources (Blackwell 1989).

Photos, figures and maps:

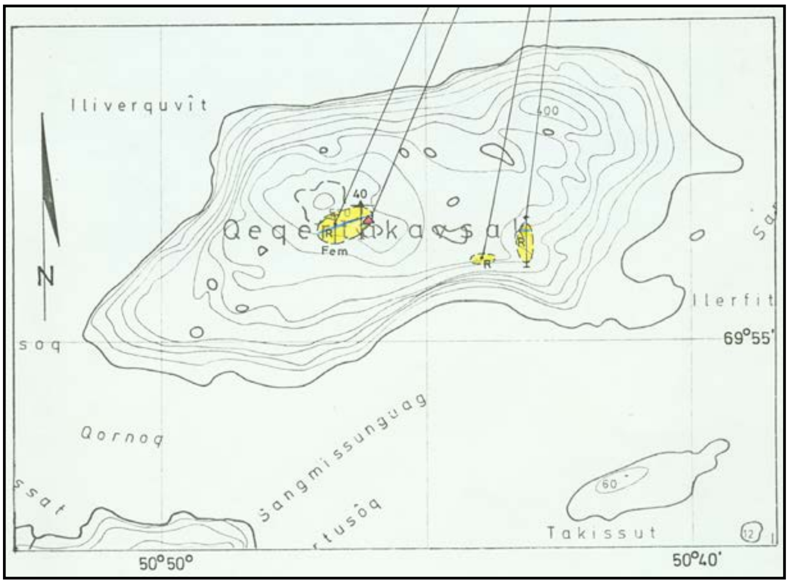

Figure 13. *Geological sketch map. Yellow is quartzite; the red triangle marks quartz veins carrying chalcopyrite. From Gothenborg (1980).*

References:

Blackwell, J. 1989: Report of 1988 field season, Disko Bay project, 18 pp., Platinova Resources Ltd. and Yellowknife Resources, Toronto, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20312).

Escher, J.C. & Pidgeon, R.T. 1976: Field mapping of nunatak 1390 m, east of Alangordlia, southern West Greenland. Rapport Grønlands Geologiske Undersøgelse 80, 84–87.

Gothenborg, J. 1980: Report on the preliminary geological exploration in Christianshåb and Jacobshavn areas. 1978. [KØ/191], 34 pp., 2 plates. Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20210).

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Kalsbeek, F. 1992: Large-scale albitisation of siltstones on Qeqertakavsak Island, Northeast Disko Bugt, West Greenland. Chemical Geology 95, 213–233.

Ryan, M.J. & Escher, J.C. 1999: Albitised gneisses in the area between Paakitsoq and kangerluarsuk, north-east Disko Bugt, West Greenland. Geology of Greenland Survey Bulletin 181, 113–117.

Compiler and date (dd-mm-yyyy):

HST 04-12-2003

Naajaat Qaqqaat (iron) Type id. no. 11

Type locality id. no.: 11

Type locality for id. nos.: 11

Locality name: Naajaat Qaqqaat

Area: Nuussuaq

Genetic relation: Iron-formation

GSC deposit type: 3.2 – Algoma-type iron-formation

Commodity group: Iron and iron alloys

Commodities (minor): Iron

Economic significance: 4

Geological characteristics:

Description of occurrence: Layers of banded iron-formation is located within the supracrustal sequence, which is dominated by staurolite-muscovite- and biotite-rich schists alternating with amphibolitic greenstone units (Rasmussen & Pedersen 1999). Two amphibolites are present, a lower unit up to 100 m thick and an upper unit up to 250 m thick in central Naajaat Qaqqaat. Like the lower greenstone unit, the upper unit is dominated by fine-grained, homogeneous to faintly laminated amphibolites interbedded with thin felsic bands (Rasmussen & Pedersen 1999).

Geotectonic setting: The geotectonic setting of the Archaean supracrustal rocks of the area north of Torsukattak represent a continental margin or basin.

Depositional environment/Geological setting: Three layers of banded iron-formation, each less than one metre thick are located in the lower amphibolitic unit. They are laminated at mm-cm scale, with irregularly alternating layers of quartz and magnetite. Quartz bands comprise about 50% of the banded iron-formation (Rasmussen & Pedersen 1999). The depositional environment is mafic volcanic rocks intercalated with exhalites (chert and iron-formation).

Age of mineralisation: The age is of the mineralisation is uncertain but syngenetic with the Archaean host rocks.

Host/Associated rock types: The host rocks are mafic volcanic rocks.

Deposit form: Stratiform dm-m beds.

Texture/Structure: Cm-banding between magnetite and quartz bearing bands.

Ore mineralogy (principal and *subordinate*): Magnetite.

Gangue mineralogy (principal and *subordinate*): Quartz.

Alteration: None.

Weathering: Relatively fresh rocks.

Ore controls: Syngenetic banded iron-formation in mafic volcanic rocks intercalated with exhalites (chert and iron-formation).

Genetic models: Banded iron-formation associated with mafic volcanic activity - Algoma type BIF.

Analytical data:
No data.

Exploration:
Kryolitselskabet Øresund A/S initiated exploration in the Itilliarsuk area (Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). GGU conducted reconnaissance investigations in the area in the late 1980s.

Photos, figures and maps:

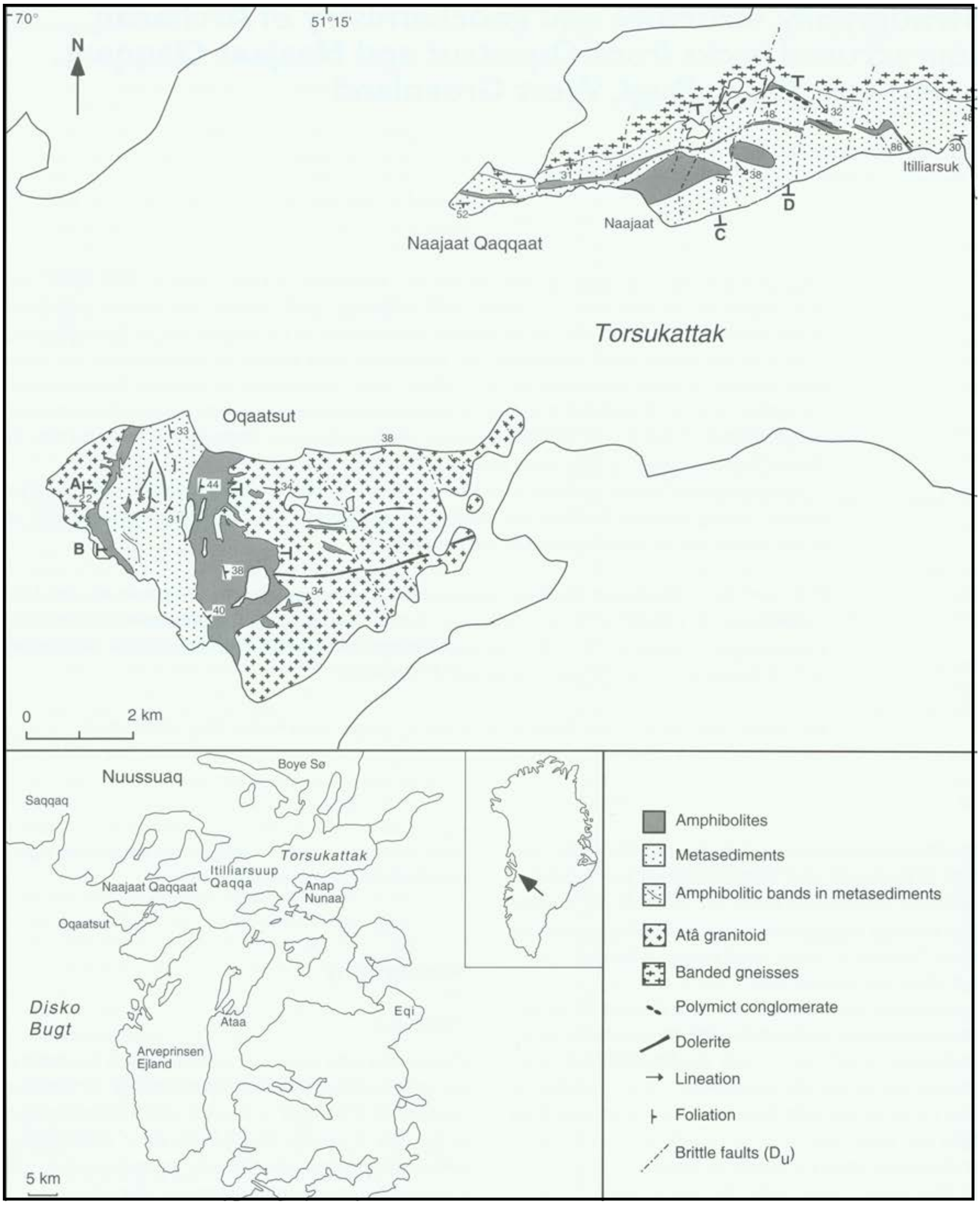

Figure 14. *Geological sketch map of Qaatsut and Naajaat Qaqqaat, north-east Disko Bugt. The letters on the map mark profiles described in Rasmussen and Pedersen (1999).*

References:

Gothenborg, J. & Morthorst, J. 1981: Report on the ore exploration in Atâ area, Jakobshavn, 1980, 80 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).

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Compiler and date (dd-mm-yyyy):

HST 04-12-2003

Anap Nunaa 1 (copper) **Type id. no. 12**

Type locality id. no.: 12

Type locality for id. nos.: 12

Locality name: Anap Nunaa (1)

Area: Disko Bugt

Genetic relation: Copper in fault zone

GSC deposit type: 17 – Vein copper and hydrothermal alteration

Commodity group: Precious metals

Commodities (minor): Copper (gold)

Economic significance: 3

Geological characteristics:

Description of occurrence: Breccia zones with quartz veins and Cu mineralisation occur within the well preserved Palaeoproterozoic metasediments, overlying Archaean supracrustal rocks and granitoids (c. 2800 Ma). This Palaeoproterozoic sequence comprises of a basal quartzite (30 m) followed by an approximately 50 m thick carbonate/marble horizon, which is succeeded by shallow water siltstones grading into an upper turbidite succession (Andersen 1991).

Geotectonic setting: A bedded carbonate/marble sequence is cut by an approximately 15 m wide breccia zone, which presumably is related to minor tectonic movements. The breccia zone contains of up to ten metres thick limestone, which partly is dolomitised.

Depositional environment/Geological setting: The Archaean supracrustal succession is south-east of Torsukattak unconformably overlain by a weakly metamorphosed Palaeoproterozoic sequence of shallow water sediments, the Anap nunâ Group. The sedimentary sequence is deposited in a platform environment.

Age of mineralisation: The age is of the mineralisation belongs to the Palaeoproterozic shear and vein systems formed around 1900 Ma (Stendal 1998).

Host/Associated rock types: The host rocks are metaquartzite and metagraywackes. A thin bedded, laminated magnetite and hematite-bearing black chert and siliceous mudstone is part of the sequence (Blackwell 1989). The total thickness of the Palaeoproterozoic sequence (Anap nunâ Group) is at least 3.6 km.

Deposit form: Quartz veins in fault zones. Disseminated chalcopyrite and pyrite occur together with quartz and secondary sparry calcite in the matrix.

Texture/Structure: The sulphides constitute less than 1% of the breccia-zone and botryoidal textures occur locally as up to few centimetres across.

Ore mineralogy (principal and *subordinate*): Pyrite, chalcopyrite and *chalcocite*.

Gangue mineralogy (principal and *subordinate*): Secondary sparry calcite, dolomite and *quartz*.

Alteration: Dolomitisation.

Weathering: No distinct weathering except for malachite staining.

Ore controls: Fault system.

Genetic models: Hydrothermal activity associated with dolomitisation.

Analytical data:
Sulphide-bearing grab samples yielded up to 0.56 %Cu (Gothenborg & Morthorst 1981) and 600 ppb gold (Blackwell 1989).

Exploration:
Kryolitselskabet Øresund A/S initiated exploration in the area (Gothenborg & Morthorst 1981). Contemporaneously with GGU activities in the late 1980s exploration was done by Platinova Resources Ltd. and Yellowknife Resources (Blackwell 1989).

Photos, figures and maps:

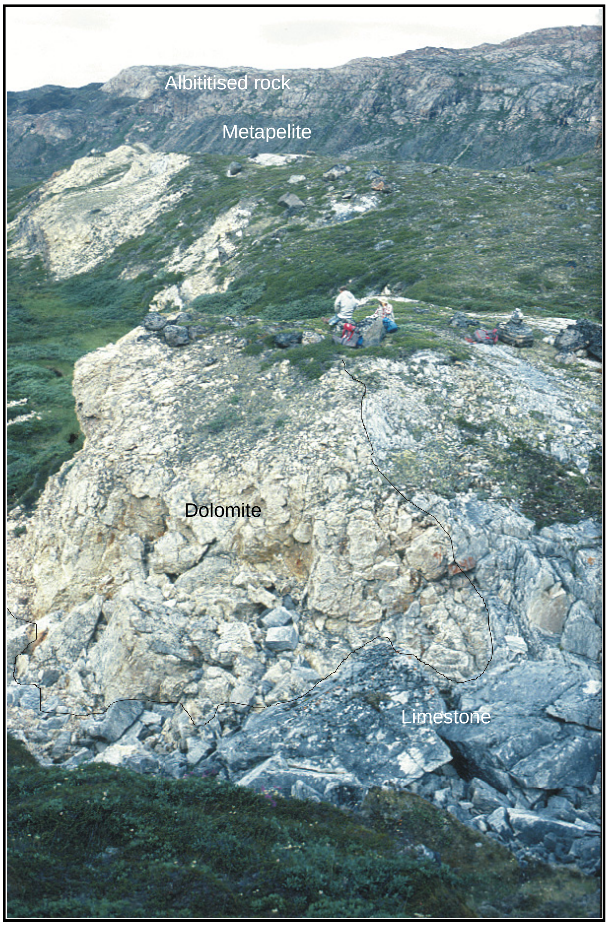

Figure 15. *Carbonates (breccia zone with dolomitization) from the Palaeoproterozoic Anap nunâ Group and albitised rock in the background.*

References:

Andersen, J. 1991: Tidlig proterozoisk rift-relateret sedimentation og post-sedimentær deformation. Anap Nunâ, Diskobugten, 73 pp. Unpublished Cand.scient. (M.Sc.) thesis, University of Copenhagen, Denmark.

Blackwell, J. 1989: Report of 1988 field season, Disko Bay project, 18 pp., Platinova Resources Ltd. and Yellowknife Resources, Toronto, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20312).

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Stendal, H. 1998: Contrasting Pb isotopes of Archaean and Palaeoproterozoic sulphide mineralisation, Disko Bugt, central West Greenland. Mineralium Deposita **33**, 255–265.

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Anap Nunaa 2 (copper) Type id. no. 13

Type locality id. no.: 13

Type locality for id. nos.: 13

Locality name: Anap Nunaa (2)

Area: Disko Bugt

Genetic relation: Veins

GSC deposit type: 17 – Vein copper and hydrothermal alteration

Commodity group: Base metals

Commodities (minor): Copper

Economic significance: 3

Geological characteristics:

Description of occurrence: Vein copper mineralisations in quartz veins are located in gabbroic dykes and sills of Proterozoic age, which have intruded the Palaeoproterozoic sediments of Anap Nunaa.

Geotectonic setting: The gabbro dykes and sills are intruded into a sedimentary sequence comprising a basal quartzite (30 m) followed by an approximately 50 m thick marble horizon, which is succeeded by shallow water siltstones grading into an upper turbidite succession (Andersen 1991).

Depositional environment/Geological setting: The Archaean supracrustal succession is south-east of Torsukattak unconformably overlain by a non-metamorphosed Palaeoproterozoic sequence of shallow water sediments, the Anap nunâ Group in a platform environment. The veins are presumably tension gashes related to strike-slip movements along the contacts of the intrusions. Chalcopyrite and epidote occur disseminated in these often coarse-grained quartz-carbonate veins.

Age of mineralisation: The age is of the mineralisation belongs to the Palaeoproterozic shear and vein systems formed around 1900 Ma (Stendal 1998).

Host/Associated rock types: The host rocks are mafic intrusive rocks.

Deposit form: Quartz veins in gabbroic rocks. The veins are 5–50 cm wide, 5–30 m long.

Texture/Structure: Vein and veinlets.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, pyrite, c*halcopyrite.*

Gangue mineralogy (principal and *subordinate*): Quartz and carbonate.

Alteration: Silicification, epidotisation and bleaching.

Weathering: No distinct weathering except for malachite staining.

Ore controls: Vein system.

Genetic models: Veining and shearing in connection with the regional deformation.

Analytical data:
No data.

Exploration:
Kryolitselskabet Øresund A/S initiated exploration Maniitsoq area (Gothenborg 1980; Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). GGU has had reconnaissance activity in the area in the late 1980s.

Photos, figures and maps:

Figure 16. *Quartz carbonate veins in metagabbro dyke with malachite, Anap Nunaa. The same type can be found at Qapiarfiit.*

References:
Andersen, J. 1991: Tidlig proterozoisk rift-relateret sedimentation og post-sedimentær deformation. Anap Nunâ, Diskobugten, 73 pp. Unpublished Cand.scient. (M.Sc.) thesis, University of Copenhagen, Denmark.

Gothenborg, J. 1980: Report on the preliminary geological exploration in Christianshåb and Jacobshavn areas. 1978. [KØ/191], 34 pp., 2 plates. Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20210).

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Gothenborg, J. & Morthorst, J. 1982: Report on the ore exploration in the Atâ area, Jakobshavn, 1981, 88 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20202).

Gothenborg, J. & Keto, L. 1986: Exploration in the Atâ area, Jakobshavn, 1980–1985, 12 pp., Unpublished report, Kryolithselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20220).

Stendal, H. 1998: Contrasting Pb isotopes of Archaean and Palaeoproterozoic sulphide mineralisation, Disko Bugt, central West Greenland. Mineralium Deposita **33**, 255–265.

Compiler and date (dd-mm-yyyy):

HST 04-12-2003

Oqaatsut (iron) **Type id. no. 14**

Type locality id. no.: 14

Type locality for id. nos.: 14

Locality name: Oqaatsut

Area: Arveprinsen Ejland

Genetic relation: Iron-formation

GSC deposit type: 3.2 – Algoma-type iron-formation

Commodity group: Iron and iron alloys

Commodities (minor): Iron

Economic significance: 4

Geological characteristics:

Description of occurrence: Banded iron-formation is located within quartz-biotite schist quartz-magnetite rich rocks near Oqaatsut, the westernmost occurrence of the Archaean supracrustal rocks south of Torsukattak. This is the N-S striking and E-dipping supracrustal sequence sandwiched within the Atâ granitoids (Rasmussen & Pedersen 1999). The upper contact is a thrust whereas the lower contact is intrusive.

Geotectonic setting: The volcanic sequence represents low-K tholeiites to calc-alkaline, bimodal volcanic extrusions. The pillowed lavas represent ocean floor basalts related to an oceanic-island arc or back arc setting.

Depositional environment/Geological setting: Quartz-magnetite rich rocks were found in the quartz-biotite schist at two localities as 1–2 m thick layers. They consist of alternating quartz and magnetite laminae from a few millimetres to about 1–2 cm wide. The sulphide facies part of the sequence is ocated within quartz-sericite schist (Gothenborg & Morthorst 1981).

Age of mineralisation: The age is of the mineralisation is uncertain but syngenetic with the Archaean host rocks.

Host/Associated rock types: The succession can be divided into three main units: a lower and an upper amphibolitic greenstone unit, with a metasedimentary unit in between. The structurally lower (western part) is up to 1150 m thick and is dominated by siliciclastic rocks interlayered with some mafic intrusive and extrusive rocks. The upper, eastern part comprises of amphibolitic greenstones of both intrusive and extrusive origin with mixed tholeiitic and komatiitic suites interlayered with a minor amount of thin felsic layers. The amphibolitic greenstone package is up to 900 m thick (Rasmussen & Pedersen 1999). The western siliciclastic succession is tentatively correlated with the siliciclastic sequence on Arveprinsen Ejland and in the Eqi area, and consequently the amphibolitic greenstone package will be correlated with the upper unit (c) of the greenstone sequence. This implies that the Oqaatsut supracrustal rocks are inverted, as in the Eqi area.

Deposit form: Stratiform beds.

Texture/Structure: Cm-banding between magnetite and quartz bearing bands.

Ore mineralogy (principal and *subordinate*): Magnetite, pyrite, pyrrhotite and *chalcopyrite*.

Gangue mineralogy (principal and *subordinate*): Quartz, sericite and chlorite.

Alteration: Rust gossan.

Weathering: Relatively fresh rocks. Rust and malachite staining.

Ore controls: Syngenetic banded iron-formation formed contemporaneously with mafic volcanic activity.

Genetic models: The syngenetic banded iron-formation associated with mafic volcanic activity has similarities with the Algoma type BIF. Iron-formation is located at different levels in the volcanic sequence and is gold-bearing at Oqaatsut.

Analytical data:
Sheared amphibolite with disseminated pyrite revealed anomalous gold values e.g. 1 ppm over 1 m and 0.39 ppm over 2 m (Blackwell 1989). Sulphide rich parts are reported to contain 400 ppm Cu, 800 ppm Ni and 300 ppm Zn (Gothenborg & Morthorst 1981).

Exploration:
Kryolitselskabet Øresund A/S initiated exploration in the Itilliarsuk area (Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). Contemporaneously with GGU activities in the late 1980s exploration was done by Platinova Resources Ltd. and Yellowknife Resources (Blackwell 1989).

Photos, figures and maps:

See map under type locality id. no. 11.

References:

Blackwell, J. 1989: Report of 1988 field season, Disko Bay project, 18 pp., Platinova Resources Ltd. and Yellowknife Resources, Toronto, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20312).

Gothenborg, J. & Morthorst, J. 1981: Report on the ore exploration in Atâ area, Jakobshavn, 1980, 80 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).

Gothenborg, J. & Morthorst, J. 1982: Report on the ore exploration in the Atâ area, Jakobshavn, 1981, 88 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20202).

Gothenborg, J. & Keto, L. 1986: Exploration in the Atâ area, Jakobshavn, 1980–1985, 12 pp., Unpublished report, Kryolithselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20220).

Rasmussen, H. & Pedersen, L.F. 1999: Stratigraphy, structure and geochemistry of Archaean supracrustal rocks from Oqaatsut and Naajaat Qaqqaat, north-east Disko Bugt, West Greenland. Geology of Greenland Survey Bulletin **181**, 65–78.

Compiler and date (dd-mm-yyyy):

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Anderson showing (copper) Type id. no. 15

Type locality id. no.: 15

Type locality for id. nos.: 15

Locality name: Anderson showing

Area: Arveprinsen Ejland,

Genetic relation: Volcanic-associated massive sulphide

GSC deposit type: 6.4 – Volcanic-associated massive sulphide gold

Commodity group: Base metals

Commodities (minor): Copper, zinc (gold)

Economic significance: 2

Geological characteristics:

Description of occurrence: The Anderson prospect on Arveprinsen Ejland stands out as the best sulphide occurrence among the massive sulphide lenses in the transitional zone. The prospect occurs in a sequence of cherty and volcaniclastic sediments, which forms a raft within the sill complex (Nielsen 1992). The tract of sediments can be followed for about 400 m and is approximately 50 m thick. The greenstone sequence: The Arveprinsen Ejland and Eqi-Maniitsoq areas and can be divided into three units. (a) A lower unit of massive to pillowed greenstones, (b) a middle unit of greenstones with frequent layers of mafic and felsic volcaniclastic sediments interlayered with felsic igneous rocks, (c) an upper unit dominated by greenstones of mixed extrusive (pillow lavas) and intrusive origin (Stendal & Schønwandt 2003).

Geotectonic setting: The volcanic sequence (Eqi and Arveprinsen Ejland) represents low-K tholeiites to calc-alkaline, bimodal volcanic extrusions. The pillowed lavas possibly represent ocean floor basalts related to an oceanic-island arc or back arc setting.

Depositional environment/Geological setting: The sequence comprises of a unit of mafic and felsic tuffs and hyaloclastite which interlayers a lower siliciclastic unit dominated by "dirty" sandstone to pelite and an upper unit grading from sandstone to chert. The sulphide mineralisation occurs in bedded chert in the uppermost part of the sedimentary sequence. The sulphide mineral occurrence outcrops as two separate massive lenses up to 0.5 m wide and two to three metres long. The lenses occur on the upper and lower limbs of a small isoclinal fold approximately 15–20 m apart. It is not known whether they belong to the same sulphide lens in three dimensions or represent two separate bodies. Both lenses are surrounded by a halo up to 3 m of sulphide mineralisation characterised by veinlets and disseminated sulphides (Nielsen 1992).

A fault sub-parallel to the trace of the axial plane of gentle to open meso-scale folds cuts through one of the sulphide lenses and has been strongly hydrothermal altered to a "sulphide-bearing clay" (gouge up to 1 m thick). Locally along the fault zone, minor carbonate quartz veins with pyrite and chalcopyrite occurs.

Age of mineralisation: The age is of the mineralisation is uncertain but syngenetic with the Archaean host rocks. The Anderson prospect has a Pb-Pb signature, which is comparable to Palaoproterozoic (1900 Ma) shear and hydrothermal events of the region (Stendal 1998).

Host/Associated rock types: The Anderson occurrence is located in a prominent mafic sill complex, which intrudes the upper part of the stratigraphic sequence in the northeastern part of Arveprinsen Ejland (Marshall & Schønwandt 1999). The mafic sill complex, which has undergone greenschist facies metamorphism, comprises a magmatic differentiated pile of leuconorite, anorthositic gabbro, gabbro and hornblendite. The sill complex has a strike length of 7.5 km and a cumulative preserved thickness of 2–2.5 km and amounts to nearly 50% of the exposed thickness of the supracrustal rocks.

Deposit form: Semi-massive ore lenses.

Texture/Structure: Semi-massive ore lenses

Ore mineralogy (principal and *subordinate*): Pyrrhotite and pyrite dominate the sulphide mineralisation, chalcopyrite and sphalerite and accessory minerals are galena and native bismuth.

Gangue mineralogy (principal and *subordinate*): Quartz.

Alteration: The stratiform pyrite and pyrrhotite sulphide horizons show no alteration halos and metal zonation is absent.

Weathering: Gossan.

Ore controls: Syngenetic features.

Genetic models: A syngenetic exhaltive volcanic-associated massive sulphide system but deposited relatively distal in relation to a proximal massive sulphide deposits. The sulphide occurrences are associated with chert typical for marine volcanogenic exhalative deposits formed at the top of pillowed lavas.

Analytical data:

	Au ppb	Cu %	Pb %	Zn %
1,5m chip: Upper sulphide lense	600	3.7	0.6	1.0
1,5m chip: Lower sulphide lense	85	0.7	0.2	3.1
1,5m chip: Halo	11	0.2	0.08	0.09

Gold contents of the sulphide alteration gouge vary between 8 - 25 ppm.

Exploration:

Kryolitselskabet Øresund A/S initiated exploration in the Anderson area (Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). Contemporaneously with GGU activities in the late 1980s exploration was done by Platinova Resources Ltd. and Yellowknife Resources (Blackwell 1989).

Photos, figures and maps:

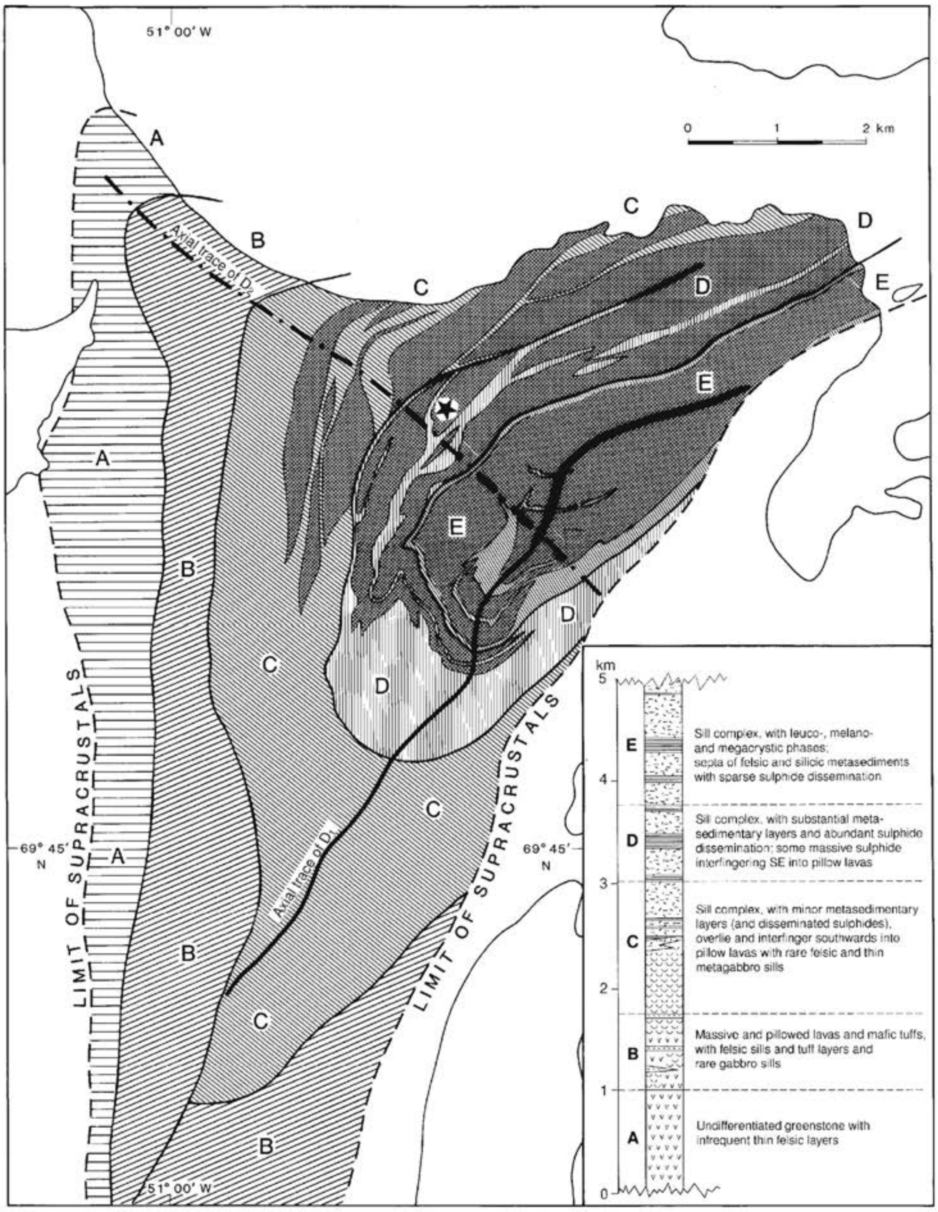

Figure 17. *The sill complex on Arveprinsen Ejland. The star locates Anderson prospect - from Marshall & Schønwandt (1999).*

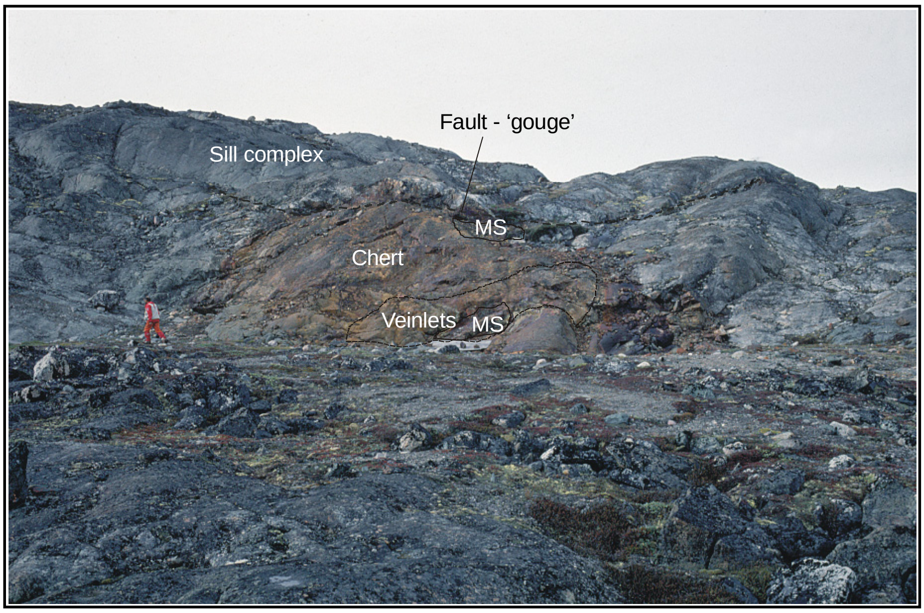

Figure 18. *Anderson prospect, Arveprinsen Ejland with the sulphide occurrence. MS = Massive sulphides.*

References:

Blackwell, J. 1989: Report of 1988 field season, Disko Bay project, 18 pp., Platinova Resources Ltd. and Yellowknife Resources, Toronto, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20312).

Gothenborg, J. & Morthorst, J. 1981: Report on the ore exploration in Atâ area, Jakobshavn, 1980, 80 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).

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Marshall, B. & Schønwandt, H.K. 1999: An Archaean sill complex and associated supracrustal rocks, Arveprinsen Ejland, north-east Disko Bugt, West Greenland. Geology of Greenland Survey Bulletin **181**, 87–102.

Nielsen, A.T. 1992: Geologi, geokemi og tektonisk setting for Andersens mineraliseringen: En vulkansk massiv sulfidforekomst i det arkæiske supracrustalbælte, Arveprinsen Ejland, Vestgrønland, 98 pp.. Unpublished Cand.scient. (M.Sc.) thesis, University of Copenhagen.

Stendal, H. 1998: Contrasting Pb isotopes of Archaean and Palaeoproterozoic sulphide mineralisation, Disko Bugt, central West Greenland. Mineralium Deposita **33**, 255–265.

Compiler and date (dd-mm-yyyy):

HST 04-12-2003

Qapiarfiit (copper) Type id. no. 16

Type locality id. no.: 16

Type locality for id. nos.: 16

Locality name: Qapiarfiit

Area: Disko Bugt

Genetic relation: Copper in veins

GSC deposit type: 17 – Vein copper and hydrothermal alteration

Commodity group: Precious metals

Commodities (minor): Copper (cobalt, gold)

Economic significance: 3

Geological characteristics:

Description of occurrence: Vein copper mineralisations in quartz veins are located in gabbroic dykes and sills of Proterozoic age, which have intruded the Palaeoproterozoic sediments of Qapiarfiit area.

Geotectonic setting: The gabbro dykes and sills are intruded into a sedimentary sequence.

Depositional environment/Geological setting: The veins are presumably tension gashes related to strike-slip movements along the contacts of the intrusions. Chalcopyrite and epidote occur disseminated in these often coarse-grained quartz-carbonate veins.

Age of mineralisation: The age of the mineralisation is probably Palaeoproterozoic as the same type of veins from Anap Nunaa.

Host/Associated rock types: The host rocks are mafic intrusive rocks.

Deposit form: Quartz veins in gabbroic rocks. The veins are 5–50 cm wide, 5–30 m long.

Texture/Structure: Vein and veinlets.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, pyrite, c*halcopyrite, and gersdorfite.*

Gangue mineralogy (principal and *subordinate*): Quartz and carbonate.

Alteration: Silicification and bleaching.

Weathering: No distinct weathering except for malachite staining.

Ore controls: Vein system.

Genetic models: Veining and shearing in connection with the regional deformation.

Analytical data:

Cu up to 1.8%, 0.28% Co, Ni 300 ppm and 0,3 ppm Au.

Exploration:

Kryolitselskabet Øresund A/S initiated exploration in the Ataa region (Gothenborg 1980; Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). Contemporaneously with GGU activities in the late 1980s exploration was done by Platinova Resources Ltd. and Yellowknife Resources (Blackwell 1989).

Photos, figures and maps:

See figure under type locality number 13.

References:

Andersen, J. 1991: Tidlig proterozoisk rift-relateret sedimentation og post-sedimentær deformation. Anap Nunâ, Diskobugten, 73 pp. Unpublished thesis (M.Sc.), University of Copenhagen, Denmark.

Blackwell, J. 1989: Report of 1988 field season, Disko Bay project, 18 pp. Unpublished internal report Platinova Resources Ltd. and Yellowknife Resources, Toronto, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20312).

Gothenborg, J. 1980: Report on the preliminary geological exploration in Christianshåb and Jacobshavn areas. 1978. [KØ/191], 34 pp., 2 plates. Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20210).

Gothenborg, J. & Morthorst, J. 1981: Report on the ore exploration in Atâ area, Jakobshavn, 1980, 80 pp. Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).

Gothenborg, J. & Morthorst, J. 1982: Report on the ore exploration in the Atâ area, Jakobshavn, 1981, 88 pp. Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20202).

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Amazone prospect (copper) Type id. no. 17

Type locality id. no.: 17

Type locality for id. nos.: 17, 18

Locality name: Amazone prospect

Area: Arveprinsen Ejland

Genetic relation: Volcanic-associated massive-sulphide

GSC deposit type: 6.3 – Volcanic-associated massive-sulphide base metals

Commodity group: Base metals

Commodities (minor): Copper, lead, (gold)

Economic significance: 3

Geological characteristics:

Description of occurrence: Sulphide mineralisation associated with the interflow sediments is minor but widespread within the local greenstone sequence. The greenstone sequences in Arveprinsen Ejland and Eqi-Maniitsoq areas and can be divided into three units. (a) A lower unit of massive to pillowed greenstones, (b) a middle unit of greenstones with frequent layers of mafic and felsic volcaniclastic sediments interlayered with felsic igneous rocks, (c) an upper unit dominated by greenstones of mixed extrusive (pillow lavas) and intrusive origin (Stendal & Schønwandt 2003).

Geotectonic setting: The volcanic sequence (Eqi and Arveprinsen Ejland) represents low-K tholeiites to calc-alkaline, bimodal volcanic extrusions. The pillowed lavas represent ocean floor basalts related to an oceanic-island arc or back arc setting. The felsic metavolcanic rocks related to the dome complex at Eqi have geochemical characteristics of volcanic arc rocks (Garde *et al.* 1991; Stendal *et al.* 1999a). The volcanic arc in the Eqi and Arveprinsen area is formed at c. 2800 Ma.

Depositional environment/Geological setting: On Arveprinsen Ejland mineral occurrences in the middle greenstone succession are associated with interflow sediments and minor ductile shears in greenstones. Additionally a few mineral occurrences related to shear movements have been observed: a) quartz veins occurring en echelon are gold bearing, and b) veinlets of chalcopyrite occurring in a metre wide sheared greenstone are copper and gold bearing. Other sulphide occurrences on Arveprinsens Ejland contain widespread pyrite, mainly in argillaceous sediments from the lower part of the siliciclastic sequence.

Age of mineralisation: The age is of the mineralisation is uncertain but syngenetic with the Archaean host rocks. The quartz veining/silicification is of uncertain age.

Host/Associated rock types: The host rocks are mostly mafic volcanic rocks. The total thickness of the greenstone sequence is about 3–4 km. The greenstone succession on Arveprinsens Ejland is intruded by the Atâ pluton and its base is therefore unknown.

Deposit form: Semi-massive ore lenses and quartz veins.

Texture/Structure: Disseminated, semi-massive sulphide and quartz veins.

Ore mineralogy (principal and *subordinate*): The dominant sulphide is pyrite but locally minor *chalcopyrite, galena and bismuth* occur.

Gangue mineralogy (principal and *subordinate*): Quartz.

Alteration: Silicification is in places very extensive.

Weathering: Malachite

Ore controls: Syngenetic features overprinted by quartz veining.

Genetic models: Relatively distal positions of the sulphide occurrences in relation to proximal massive sulphide deposits. The chert-bearing sulphide occurrences are marine volcanogenic exhalative deposits formed at the top of pillowed lavas (Stendal & Schønwandt 2003).

Analytical data:

Chip samples of the interflow sediments clearly show that layers with quartz-feldspar phenocrysts yield Cu contents of 200–800 ppm, whereas the pure siliciclastic sediments have contents below 160 ppm Cu. Base metal mineralisation is also associated with the chemical sediments. Chip samples have yielded up to 670 ppm Pb, 100 ppm Zn and 240 ppm Cu over 7 m.

Additionally a few mineral occurrences related to shear movements have been found (id no. 18): quartz veins occurring en echelon of which one yielded up to 2.6 ppm Au over 2 m veinlets of chalcopyrite occurring in a metre wide sheared greenstone returned 2% Cu and 230 ppb Au from a composite grab sample.

Exploration:

Kryolitselskabet Øresund A/S initiated exploration in the Itilliarsuk area (Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). Contemporaneously with GGU activities in the late 1980s exploration was done by Platinova Resources Ltd. and Yellowknife Resources (Blackwell 1989).

Photos, figures and maps:

Figure 19. *Amazone prospect. A: mafic tuff sequence, B: rust colour mafic tuff with pyrite in veins and disseminated, C_1: rust coloured chert with quartz veins, mineralised with 1–2% chalcopyrite and galena C_2: chert with quartz veins, D: not exposed, F: gradual transition into dolomite-mafic tuff sequence, G: greenstone, mafic tuff. From Nielsen (1992).*

Figure 20. *Quartz vein in breccia of mafic tuff and chert from the Pb-Cu mineralised zone at Amazone prospect. Picture from Nielsen (1992) .*

References:

Blackwell, J. 1989: Report of 1988 field season, Disko Bay project, 18 pp., Platinova Resources Ltd. and Yellowknife Resources, Toronto, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20312).

Gothenborg, J. & Morthorst, J. 1981: Report on the ore exploration in Atâ area, Jakobshavn, 1980, 80 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).

Gothenborg, J. & Morthorst, J. 1982: Report on the ore exploration in the Atâ area, Jakobshavn, 1981, 88 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20202).

Gothenborg, J. & Keto, L. 1986: Exploration in the Atâ area, Jakobshavn, 1980–1985, 12 pp., Unpublished report, Kryolithselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20220).

Nielsen, A.T. 1992: Geologi, geokemi og tektonisk setting for Andersens mineraliseringen: En vulkansk massiv sulfidforekomst i det arkæiske supracrustalbælte, Arveprinsen Ejland, Vestgrønland, 98 pp. Unpublished Cand.scient. (M.Sc.) thesis, University of Copenhagen.

Stendal, H. & Schønwandt, H.K. 2003: Precambrian supracrustal rocks and mineral occurrences, Northeast Disko Bugt. Danmarks og Grønlands Geologiske Undersøgelse Rapport **2003/24**, 57pp.

Compiler and date (dd-mm-yyyy):

HST 04-12-2003

Qingaarssuaq (copper) Type id. no. 19

Type locality id. no.: 19

Type locality for id. nos.: 19

Locality name: Qingaarssuaq

Area: Disko Bugt

Genetic relation: Volcanic-associated massive-sulphide

GSC deposit type: 3.2 – Algoma-type iron-formation

Commodity group: Base metals

Commodities (minor): Copper

Economic significance: 4

Geological characteristics:

Description of occurrence: Sulphide bearing sediments within greenstone in the Qingarssiaq area is similar to sequences in Arveprinsen Ejland and Eqi-Maniitsoq areas and can be divided into three units. (a) A lower unit of massive to pillowed greenstones, (b) a middle unit of greenstones with frequent layers of mafic and felsic volcaniclastic sediments interlayered with felsic igneous rocks, (c) an upper unit dominated by greenstones of mixed extrusive (pillow lavas) and intrusive origin (Stendal & Schønwandt 2003).

Geotectonic setting: The volcanic sequence represents low-K tholeiites to calc-alkaline, bimodal volcanic extrusions. The pillowed lavas represent ocean floor basalts related to an oceanic-island arc or back arc setting.

Depositional environment/Geological setting: Similar mineralisation types as on Arveprinsen Ejland and Eqi are reported in the Qingarssuaq area with pyrite bearing metalliferous sediments in highly deformed siliciclastic sediments (M. Marker pers.comm.).

Age of mineralisation: The age of the mineralisation is not dated but probably syngenetic with the Archaean host rocks (2800 Ma).

Host/Associated rock types: The host rocks are quartzite, quartz-mica schist and chlorite schist. The total thickness of the greenstone sequence is 3–4 km.

Deposit form: Stratabound sulphide bearing sediments.

Texture/Structure: Disseminations of pyrite and pyrrhotite.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, pyrite and *chalcopyrite*.

Gangue mineralogy (principal and *subordinate*): Quartz.

Alteration: No distinct alteration.

Weathering: No distinct weathering except for limonite and malachite staining.

Ore controls: Syngenetic features.

Genetic models: Iron-formation (sulphide facies) of the Algoma-type. This type of occurrence may be relatively distal position in relation to proximal massive sulphide deposits.

Analytical data:

The only interesting result is a Cu-content with up to 0,5%.

Exploration:

Kryolitselskabet Øresund A/S initiated exploration in the Qingarssuaq area (Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). GGU carried out investigations in the area in the late 1980s.

Photos, figures and maps:

References:

Gothenborg, J. & Morthorst, J. 1981: Report on the ore exploration in Atâ area, Jakobshavn, 1980, 80 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).

Gothenborg, J. & Morthorst, J. 1982: Report on the ore exploration in the Atâ area, Jakobshavn, 1981, 88 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20202).

Gothenborg, J. & Keto, L. 1986: Exploration in the Atâ area, Jakobshavn, 1980–1985, 12 pp., Unpublished report, Kryolithselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20220).

Stendal, H. & Schønwandt, H.K. 2003: Precambrian supracrustal rocks and mineral occurrences, Northeast Disko Bugt. Danmarks og Grønlands Geologiske Undersøgelse Rapport **2003/24**, 57pp.

Compiler and date (dd-mm-yyyy):

HST 04-12-2003

Eqi 1 (gold) **Type id. no. 22**

Type locality id. no.: 22

Type locality for id. nos.: 21, 22

Locality name: Eqi (1)

Area: Disko Bugt

Genetic relation: Gold in massive sulphides

GSC deposit type: 6.4 – Volcanic-associated massive sulphide gold

Commodity group: Precious metals

Commodities (minor): Gold (copper)

Economic significance: 3

Geological characteristics:

Description of occurrence: Gold occurs in pyrite dominated semi-massive sulpides in the transition zone between massive rhyolitic rocks and sericite schist. The volcanic-associated massive sulphide gold in the Eqi area is closely related to a rhyolite dome complex and greenstones (Stendal *et al.* 1999).

Geotectonic setting: The volcanic sequence represents low-K tholeiites to calc-alkaline, bimodal volcanic extrusions. The pillowed lavas represent ocean floor basalts related to an oceanic-island arc or back arc setting. The felsic metavolcanic rocks related to the dome complex at Eqi have geochemical characteristics of volcanic arc rocks. The volcanic arc in the Eqi and Arveprinsen area is formed at c. 2800 Ma.

Depositional environment/Geological setting: Gold occurs in pyrite dominated semi-massive sulpides, which occurs in a 50–200 m thick transition zone between massive rhyolitic rocks and sericite schist. This mineralisation appears as rusty zones due to disseminated pyrite. Locally small lenses of massive to semi-massive pyrite in up to 20 cm thick lenses are often sheared. The volcanic eruptions are bimodal and intruded by rhyolitic acid rocks and mafic sills.

Age of mineralisation: The age is determined by Pb-Pb isotope investigation of pyrite (Stendal 1998), where the semi-massive sulphides represent a syngenetic stage yielding c. 2800 Ma.

Host/Associated rock types: The supracrustal sequence at Eqi area can be divided into three units: (a) a lower unit of massive to pillowed greenstones, (b) a middle unit of greenstones with frequent layers of mafic and felsic volcaniclastic sediments interlayered with felsic igneous rocks, (c) an upper unit dominated by greenstones of mixed extrusive (pillow lavas) and intrusive origin. The total thickness of the greenstone sequence is about 3–4 km.

Deposit form: Stratiform beds in sericitic schist.

Texture/Structure: Disseminated pyrite and porphyroblasts of pyrite in quartz veins.

Ore mineralogy (principal and *subordinate*): Pyrite, *pyrrhotite and chalcopyrite*.

Gangue mineralogy (principal and *subordinate*): Quartz.

Alteration: Sericitisation, silicification and formation of fuchsite.

Weathering: Rusty zones due to disseminated pyrite and dark grey colours over more massive pyrite rich parts.

Ore controls: Syngenetic semi-massive ores stratiformly layered in sericite schist.

Genetic models: Archaean iron-formation-hosted stratabound gold.

Analytical data:
Composite grab samples of the pyrite mineralisation has yielded up to 0.2% Cu and 1 ppm Au.

Exploration:
Discovery of gold anomalies by the Geological Survey of Greenland (GGU) in north-east Disko Bugt in 1988. It was followed by further exploration by Platinova resources Ltd – Faxe Kalk A/S in 1989–1991 (Knudsen *et al.* 1988; Knudsen *et al.* 1990; Knudsen & Nielsen 1992) and GGU in 1991. NunaMinerals A/S has also done some exploration in the area (Nunaminerals 2000).

Photos, figures and maps:

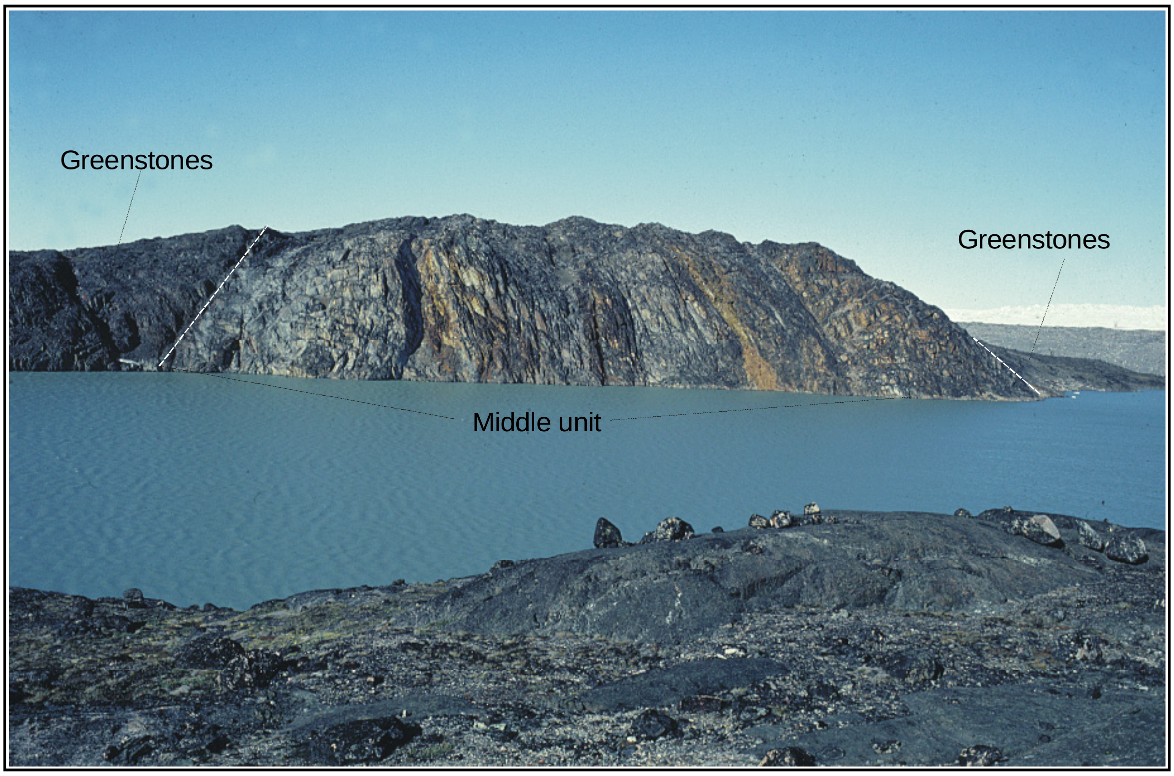

Figure 21. *The middle unit of the Eqi area comprising semi-massive pyrite in the rusty layers.*

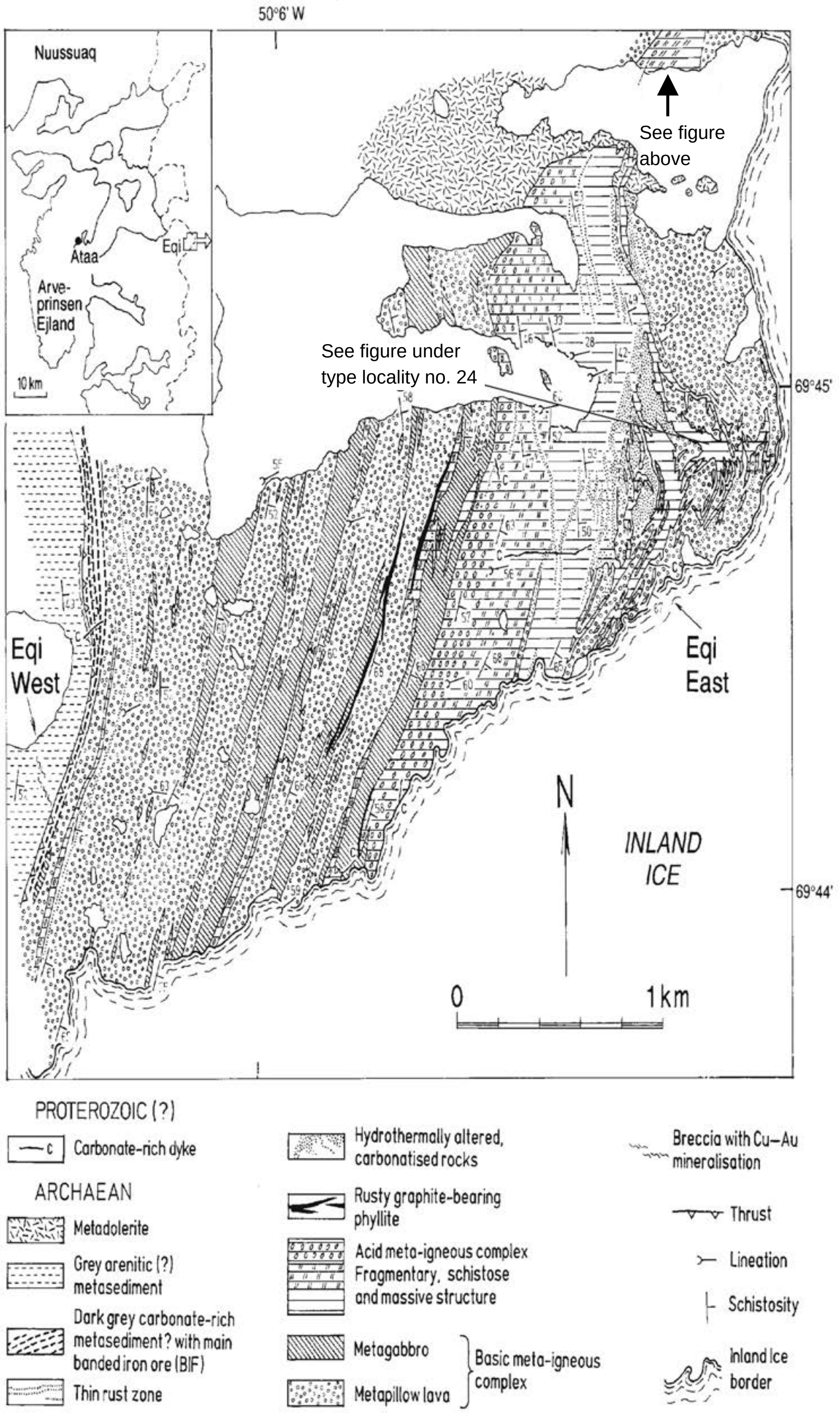

Figure 22. *Geological map of the part of the Eqi area. From Stendal et al. (1999).*

References:

Knudsen, C. & Nielsen, J.P. 1992: Final report on detailed gold exploration in the Eqe East Gold Prospect, NE Disko Bay, August 1991, 10 pp., Unpublished report, Platinova Resources Ltd. and Faxe Kalk A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20705).

Knudsen, C., Atkinson, J. & Gothenborg, J. 1990: Evaluation of gold potential of Archaean rocks from an area in the Disko Bay region of Greenland, 15 pp., Unpublished report, Platinova resources Ltd. and Faxe Kalk A/S, Copenhagen, Denmark (in archives Geological Survey of Denmark and Greenland, GEUS Report File 20445).

Knudsen, C., Appel, P.W.U., Hageskov, B. & Skjernaa, L. 1988: Geological reconnaissance in the Precambrian basement of the Ata area, central West Greenland. In: Anonymous (ed.): Report of activities, 1987. **140**, 9–17. Copenhagen, Denmark: Grønlands Geologiske Undersøgelse.

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Stendal, H. 1998: Contrasting Pb isotopes of Archaean and Palaeoproterozoic sulphide mineralisation, Disko Bugt, central West Greenland. Mineralium Deposita **33**, 255–265.

Stendal, H., Knudsen, C., Marker, M. & Thomassen, B. 1999: Gold mineralisation at Eqi, north-east Disko Bugt, West Greenland. Geology of Greenland Survey Bulletin **181**, 129–140.

Compiler and date (dd-mm-yyyy):

HST 03-12-2003

Eqi 2 (gold) **Type id. no. 24**

Type locality id. no.: 24

Type locality for id. nos.: 23, 24

Locality name: Eqi (2)

Area: Disko Bugt

Genetic relation: Greenstone-hosted mesothermal gold deposit

GSC deposit type: 15.2 – Quartz carbonate vein gold

Commodity group: Precious metals

Commodities (minor): Gold

Economic significance: 2

Geological characteristics:

Description of occurrence: Mesothermal gold occurrences at Eqi is located in breccia zones within the Eqi-Maniitsoq greenstone sequence.

Geotectonic setting: The volcanic sequence represents low-K tholeiites to calc-alkaline, bimodal volcanic extrusions. The pillowed lavas represent ocean floor basalts related to an oceanic-island arc or back arc setting. The felsic metavolcanic rocks related to the dome complex at Eqi have geochemical characteristics of volcanic arc rocks. The volcanic arc in the Eqi and Arveprinsen area is formed at c. 2800 Ma.

Depositional environment/Geological setting: Mesothermal gold at Eqi is discussed by Stendal *et al.* (1999). The pervasive gold mineralisation was caused by hydrothermal leaching and carbonate alteration of the rock pile related to acid igneous activity.

Age of mineralisation: The age is determined indirectly by Pb-Pb isotope investigation of pyrite (Stendal 1998), where the semi-massive sulphides represent a syngenetic stage yielding c. 2800 Ma. This means that the carbonate alteration is a little bit younger.

Host/Associated rock types: The original host rocks are mafic volcanics. The host rocks can be divided into three units: (a) a lower unit of massive to pillowed greenstones, (b) a middle unit of greenstones with frequent layers of mafic and felsic volcaniclastic sediments interlayered with felsic igneous rocks, (c) an upper unit dominated by greenstones of mixed extrusive (pillow lavas) and intrusive origin. The total thickness of the greenstone sequence is about 3–4 km

Deposit form: The carbonatised mafic rocks cover at the largest locality 200x400 m (Stendal *et al.* 1999)

Texture/Structure: Disseminated pyrite and porphyroblasts of pyrite in quartz veins.

Ore mineralogy (principal and *subordinate*): Pyrite, *pyrrhotite and chalcopyrite*.

Gangue mineralogy (principal and *subordinate*): The carbonatised rocks consist of ankerite, chlorite, green fuchsite and disseminated pyrite.

Alteration: The pervasive carbonate alteration has completely destroyed the primary textures of the original rocks. The carbonate alteration is mainly localised to an about 200 m thick zone at the boundary of the rhyolite dome and the hosting greenstone succession. Minor carbonate alteration occurs in up to 5-m thick zones cutting through the rhyolite complex sub-parallel to the fabric of the rocks. Locally centimetre-wide quartz veins occur within the carbonate alteration.

Weathering: Limited, except for goethite and malachite staining.

Ore controls: The gold distribution is defined by the quartz-carbonate vein systems.

Genetic models: The gold occurs in pyrite, which is disseminations in the carbonate altered host.

Analytical data:
Part of the carbonate alteration has been chip sampled yielding up to 2.3 ppm Au over 2.5 m. Grab samples of the quartz veined rocks vary between 5 ppb and 60 ppm gold (Stendal *et al.* 1999b).

Exploration:
Discovery of gold anomalies by the Geological Survey of Greenland (GGU) in north-east Disko Bugt in 1988. It was followed by further exploration by Platinova resources Ltd – Faxe Kalk A/S in 1989–1991 (Knudsen *et al.* 1988; Knudsen *et al.* 1990; Knudsen & Nielsen 1992) and GGU in 1991. NunaMinerals A/S has also done some exploration in the area (Nunaminerals 2000).

Photos, figures and maps:

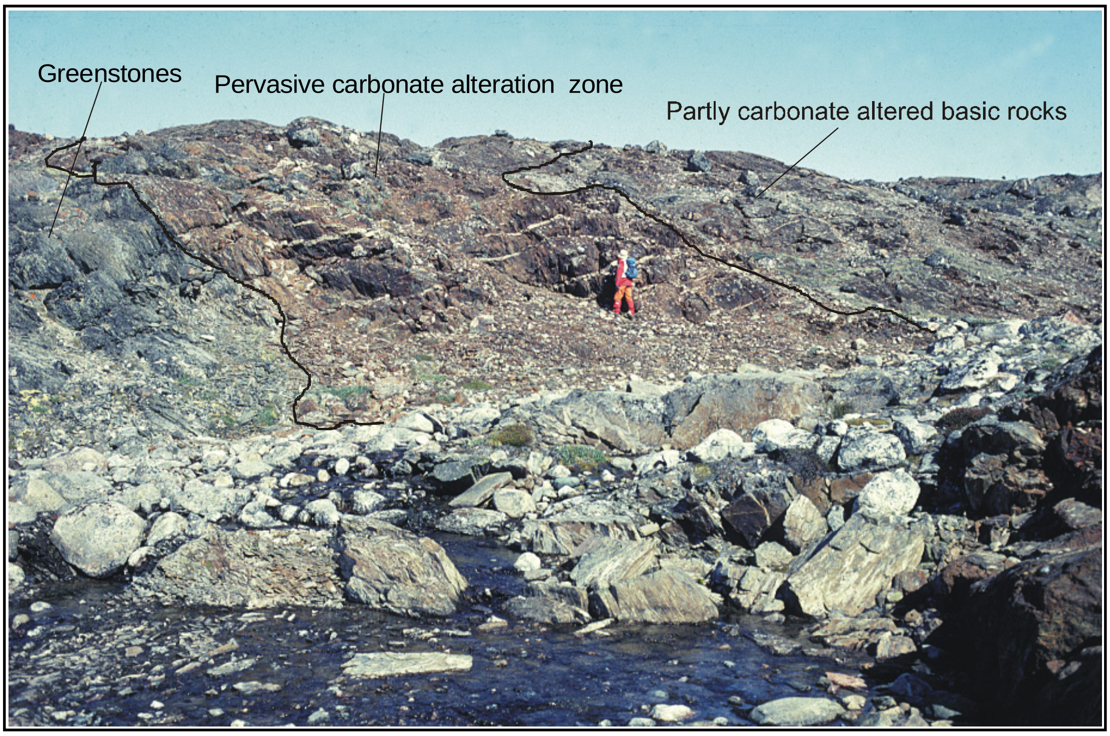

Figure 23. *Carbonate alteration of the greenstones (basic rocks) at Eqi and quartz veining. For location see map under type locality no. 22.*

References:

Knudsen, C. & Nielsen, J.P. 1992: Final report on detailed gold exploration in the Eqe East Gold Prospect, NE Disko Bay, August 1991, 10 pp., Unpublished report, Platinova Resources Ltd. and Faxe Kalk A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20705).

Knudsen, C., Atkinson, J. & Gothenborg, J. 1990: Evaluation of gold potential of Archaean rocks from an area in the Disko Bay region of Greenland, 15 pp., Unpublished report, Platinova resources Ltd. and Faxe Kalk A/S, Cpoenhagen, Denmark (in archives Geological Survey of Denmark and Greenland, GEUS Report File 20445).

Knudsen, C., Appel, P.W.U., Hageskov, B. & Skjernaa, L. 1988: Geological reconnaissance in the Precambrian basement of the Ata area, central West Greenland. In: Anonymous (ed.): Report of activities, 1987. **140**, 9–17. Copenhagen, Denmark: Grønlands Geologiske Undersøgelse.

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Compiler and date (dd-mm-yyyy):

HST 03-12-2003

Eqi West (gold) Type id. no. 26

Type locality id. no.: 26

Type locality for id. nos.: 20, 25, 26, 27

Locality name: Eqi West

Area: Disko Bugt

Genetic relation: Breccia-hosted mesothermal gold occurrence

GSC deposit type: 17 – Vein copper and hydrothermal alteration

Commodity group: Precious metals

Commodities (minor): Gold, (copper, bismuth)

Economic significance: 2

Geological characteristics:

Description of occurrence: The gold-bearing vein copper type is found in the Eqi West area, which in (Gothenborg & Morthorst 1982; Sotka 1984) is called Eqip and in (Stendal & Schønwandt 2003) is named Eqi West prospect. Epigenetic gold-copper-bismuth mineralisation in a siliciclastic sequence is related to shear movements.

Geotectonic setting: The occurrences are structurally controlled and occur in fault systems and vein breccia zones. The type is similar to other Archaean and/or Palaeoproterozoic vein copper ± gold occurrences.

Depositional environment/Geological setting: At Eqi West gold is placed in a sulphide (Cu-Bi) bearing breccia zone closely connected to a thrust zone. Blackwell (1989) has interpreted the breccia zone as a tension fracture related to a sinistral shear movement focused on laminated pyrite and graphite layers.

Age of mineralisation: As discussed by (Stendal 1998) it is uncertain what the timing of the Eqi gold-bearing copper vein type is. But the author concluded that the paragenetic evolution that deduced from Pb-Pb ratios of two samples indicate at least two mineralising events with mixed fluids from different lead reservoirs.

Host/Associated rock types: The epigenetic gold occurrence is hosted in a breccia zone in an Archaean siliciclastic sedimentary sequence, which overlay the Eqi greenstone sequence.

Deposit form: The main breccia zone is 10 m wide and up to 100 m long. Blackwell (1989) reports that dimensions of breccia zones are up to 10 m wide and 65 m long.

Texture/Structure: The sulphides occur as veinlets and specks of sulphides.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, pyrite associated with chalcopyrite and minor amounts of *sphalerite, arsenopyrite and Bi-minerals*.

Gangue mineralogy (principal and *subordinate*): The breccia zone comprises mica schist and phyllite fragments cemented by calcite, quartz and sulphides.

Alteration: Carbonatisation (generally calcite and dolomite) is prominent. Sulphidisation (pyritisation, arsenopyritisation and pyrrhotitisation) is common in wall rocks adjacent to crosscutting quartz veins.

Weathering: Limited except for goethite and malachite staining.

Ore controls: The occurrences are structurally controlled and occur in breccia zones.

Genetic models: The ore is formed under hypo-mesothermal conditions and contain some Bi in association with gold.

Analytical data:

The best drill core section assayed 1.3% Cu and 12 ppm Au over 3.2 m (Sotka 1984; Voigt 1998). (Blackwell 1989) reports that dimensions of these breccia zones are up to 10 m wide and 65 m long. The main zone yielded up to 1.7 ppm Au over 1 metre.

Exploration:

Kryolitselskaber Øresund A/S has located the epigenetic gold occurrence. In 1982 the Kryolitselskabet Øresund A/S drilled 12 short holes totalling 487 m (Gothenborg & Morthorst 1982; Sotka 1984).

Photos, figures and maps:

See map under type locality id. no 22.

References:

Blackwell, J. 1989: Report of 1988 field season, Disko Bay project, 18 pp., Platinova Resources Ltd. and Yellowknife Resources, Toronto, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20312).

Garde, A.A. & Steenfelt, A. 1999: Precambrian geology of Nuussuaq and the area northeast of Disko Bugt, West Greenland. Geology of Greenland Survey Bulletin **181**, 6–40.

Gothenborg, J. & Morthorst, J. 1982: Report on the ore exploration in the Atâ area, Jakobshavn, 1981, 88 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20202).

Sotka, P. 1984: Kryolitselskabet Øresund A/S. Report on samples from gold showings in Atâ area, West Greenland, 54 pp., Unpublished internal report Outokumpu OY, Ou-

tokumpu, Finland (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20208).
Stendal, H. 1998: Contrasting Pb isotopes of Archaean and Palaeoproterozoic sulphide mineralisation, Disko Bugt, central West Greenland. Mineralium Deposita **33**, 255–265.
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Stendal, H., Knudsen, C., Marker, M. & Thomassen, B. 1999: Gold mineralisation at Eqi, north-east Disko Bugt, West Greenland. Geology of Greenland Survey Bulletin **181**, 129–140.
Voigt, B. 1998: En beskrivelse af Eqip-Cu mineraliseringen, Disko Bugt, Vestgrønland, 89 pp. Unpublished Cand.scient. (M.Sc.) thesis, University of Copenhagen, Denmark.

Compiler and date (dd-mm-yyyy):
HST 03-12-2003

Maniitsoq (zinc) Type id. no. 28

Type locality id. no.: 28

Type locality for id. nos.: 28

Locality name: Maniitsoq (Anap)

Area: Disko Bugt

Genetic relation: Volcanic-associated massive sulphide

GSC deposit type: 6.3 – Volcanic-associated massive sulphide base metals

Commodity group: Base metals

Commodities (minor): Zinc, lead

Economic significance: 3

Geological characteristics:

Description of occurrence: The sulphide mineralisation is hosted in supracrustal rocks. The sulphide occurrence is disseminated with iron sulphides with transistions into massive to semi-massive lenses of pyrite and/or pyrrhotite.

Geotectonic setting: The volcanic sequence similar to that at Eqi represents low-K tholeiites to calc-alkaline, bimodal volcanic extrusions. The pillowed lavas represent ocean floor basalts related to an oceanic-island arc or back arc setting.

Depositional environment/Geological setting: The greenstone sequence in the Maniit-soq area is a prolongation towards south of Eqi.

Age of mineralisation: The age is of the mineralisation is syngenetic with the Archaean host rocks, which is the same as the formation of the volcanic arc at c. 2800 Ma.

Host/Associated rock types: The host rocks are quartz-mica schists.

Deposit form: The sulphide lenses are 0.5 m wide and a few metres long and contain small to moderate amounts of fine- to medium-grained pyrite as network, and fine- to coarse-grained quartz (Gothenborg & Morthorst 1981).

Texture/Structure: Stratiform.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, pyrite, c*halcopyrite, sphalerite and galena.*

Gangue mineralogy (principal and *subordinate*): Quartz, sericite.

Alteration: No distinct alteration.

Weathering: No distinct weathering except for rust over iron sulphide rich parts and malachite staining.

Ore controls: Syngenetic features.

Genetic models: Iron-formation (sulphide facies) of the Algoma-type.

Analytical data:

The only locality with significant amounts of Pb and Zn is in the Maniitsoq area where a grab sample from a rusty quartz-mica schist returned 4% Zn and 0.5% Pb (Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). Ohter metal contents are up to 800 ppm Cu, 700 ppm Ni and 200 ppm Co.

Exploration:

Kryolitselskabet Øresund A/S has carried out the first exploration Maniitsoq area (Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). GGU carried out reconnaissance in the area in the late 1980s.

Photos, figures and maps:

References:

Gothenborg, J. & Morthorst, J. 1981: Report on the ore exploration in Atâ area, Jakobshavn, 1980, 80 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).

Gothenborg, J. & Morthorst, J. 1982: Report on the ore exploration in the Atâ area, Jakobshavn, 1981, 88 pp., Unpublished internal report Kryolitselskabet Øresund Øresund, Copenhagen, Denmark, (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20202).

Gothenborg, J. & Keto, L. 1986: Exploration in the Atâ area, Jakobshavn, 1980–1985, 12 pp., Unpublished report, Kryolithselskabet Øresund A/S, Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20220).

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Nunatarsuaq (copper) Type id. no. 33

Type locality id. no.: 33

Type locality for id. nos.: 29, 30, 31, 32, 33, 34, 35

Locality name: Nunatarsuaq

Area: Ilulissat

Genetic relation: Iron-formation

GSC deposit type: 3.2 – Algoma-type iron-formation

Commodity group: Base metals

Commodities (minor): Copper, zinc

Economic significance: 4

Geological characteristics

Description of occurrence: Supracrustal rocks at the northern part of Nunatarsuaq comprises several pyrite-bearing schists, which can be followed over several kilometres. In shear/fault zones the metals of the sulphide-bearing schists are mobilised. The supracrustal sequence consists of mica gneisses ±garnets, amphibolite and pyrite bearing metasediments. Red granites and pegmatites intrude this supracrustal sequence and are deformed regionally. Marble floats are distributed in the whole area and in situ marble has been reported locally (A. Garde pers.com.2002). The general strike of the supracrustal package is close to E-W with steep dips to the south. The metamorphic grade is middle amphibolite facies.

Geotectonic setting: Platform sediments (quartzites, pelites and marble) intercalated with pyrite-bearing sediments. Amphibolites is also intercalated in the sequence and indicate a minor volcanic input with the possibility for exhalite formations (chert and sulphides).

Depositional environment/Geological setting: Sedimentary and volcanic sequences with syngenetic precipitations of exhalites and iron sulphides.

Age of mineralisation: Palaeoproterozoic age of the host rocks based on zircon determinations (Thrane *et al.* 2004).

Host/Associated rock types: The sulphide layers are found both in the paragneiss (biotite gneiss) and within and at the contact of the amphibolite. Most of the sulphide bands are within the biotite gneiss but the extensive mineralisation occurs close to the contact between paragneiss and amphibolite.

Deposit form: Rusty sulphide-bearing layers strikes through the landscape. These layers are parallel to the general strike and are found in 3-m wide zones (varies from 1–5 m). The sulphide richest parts are the more quartzitic rocks but can also occur in the amphibolite. The sulphides are disseminated pyrite in amounts up to 10-volume % but mm-thick laminae of massive pyrite occur as well. Magnetite is common within the host rocks.

Texture/Structure: The iron sulphide content is disseminated and the content is 5–10 volume percent. The quartzitic parts have the best-preserved pyrite. The beds are 1–5 m thick where the centre comprises of quartz, muscovite and disseminated pyrite. The rusty layers are folded together with paragneiss and amphibolite in open and isoclinal folds with 1–5 m amplitude. The fold axes are parallel to the general schistosity. In some areas steep brecciated pyrite-bearing band (1m thick) occur. In one of the subareas up to four parallel rust zones occur. N-S fault zones are common in the area (some minor strikes NW-SE) and have K-alteration within joints filled out with quartz and epidote.

Ore mineralogy (principal and *subordinate*): Pyrite, magnetite, *pyrrhotite*, *chalcopyrite and sphalerite are observed in the pyrite bearing beds.* The breccia comprises of quartz, mica, actinolite, 20% coarse-grained pyrite and *magnetite.*

Gangue mineralogy (principal and *subordinate*): Vein quartz, muscovite, kaolinite, and feldspar (albite).

Alteration: The pyrite-bearing zones are intensive altered and weathered. Kaolinisation, sericitisation and albitisation are common.

Weathering: The pyrite bearing bands have a characteristic light-yellow weathering colour and 10-volume % pyrite. The host rock is mica rich (schist), which has reddish weathering colour; feldspars are kaolinised.

Ore controls: Pyrite mineralisation occurs within the same strata but related to the regional deformation and local structures.

Genetic models: One model proposal for this sulphide iron-formation may come from hydrothermal fluids in a basin. Thus, the geological environment is syngenetic with exhalative system forming chemical sedimentary strata (chert). Replacement and vein features are found as well and due to deformation in Palaeoproterozoic time.

Analytical data:

The pyrite-bearing beds have low contents of base metals with Cu up to 0.3% and Zn up to 0.4%. Ba average 500 ppm with 1200 ppm as maximum. The Mn content is around 0.2%. The total iron content exceeds only 15% in one third of the pyrite-bearing samples. The gold content is detected in half of the samples varying from 4–21 ppb.

Exploration:

The pyrite occurrences have no commercial value.

Photos, figures and maps:

Figure 24. *The pyrite layers at Nunatarsuaq, north of Jakobshavn Isfjord.*

References:

Thrane, K., Connelly, J.N., Garde, A.A., Grocott, J. & Krawiec, A.W. 2003: Linking the Palaeoproterozoic Rinkian and Nagssugtoqidian belts of central West Greenland: implications of new U-Pb and Pb-Pb zircon ages. Geophysical Research Abstracts 5 (EGS-AGU-EUG Joint Assembly), 09275., Nice, France 2003.

Compiler and date (dd-mm-yyyy):

HST 18-11-2003

Tasiussaq (copper) Type id. no. 36

Type locality id. no.: 36

Type locality for id. nos.: 36

Locality name: Tasiussaq

Area: Jakobshavn Isfjord

Genetic relation: Hydrothermal mineralisation

GSC deposit type: 17.0 – Vein copper and hydrothermal alteration

Commodity group: Base metals

Commodities (minor): Copper

Economic significance: 4

Geological characteristics:

Description of occurrence: Pyrite and chalcocite occurs in the malachite stains within N to NNW oriented fracture/fault zones cutting through grey orthogneisses with abundant of silicic migmatitic material. Malachite stained areas are up to 0.5 m wide.

Geotectonic setting: Fracture/fault zones

Depositional environment/Geological setting: Hydrothermal in fracture zones.

Age of mineralisation: Unknown, possibly Palaeoproterozoic.

Host/Associated rock types: Archaean orthogneisses.

Deposit form: Patches with malachite staining (diameter seldom more than half a meter). Patches are found in linear fractures zones in a c. 100 m x 100 m large area.

Texture/Structure: Microcrystalline crusts and stains.

Ore mineralogy (principal and *subordinate*): Malachite, pyrite and *chalcocite.*

Gangue mineralogy (principal and *subordinate*): Quartz, feldspar, biotite.

Alteration: Fault zones in the area are often associated with red feldspar and green epidote

Weathering: Malachite is a product of weathering. Many of the stained rocks outcrop in frost-boils.

Ore controls: Fractures zones, possibly fault intersections.

Genetic models: Hydrothermal mineralisation.

Analytical data:

Four samples of the patches of malachite staining have been analysed. One sample from the most intensely mineralised parts of the patches yields 2742 ppm Cu, 403 ppb Au and 26 ppm Ag. Beside these elevated values are Sb and U elevated (25 ppm and 203 ppm respectively).

Exploration:

GEUS carried out investigation in the area in 2002, no other exploration has been carried out in the are.

Photos, figures and maps:

Figure 25. *Typical outcrop of the frost-boils with malachite staining in the fracture-zones.*

References:

Compiler and date (dd-mm-yyyy):

BMN 22-11-2003

<u>Paradisbugt 1 (copper) Type id. no. 37</u>

Type locality id. no.:	37
Type locality for id. nos.:	37
Locality name:	Paradisbugt (1)
Area:	Qasigiannguit
Genetic relation:	Copper in a fault zone
GSC deposit type:	17 – Vein copper and hydrothermal alteration
Commodity group:	Base metals
Commodities (minor):	Copper
Economic significance:	4

<u>Geological characteristics:</u>

Description of occurrence: Steep wall at Bing's cave south of Qasigiannguit has malachite staining. The malachite is concentrated in a 2-m wide zone quartzitic schists (43°/66°SE).

Geotectonic setting: Fault zone (NE-SW) in a metasedimentary sequence – platform sediments(?).

Depositional environment/Geological setting: Epigenetic - hydrothermal.

Age of mineralisation: Probably Palaeoproterozoic.

Host/Associated rock types: Paragneisses.

Deposit form: Linear structure - the mineralisation is concentrated in a 2-m wide zone and can be followed for several 100s of m (43°/66°SE). The host rock is penetrated by lots of tiny veins (veinlets), which are bleached up to a cm indicating hydrothermal activity.

Texture/Structure: The mineralised zone is related to a lineament and the mineralisation is connected to joints.

Ore mineralogy (principal and *subordinate*): Malachite, pyrite, chalcopyrite and *chalcocite* related to joints and veinlets.

Gangue mineralogy (principal and *subordinate*): Quartz; K-feldspar pegmatite is intruded in the same zone.

Alteration: Brown colouring is common on joints probably due to ankeritisation.

Weathering: Malachite staining.

Ore controls: The mineralisation is related to the fault zone (NE-SW).

Genetic models: Hydrothermal vein copper type.

Analytical data:
The metasedimets had copper content <0.1%.

Exploration:
No exploration has been carried out and no commercial grade of any metals is identified.

Photos, figures and maps:

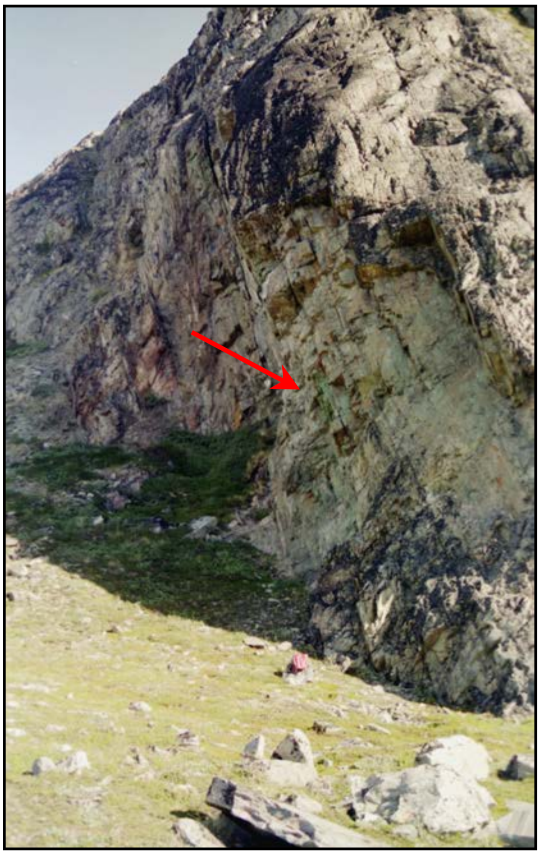

Figure 26. *Malachite staining (red arrow) in the fault zone at Paradisbugt.*

References:

Compiler and date (dd-mm-yyyy):
HST 18-11-2003

<u>Paradisbugt 2 (iron)   Type id. no. 38</u>

Type locality id. no.:	38
Type locality for id. nos.:	38
Locality name:	Paradisbugt (2)
Area:	Qasigiannguit
Genetic relation:	Skarn
GSC deposit type:	20 – Skarn deposit
Commodity group:	Iron and iron alloys
Commodities (minor):	Iron (copper)
Economic significance:	4

<u>Geological characteristics:</u>

Description of occurrence: Contact zone (66°/77°SE) between mica schist/gneiss/quartzite and marble/calc-silicate. The marble forms an open fold and comprises magnetite skarn (0.5 m) in close contact to the mica gneiss/quartzite. The magnetite skarn is to the south followed by calc-silicates (2 m), marble (5 m) including a quartzitic sulphide rich band (0,5 m), epidote skarn (1 m), epidote skarn ± pyrite (1m), calc-silicates and marble (6 m) ending up in a pegmatite.

Geotectonic setting: Platform sequence(?).

Depositional environment/Geological setting: Metasedimentary sequence.

Age of mineralisation: Probably Palaeoproterozoic.

Host/Associated rock types: Paragneisses.

Deposit form: The skarn occurrence is only found on the northern flank of the fold structure and is up to ten m wide and 100 m long. The fold flank follows a fault zone (NE-SW).

Texture/Structure: The skarn is massive with either magnetite or epidote.

Ore mineralogy (principal and *subordinate*): Magnetite, *pyrite and malachite*.

Gangue mineralogy (principal and *subordinate*): Epidote and calcite.

Alteration: None.

Weathering: Limited, but malachite staining occurs.

Ore controls: The mineralisation is related to the contact zone mica gneiss/quartzite and marble.

Genetic models: Skarn formation along strike in a combined fold and fault system (NE-SW).

Analytical data:

The magnetite skarn has up to 16.5% Fe, 13% Ca, 0.44% Sr, 0.1% Mn and 0.1% Cu.

Exploration:

No exploration has been done and no commercial value of any metals.

Photos, figures and maps:

Figure 27. *Magnetite skarn at Paradisbugt.*

References:

Compiler and date (dd-mm-yyyy):

HST 18-11-2003

Akulliq (soapstone) Type id. no. 39

Type locality id. no.: 39

Type locality for id. nos.: 39

Locality name: Akulliq

Area: Qasigannguit

Genetic relation: Calc-magnesium silicates (soapstone)

GSC deposit type: 20 – Skarn deposit

Commodity group: Industrial minerals

Commodities (minor): Soapstone

Economic significance: 4

Geological characteristics:

Description of occurrence: The soapstone is found in ENE striking fault zones and is associated with K-feldspar and epidote. These fault zones is equivalent to the general NE-striking fault zones of the region. In the sheared parts of these zones the soapstone was outcropping as 1–10 cm thick layers, where it can be followed more than 100 m. In open spaces quartz crystals were deposited.

Geotectonic setting: Fault zone

Depositional environment/Geological setting: Shearing in a fault zone

Age of mineralisation: Palaeoproterozoic.

Host/Associated rock types: Hosted in gneiss.

Deposit form: The soapstone is found in shear and along joint fractures in up to 10 cm thickness.

Texture/Structure: Shear related.

Ore mineralogy (principal and *subordinate*): Talc and chlorite.

Gangue mineralogy (principal and *subordinate*): Epidote, K-feldspar, quartz.

Alteration: Alteration along cracks where bleaching is observed.

Weathering: Not important.

Ore controls: Fault and shear controlled.

Genetic models: Formed during shearing.

Analytical data:
No data.

Exploration:
Local people use the soapstone for ornamental carvings.

Photos, figures and maps:

Figure 28. *Soapstone (arrow heads) along fault planes at Akulliq.*

References:

Compiler and date (dd-mm-yyyy):
HST 26-11-2003

Kangersuneq 1 (copper) Type id. no. 45

Type locality id. no.: 45

Type locality for id. nos.: 40, 41, 42, 43, 44, 45

Locality name: Kangersuneq (1)

Area: Qasigiannguit

Genetic relation: Iron-formation

GSC deposite type: 3.2 – Algoma-type iron-formation

Commodity group: Base metals

Commodities (minor): Copper, zinc

Economic significance: 4

Geological characteristics:

Description of occurrence: Several occurrences of semi-massive to massive iron sulphides are situated in the supracrustal belt that forms the central part of the peninsula south of Qasigiannguit. The supracrustal rocks at the peninsula can be correlated and extended southward across the fjord to similar supracrustal rock sequences, where pronounced sulphide occurrences are located.

The supracrustal rocks consists of quartzo-feldspathic paragneiss (locally with garnets), pelitic gneiss, garnet-biotite-silimanite bearing biotite schist and minor amphibolite.

The supracrustal sequence at the peninsula is folded into a major antiform and is up to c. 10 km thick. At the Qasigiannguit peninsula the sulphide occurrences are only found in the supracrustal rocks near the northern shore of the Kangersuneq fjord.

Geotectonic setting: The occurrences are probably formed in a platform environment.

Depositional environment/Geological setting: Sedimentary and submarine volcanic sequences in a sedimentary environment.

Age of mineralisation: The volcanic-associated massive sulphide occurrences at Kangersuneq are probably Palaeoproterozoic in age.

Host/Associated rock types: Mafic pelitic schist and paragneiss lithologies, with some amphibolitic sequences.

Deposit form: Massive sulphide lenses (70–90 vol.%) are commonly up to 2 m x 5 m. The lenses are either found isolated or as trains of lenses which can be followed along NE-strike for 100 m to 300 m. The disseminated to semi-massive forms of the sulphides (10–40 vol.%) occur as zones parallel to the NE-foliation of the host rock. The parallel zones can be followed for 20 m to 100 m along strike, with varying shape and concentration of sulphide mineralisation.

Texture/Structure: The sulphide minerals are disseminated to massive.

Ore mineralogy (principal and *subordinate*): Pyrrhotite dominates with minor pyrite and chalcopyrite including subordinate *magnetite.*

Gangue mineralogy (principal and *subordinate*): Mafic minerals such as biotite and amphiboles together with a relative high content of quartz.

Alteration: Possible silification.

Weathering: Locally the sulphide-rich part produces significant gossan. The disseminated to semi-massive forms often show rust colours.

Ore controls: The sulphide occur in distinct strata, which are believed to be a primary. Mobilisation and concentration of ore minerals in 'low-pressure' zones are believed to occurred during later deformation.

Genetic models: Based on the sub-marine host rock lithologies and present terrane and interpreted environment the occurrences are classified as iron-formation formed by hydrothermal fluids in a volcanogenic submarine exhalative system. Remobilisation and concentrations in tectonic structures are due to deformation and metamorphism in Palaeoproterozoic time.

Analytical data:
Samples collected by GEUS in 2002 from the semi-massive to massive sulphide occurrences of the Qasigiannguit peninsula show 17 ppb Au and 124 ppm Zn.

Exploration:
Semi-massive to massive sulphide occurrences at the Qasigiannguit peninsula was first described by Kryolitselskabet Øresund A/S during helicopter-prospecting in 1962 (Keto 1963a). The occurrences was further investigated by Kryolitselskabet Øresund A/S in 1964 (Kurki 1965). Kryolitselskabet Øresund A/S finds no interesting analytical results.

Geochemical stream sediment sampling by GGU targeted two Au anomalies in the area south of Kangersuneq fjord (Steenfelt *et al.* 1992). Three samples with 1–4 ppm Au in heavy mineral concentrate are also reported from the same area by Nunaoil A/S in 1992 (Sieborg 1992a). Based on these results was a follow-up program initiated in the area by Nunaoil A/S in 1992 (Grahl-Madsen 1993a). But anomalies were not reproduced.

The sulphide occurrences at the southern tip of the Qasigiannguit peninsula was investigated by Nunaoil in 1996 (Petersen 1997) during gold exploration in the area. Only low gold values was encountered in the sediment programme (highest value 60 ppb Au) and only four rock samples had more than 10 ppb Au with maximum values of 17 and 15 ppb Au from massive pyrrhotite occurrences.

GEUS carried out investigation in 2002, including stream sediment and heavy mineral sampling on former sampling positions, together with magnetometer and magnetotelluric surveying on selected structures. No additional new mineralisation was discovered and the geochemical gold anomalies could not be reproduced.

Photos, figures and maps:

Figure 29. *Lenticular body/pod of massive pyrrhotite situated in paragneiss lithologies (on top of it small red flag used in connection with geophysical measurements).*

References:

Grahl-Madsen, L. 1993: Avannaa 1992: Geological reconnaissance in the Nordre Strømfjord, the Lersletten, and the Kangersuneq areas. 52 pp. Unpublished report, Nunaoil A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 21316)

Keto, L. 1963: Aerial prospecting between Holsteinsborg and Umanak, West Greenland 1962 (including a minor area east of Sukkertoppen), 65 pp. Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20154)

Kurki, J. 1965: On supracrustal gneiss series with associated sulphide mineralization at Nisat Qaqa, Christianshaab district.14 pp. Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20059).

Petersen, J.S. 1997: Gold exploration in the Saqqaq, Itilliarsuup, Eqe and Christianshaab areas. 26 pp. Unpublished report, Nunaoil A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 21497).

Sieborg, B. 1992: Geochemical exploration in West Greenland. July-August1991. 36 pp. Unpublished report, Nunaoil A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 21080).

Steenfelt, A., Dam, E. & Nielsen, J.P. 1992: Reconnaissance geochemical exploration of map sheet 68 V 2 (67º55´ to 68º45´N, 50º15´to 52º45´W´), West Greenland. Open File Series Grønlands Geologiske Undersøgelse **92/7**, 14 pp.

Compiler and date (dd-mm-yyyy):

BMN 23-11-2003

<u>Kangersuneq 2 (copper)   Type id. no. 46</u>

Type locality id. no.: 46

Type locality for id. nos.: 46

Locality name: Kangersuneq

Area: Qasigiannguit

Genetic relation: Hydrothermal mineralisation

GSC deposit type: 17.0 – Vein copper and hydrothermal alteration

Commodity group: Base metals

Commodities (minor): Copper

Economic significance: 4

<u>Geological characteristics:</u>

Description of occurrence: Several 1–10cm quartz-calcite veins with pyrite, pyrrhotite and malachite occur in a 7 m long zone in amphibolite and mica schist in the northern end of the supracrustal belt south of the middle part of Kangersuneq fjord. Smaller stringers from the veins penetrated into the wall rock. The veins strike generally 173° with a steep dip towards east. Veins are especially exposed in a 3-metre high cliff-wall.

Geotectonic setting: Host rocks are predominately of sedimentary origin and may represent platform or continental basin.

Depositional environment/Geological setting: Unknown.

Age of mineralisation: Unknown.

Host/Associated rock types: Amphibolite and mafic biotite schist.

Deposit form: 1cm – 10cm thick veins. The veined zone can be followed for c. 7m. The veins comprise 10% of the zone.

Texture/Structure: Disseminated sulphides – in some cases as 2–3 cm large mineral aggregates in the veins.

Ore mineralogy (principal and *subordinate*): Pyrite, pyrrhotite and malachite.

Gangue mineralogy (principal and *subordinate*): Quartz, calcite.

Alteration: None.

Weathering: A brown colouring of the calcite is noted.

Ore controls: Direct link with a structural control such as fracture or fault zones could not be observed.

Genetic models: Hydrothermal veins.

Analytical data:
Rock samples of the quartz veins yields elevated Au, Cu and Mn.

Sample	Au ppb	Cu ppm	Mn ppm
Quartz-calcite vein with large pyrite-pyrrhotite-malachite crystal aggregates	39	6657	2633
Calcite dominated vein	30	1699	1808

Exploration:
The occurrence was discovered during GEUS activity in 2002.

Photos, figures and maps:

Figure 30. *Close-up of the quartz-calcite veins.*

References:

Compiler and date (dd-mm-yyyy):
BMN 23-11-2003

Aasiaat (iron) **Type id. no. 47**

Type locality id. no.: 47

Type locality for id. nos.: 47

Locality name: Isuamiut

Area: Aasiaat

Genetic relation: Iron-formation

GSC deposit type: 3.2 – Algoma-type iron-formation

Commodities (minor): Iron, (manganese)

Economic significance: 4

Geological characteristics:

Description of occurrence: The islands north of Aasiaat form two different groups of low-grade meatmorphosed supracrustal rocks. The eastern islands, of which Equutit Killiat is the largest, consist of pale grey, andalusite-staurolite-muscovite-biotite-garnet-quartz-bearing metasedimentary rocks interspersed with abundant fine-grained mafic sills. Graded bedding on a scale of 5–10 cm is commonly preserved, and up to *c.* 5 cm large, undeformed andalusite porphyroblasts are found in the aluminous bed tops. The coastal exposures of the western islands (of which Isuamiut is the largest) consist of dark grey, massive greenstones interspersed with smaller volumes of dark, very fine-grained chlorite schist, mixed horizons of finely layered chert and hematite-dominated, manganiferous banded iron formation and calcareous layers less than 1 m thick rich in actinolite.

Geotectonic setting: No information.

Depositional environment/Geological setting: Both the eastern and western islands represent the deposits of a volcanic basin dominated by basic magmatism with associated chemical metasedimentary rocks such as chert, banded iron formation and calcareous rocks. The intercalated clastic metasedimentary rocks are very fine grained and were thus deposited far from continental crustal sediment sources. The origin of the aluminous metasediments on the eastern islands is less clear, although they may also be pelagic sediments.

Age of mineralisation: Archaean.

Host/Associated rock types: Quartzo-feldspathic orthogneisses.

Deposit form: Stratiform zones of iron oxide layers in mafic volcanic rocks. Host strata have generally been folded and deformed.

Texture/Structure: Semi-massive.

Ore mineralogy (principal and *subordinate*): Hematite, magnetite and *Mn-oxides.*

Gangue mineralogy (principal and *subordinate*): Chert.

Alteration: None.

Weathering: Rusty appearrance and black Mn-oxide.

Ore controls: Mineralisation is formed within mafic rocks.

Genetic models: One model proposal for this iron formation may come from exhalite fluids in a bassin. Thus, the geological environment is syngenetic in an active submarine exhalative system and association with chemical sedimentary strata.

Analytical data:
No data.

Exploration:
None.

Photos, figures and maps:

Figure 31. *Banded iron formation at Isuamiut, near Aasiaat. Photo: A.A. Garde (GEUS)*

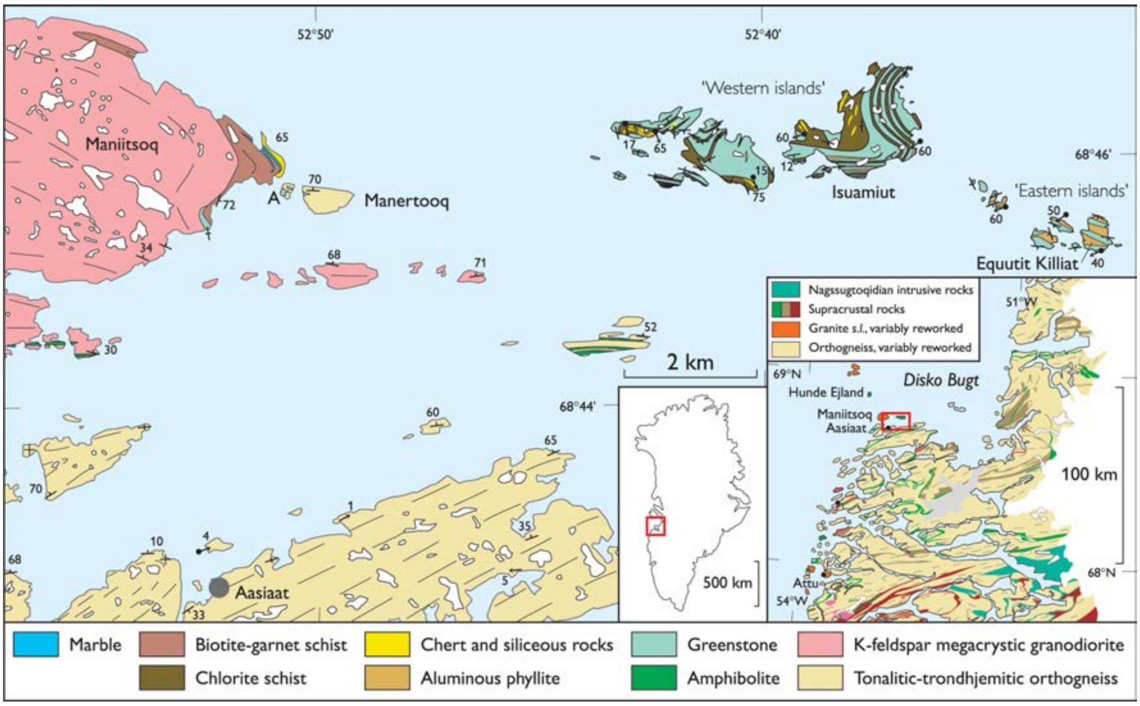

Figure 32. *Geological map of the low-grade, low-strain area north of Aasiaat. The banded iron formation occur at the island Isuamiut. Map modified from Garde et al. (2004).*

References:

Garde, A.A., Christiansen, M.S., Hollis, J.A., Mazur, S. & van Gool, J.A.M. 2004: Well preserved basaltic, chemical and clastic supracrustal rocks norht of Aasiaat: a low presure, low strain zone of presumed Archaean age, northern Nagssugtoqidian orogen, West Greenland. Danmark og Grønlands Geologiske Undersøgelse Rapport **2004/17**, 14–15.

Compiler and date (dd-mm-yyyy):

HST/AAG 04-02-2004

Ikamiut (copper) Type id. no. 48

Type locality id. no.: 48

Type locality for id. nos.: 48

Locality name: Ikamiut

Area: Aasiaat

Genetic relation: Iron-formation

GSC deposit type: 3.2 Algoma-type iron-formation

Commodity group: Base metals

Commodities (minor): Copper, zinc

Economic significance: 4

Geological characteristics:

Description of occurrence: Sulphide mineralisation within the supracrustal rocks of the Ikamiut region, which comprises mica schist and mafic metavolcanic rocks. The mica schists have rusty weathered zones with biotite-garnet schists traceable for some hundreds of metres. They are graphite bearing and could also contain cm-dm calc-silicate lenses with pyrrhotite. The Ikamiut supracrustal rocks are, in general, similar to those described from Naternaq, although no carbonate rocks, marbles, banded iron-formation or layered cherts have been recorded (Østergaard *et al.* 2002)

Geotectonic setting: The supracrustal rocks with siliceous calc-silicate lenses suggest that the iron-formations are formed as a platform sequence.

Depositional environment/Geological setting: Sedimentary and submarine volcanic sequences in a sedimentary environment. The minor iron-formation mineralisation is distal to volcanic centres.

Age of mineralisation: No precise date is known but the supracrustal sequence is anticipated to be Palaeoproterozoic.

Host/Associated rock types: Supracrustal rocks enveloped in an Archaean gneiss sequence.

Deposit form: Stratiform zones within sedimentary rocks and mafic volcanic rocks. Hosting strata have been folded and deformed and sulphides remobilised in fold hinges. About 5 kilometres west of the Ikamiut an iron sulphide mineralised siliceous calc-silicate lens with dimensions of 5 x 20 m occurs in metavolcanics. Quartz bands up to 1 cm thick together with discontinuous pyrrhotite lamination (~5 vol.%) is present together with disseminated magnetite.

Texture/Structure: Disseminated sulphide minerals in mica schist and amphibolite or sulphides in crosscutting quartz veins.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, pyrite, *chalcopyrite and graphite.*

Gangue mineralogy (principal and *subordinate*): Calc-silicates.

Alteration: None

Weathering: Sulphide-rich parts produce significant gossans.

Ore controls: Stratiform iron-formations.

Genetic models: it is proposed for that the sulphide occurrences are formed as exhalite fluids in a basin. Replacement and vein features are due to deformation in Palaeoproterozoic time.

Analytical data:

The iron-formation has varying metal contents with Cu 0.01–0.16%, Ni 0.01–0.2%, Mn 0.1–0.16% and Zn 50–540 ppm. Gold is not observed except for 5cm pyrite aggregates in pegmatite, which has 132 ppb Au.

Exploration:

No exploration has been carried out except for reconnaissance by GEUS in 2001.

Photos, figures and maps:

For location see map under type locality id no 58.

References:

Østergaard, C., Garde, A.A., Nygaard, J., Blomsterberg, J., Nielsen, B.M., Stendal, H. & Thomas, C.W. 2002: The Precambrian supracrustal rocks in the Naternaq (Lersletten) and Ikamiut areas, central West Greenland. Geology of Greenland Survey Bulletin **191**, 24–32.

Compiler and date (dd-mm-yyyy):

HST/ML 19-11-2003

Kangaatsiaq 1 (copper) Type id. no. 50

Type locality id. no.: 50

Type locality for id. nos.: 49, 50

Locality name: Kangaatsiaq (1)

Area: Aasiaat

Genetic relation: Iron-formation

GSC deposit type: 3.2 – Algoma-type iron-formation

Commodity group: Base metals

Commodities (minor): Copper, zinc

Economic significance: 4

Geological characteristics:

Description of occurrence: The sulphide bearing bands are often associated with calc-silicate lenses and siliceous gneiss/chert bands. They are graphite bearing and contain cm-dm calc-silicate lenses with trace of pyrrhotite. The mafic metavolcanics have occasional disseminated to semi-massive iron sulphide mineralisation ± copper.

Geotectonic setting: In Palaeoproterozoic supracrustal rocks deposited in a platform sequence.

Depositional environment/Geological setting: Sedimentary and submarine volcanic sequences in a sedimentary environment. The minor iron-formation mineralisation is distal to volcanic centres.

Age of mineralisation: The sedimentary platform sequence is supposed to have been formed between 1950–1920 Ma.

Host/Associated rock types: Supracrustal rocks enveloped in an Archaean gneiss sequence. The supracrustal rocks of the Kangaatsiaq region are similar to the Naternaq and Ikamiut supracrustal rocks, which comprises mica schist and mafic metavolcanic rocks. The mica schists have rusty weathered zones with biotite-garnet schists traceable for some hundreds of metres.

Deposit form: Stratiform zones of calc-silicate lenses in mafic volcanic rocks. Host strata have generally been folded and deformed.

Texture/Structure: Highly variable. Disseminated sulphide minerals in mica schist and amphibolite or sulphides in crosscutting quartz veins. Magnetite is present in some occurrences.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, pyrite, and chalcopyrite

Gangue mineralogy (principal and *subordinate*): Calc-silicates.

Alteration: Silicification of the calc-silicate lenses is observed locally.

Weathering: Sulphide-rich parts produce malachite and azurite or locally gossans.

Ore controls: Base metals occurrences are stratabound and only formed within, or near, mafic rocks.

Genetic models: The model proposal for this suphide carrying iron-formation is as exhalite fluids in a bassin. Thus, the geological environment is syngenetic in an active submarine exhalative system and in association with chemical sedimentary strata. Replacement and vein features are due to deformation in Palaeoproterozoic time.

Analytical data:
Id. no. 50: The base metal values are Cu averaging 500 ppm and Zn values below 100 ppm. The nickel contents average 200 ppm and the Mn averages nearly 0.15%.

Id. no. 49: Cu 1.26%, Zn 0.19%, Mn 0.12%, Bi 277 ppm and Au 20 ppb.

Exploration:
Some Ujarassiorit information occurs and reconnaissance has been carried out by GEUS.

Photos, figures and maps:

References:

Compiler and date (dd-mm-yyyy):
HST/ML 19-11-2003

Kangaatsiaq 2 (copper) Type id. no. 51

Type locality id. no.: 51

Type locality for id. nos.: 51

Locality name: Kangaatsiaq (2)

Area: Aasiaat

Genetic relation: Pegmatite

GSC deposit type: 21 – Granitic pegmatite

Commodity group: Precious metals

Commodities (minor): Copper, gold, (cobalt)

Economic significance: 4

Geological characteristics:

Description of occurrence: The pegmatite is hosted in grey gneiss and banded amphibolite.Quartz-feldspar-(biotite) minerals dominate white pegmatites in the area. One pegmatite has been found to contain interesting element contents with respect to exploration. It has a conspicuous brown and yellow limonite coating due to weathering of fist sized aggregates of coarse-grained pyrite. The pyrite is located in the central part of the pegmatite together with minor disseminated magnetite.

Geotectonic setting: Pegmatite formation.

Depositional environment/Geological setting: Intrusive both into gneisses and supracrustal rocks.

Age of mineralisation: Palaeoproterozoic in age, close to 1800 Ma.

Host/Associated rock types: Gneiss, amphibolites and S-type granites

Deposit form: A white pegmatite,10 m wide and 75 m long with a conspicuous brown and yellow limonite coating. The coating is due to weathering of fist sized aggregates of coarse grained pyrite occurring in the central part of the pegmatite together with minor disseminated magnetite.

Texture/Structure: Cm-dm large aggregates of pyrite.

Ore mineralogy (principal and *subordinate*): Pyrite, *chalcopyrite and magnetite*.

Gangue mineralogy (principal and *subordinate*): Quartz, feldspar and biotite.

Alteration: No general alteration.

Weathering: The pegmatite has yellow and brown rust weathering due to the pyrite content.

Ore controls: Confined to the pegmatite formation.

Genetic models: Pegmatites are formed between the regional F3 folding (c. 1825 Ma) and D4 deformation (c. 1775 Ma).

Analytical data:

Pyrite aggregates contains: Au 417 ppb, Ag 8.1 ppm, Cu ~1%, Co ~0.15%, and Ni 260 ppm.

Exploration:

No exploration has been done concerning sulphide carrying pegmatites.

Photos, figures and maps:

References:

Compiler and date (dd-mm-yyyy):

HST 27-11-2003

Naternaq (copper-zinc) Type id. no. 58

Type locality id. no.: 58

Type locality for id. nos.: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 158

Locality name: Naternaq

Area: Aasiaat

Genetic relation: Volcanic-associated massive sulphide

GSC deposit type: 6.3 – Volcanic-associated massive sulphide base metals

Commodity group: Base metals

Commodities (minor): Copper, zinc, (gold)

Economic significance: 3

Geological characteristics:

Description of occurrence: The Naternaq supracrustal belt consists of metavolcanic rocks interlayered with metasedimentary pelitic and psammitic schists and gneiss, carbonate/marble units, chert-rich layers, and minor quartzite and banded iron-formation. In total, these units define an up to 3 km thick supracrustal sequence which is folded into a major shallow-dipping WSW trending antiform. It can be traced for approximately 30 km along strike. The sequence is intruded by granite sheets and pegmatite veins. A detailed description of the stratigraphy of the supracrustal rocks is given by (Østergaard *et al.* 2002; Stendal *et al.* 2002).

Massive to semi-massive sulphide occurrences is found in several distinct rusty beds in the Naternaq supracrustal belt. This unit is near the contact of fine-grained amphibolite of the metavolcanic series and a discontinuous carbonate unit. The mineralised unit consists of banded chert layers, the sulphide-bearing sediments and carbonate schists, which occur within both the amphibolite and adjacent calc-silicate altered carbonate units. Banded iron-formation occurs locally over the amphibolite in exhalite zones composed of cm-banded layers of magnetite, siderite ± quartz and calc-silicates.

Geotectonic setting: The platform metasdiments intercalted with mafic volcanic rocks and massive sulphides is similar to Besshi-type semi-massive sulphide deposits.

Depositional environment/Geological setting: Sedimentary, submarine volcanic sequences and exhalites in a sedimentary environment. A range of variably altered, conformable horizons of very fine-grained siliceous and sulphidic lithologies associated with either amphibolite or marble are interpreted as volcanogenic-exhalitic rocks (Østergaard *et al.* 2002; Stendal *et al.* 2002).

Age of mineralisation: The volcanic-associated massive sulphide at Naternaq is probably Palaeproterozoic in age and the volcanic rocks are related to the subduction environment formed together with the Arfersiorfik complex around 1920 Ma.

Host/Associated rock types: The supracrustal rocks, which are enveloped in an Archaean gneiss terrane and intruded by granites and pegmatites.

Deposit form: Massive sulphide lenses (70–90 vol.%) are usually 2 x 4 m in size, but lenses up to 2 x 10 m are observed. Semi-massive sulphides (20–50 vol.%) occur as 0.5–1m thick parallel zones that can be followed for 50–100 m along strike. Disseminated sulphides are common in the host amphibolite, marble and mica schist adjacent to the massive and semi-massive sulphide occurrences. Many of the massive sulphide lenses occur in the hinge zones of small-scale folds. The sulphidic exhalite horizons are commonly extensively crushed along narrow, secondary fault zones.

Texture/Structure: Massive to semi-massive pyrrhotite. Light grey, finely laminated (millimetre-scale) cherty rocks predominate and usually contain up to c. 20% dark, very fine-grained sulphidic seams. The fine lamination, which may be a primary feature, is in most places destroyed by intense secondary alteration characterised in the field by a sulphide-yellow, variably rusty appearance (Østergaard *et al.* 2002). Seams of fine-grained dolomite and micaceous metasediments are commonly intercalated with the mineralised cherty layers, resulting in composite, rusty weathering outcrops with variable mineralogy.

Ore mineralogy (principal and *subordinate*): The Fe-sulphide content is generally high and pyrrhotite dominates with minor chalcopyrite and sphalerite including subordinate *pyrite, arsenopyrite, magnetite and graphite.*

Gangue mineralogy (principal and *subordinate*): Calc-silicate minerals such as tremolite-actinilite, diopside, and dolomite.

Alteration: Sulphidisation (pyrrhotitisation) is common in wall rocks adjacent to crosscutting shears and/or quartz veins.

Weathering: Sulphide-rich parts produce significant gossans.

Ore controls: The mineralisation is found in exhalite-formations and the sulphides are often remobilised within local structures (folds).

Genetic models: The Naternaq occurrence is classified as a volcanic-associated massive sulphide.

Analytical data:

Chemical analyses yield up to 2.7% Cu and 3.75% Zn (Vaasjoki 1965). Nunaoil has re-analysed the KØ drill cores for gold and found Au values of up to 0.6 ppm over 0.35 m and 190ppb over 2 m (Gowen 1992). In the same campaign Nunaoil obtained maximum analytical values for Cu, Zn and Ni as 1510, 2860, and 730 ppm respectively.

Sulphide-bearing samples from the GEUS study yield gold values between 20–80 ppb, Cu up to 0.1%, Zn 0.3%, Mn 0.25% and 500 ppm Ni. The results of GEUS and Nunaoil are comparable but the high Cu and Zn contents reported in the mid 60s have not been reproduced.

Exploration:
Vaasjoki (1965) has estimated the sulphide concentrations to be 2.4–4.8 mill.t in an indicated resource and 8.1–16.2 mill.t of inferred sulphide ore. Based on the current understanding of the structures, these figures seem to be a bit on the optimistic side.

Previous work: The Naternaq supracrustal belt was outlined by (Henderson 1969). Kryolitselskabet Øresund A/S undertook a major base metal exploration programme in the region in 1962-1964, which concentrated on the most extensively mineralised southern part of the Naternaq supracrustal belt, following the discovery of the Naternaq deposit in 1962 (Keto 1963b; Vaasjoki 1964; Vaasjoki 1965). In 1978 a regional airborne magnetic and electromagnetic survey covered parts of central West Greenland including Naternaq (Peltonen 1968). In 1990-1993 Nunaoil A/S prospected at Naternaq with ground geophysical VLF and magnetic surveys, as well as a regional sediment sampling programme (Gowen 1992; Grahl-Madsen 1992; Grahl-Madsen 1993b; Sieborg 1992b).

In 1992 a high resolution aeromagnetic survey was carried out in central West Greenland by Geoterrex Ltd (Canada), financed by Danish and Greenlandic sources. A regional interpretation of the aeromagnetic data by (Schacht 1992) distinguished several areas of supracrustal rocks, including those at Naternaq, as well as other geological features. The Lersletten supracrustal belt including the mineral occurrences stands out as a prominent magnetic low, whereas orthogneisses generally produce banded linear anomalies of intermediate amplitude.

Photos, figures and maps:

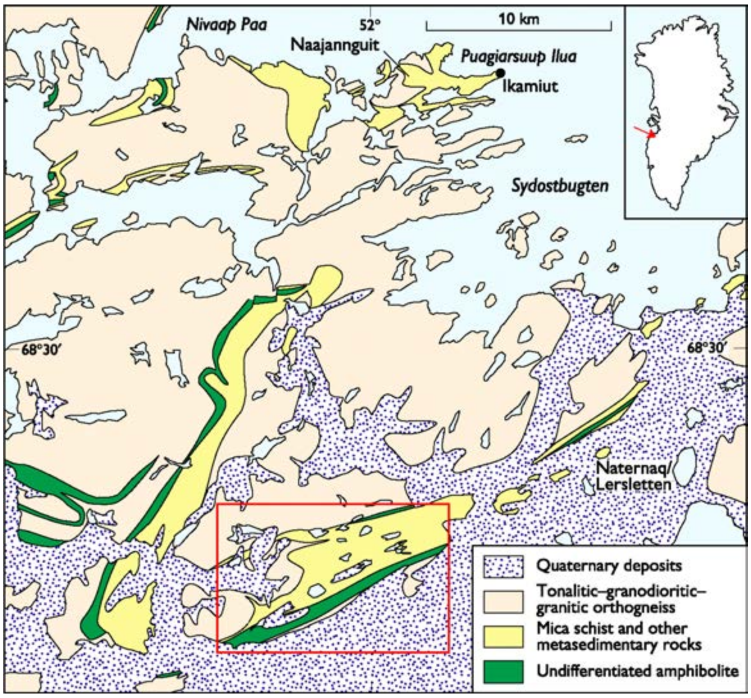

Figure 33. *Geological sketch map of Sydostbugt and the Naternaq area. Red box outlines the Naternaq map below.From Østergaard et al. (2002).*

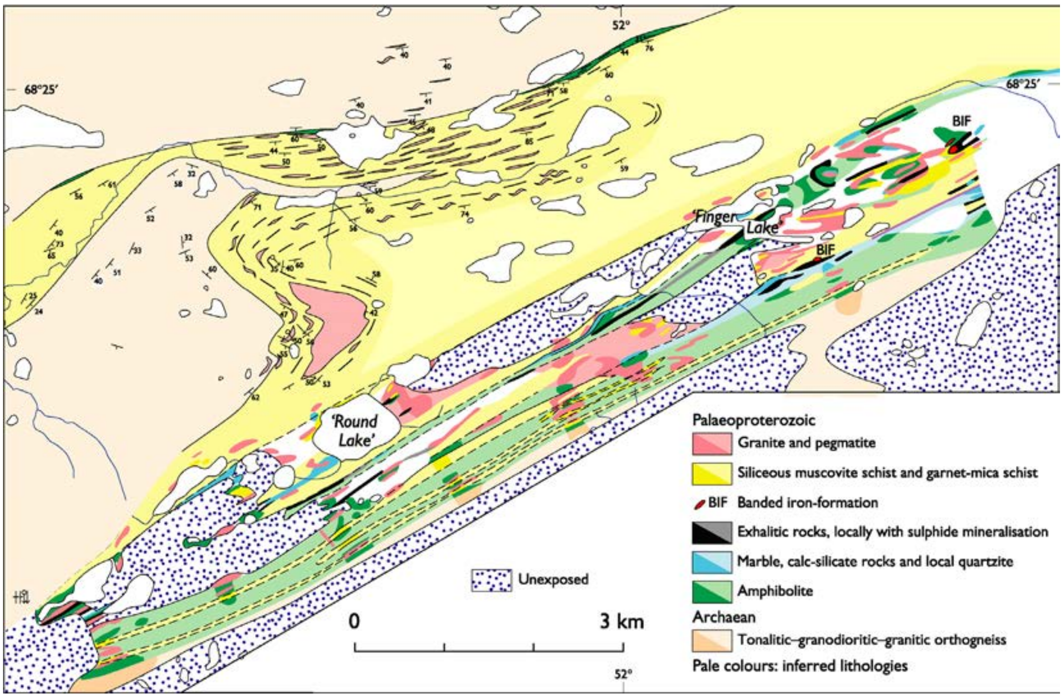

Figure 34. *Map of the central part of Naternaq with indications of banded iron formation and exhalatic rocks, locally with iron sulphides. From A.A. Garde, GEUS, (pers. com.)*

Figure 35. *Naternaq massive sulphide occurrence ('Rust Hill'). Distance across the hill is c. 100 m.*

Figure 36. *Pyrrhotite ore from Naternaq.*

Figure 37. *Carbonate-oxide facies banded iron formation in the southern part of the Naternaq supracrustal belt (see detailed map above for location).*

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Vaasjoki, O. 1965: Conclusions on the geology and ore mineralisations investigated in the Lersletten area, West Greenland 1964. [KØ /48], 22 pp., 3 plates. Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20070).

Østergaard, C., Garde, A.A., Nygaard, J., Blomsterberg, J., Nielsen, B.M., Stendal, H., & Thomas, C.W. 2002: The Precambrian supracrustal rocks in the Naternaq (Lersletten) and Ikamiut areas, central West Greenland. Geology of Greenland Survey Bulletin **191**, 24–32.

Compiler and date (dd-mm-yyyy):

HST 19-11-2003

Attu 1 (REE) **Type id. no. 63**

Type locality id. no.:	63
Type locality for id. nos.:	63
Locality name:	Attu (1)
Area:	Kangaatsiaq
Genetic relation:	Pegmatite
GSC deposit type:	21 – Granitic pegmatite
Commodity group:	Speciality metals
Commodities (minor):	REE (thorium)
Economic significance:	4

Geological characteristics:

Description of occurrence: Pegmatites in the gneisses and at contacts between major lithological units have large aggregates of magnetite, allanite and occasionally pyrite.
Throughout the study area the gneisses are intruded by granite and by common K-feldspar pegmatites with K-feldspar crystals often more than 10 cm in size. The pegmatites occur as concordant and discordant dm–m sized bodies and bands and are most frequent in the outer fjord zone between Attu and Aasiaat.

Geotectonic setting: Pegmatite formation regionally.

Depositional environment/Geological setting: The pegmatites occur both in gneiss's and suprcrustal rocks.

Age of mineralisation: Palaeoproterozoic in age (Pb-Pb of allanite) gave an isochron age of 1785$\pm$7 Ma (MSWD = 13).

Host/Associated rock types: Gneiss and S-type granites

Deposit form: The pegmatites vary in thickness from dm and up to 5-m with length of several hundreds of metres. The strike of the pegmatites differs from place to place and they are hosted in gneiss and amphibolite. Zonation is occasionally seen as quartz in the centre surrounded by K-feldspars.

Texture/Structure: Allanite and magnetite are found as cm large aggregates and allanite also as up to 5-cm large crystals. The K-feldspar crystals are often up to 10 cm in size.

Ore mineralogy (principal and *subordinate*): S*phene, allanite, apatite, magnetite and Fe-sulphides*.

Gangue mineralogy (principal and *subordinate*): K-feldspar, quartz, biotite.

Alteration: Pegmatitic gneiss in contact to amphibolite causes pyritisation of the amphibolite up to one meter. These rusty zones have often magnetite and pyrite.

Weathering: The pegmatites are generally not weathered.

Ore controls: Pegmatite related.

Genetic models: Pegmatites are formed between the regional F3 (c. 1825 Ma) and D4 (c. 1775 Ma).

Analytical data:

One allanite sample shows the following rare earth elements content: La 1.45%, Ce 1.67%, Nd 0.356%; Sm 335 ppm, and Eu 14.8 ppm. Other element contents are Zr 0.95%, Hf 254 ppm, Y 100 ppm, Sc 22.1 ppm, and Th 1790 ppm.

Exploration:

No exploration has been done concerning pegmatites.

Photos, figures and maps:

Figure 38. *Pegmatite with large black allanite crystal (1 cm wide). Photo Karl Marcussen, Attu.*

Figure 39. *Close-up of pegmatite with allanite crystals from Attu.*

References:

Compiler and date (dd-mm-yyyy):
HST 20-11-2003

Attu 2 (copper) Type id. no. 64

Type locality id. no.: 64

Type locality for id. nos.: 64, 65

Locality name: Attu (2)

Area: Kangaatsiaq

Genetic relation: Hydrothermal activity in fault zone

GSC deposit type: 17 – Vein copper and hydrothermal alteration

Commodity group: Base metals

Commodities (minor): Copper

Economic significance: 4

Geological characteristics:

Description of occurrence: Sulphide occurrences are found in within several prominent faults with a remarkably uniform orientation (SSW–NNE) cutting through all lithologies in the region. Alteration is intense silicification along the fault planes. The width of the silicified zones is in most places less than a few metres and in some cases only a few centimetres. At id. no. 65 a NNE striking valley (~one km long) represents a fault zone, which on the eastern side has a supracrustal suite and the western side is dominated by gneiss. The supracrustal rocks comprise mica-garnet schists, marble, calc-silicate rocks and sulphide-bearing rocks. Several rust sites are located on the east side of the valley and most intensely where the mica schist cut the fault zone. The sulphide occurrences all lie along the fault zone and reflect hydrothermal activity. This is the most extensive hydrothermal activity known from the Taateraat area.

Geotectonic setting: The fault zone is probably Palaeoproterozoic, which has the regional strike (NNE) of fault zones.

Depositional environment/Geological setting: Hydrothermal formation.

Age of mineralisation: Probably Palaeoproterozoic.

Host/Associated rock types: The host rocks are Archaean grey gneiss and supracrustal rocks.

Deposit form: Linear hydrothermal zone followed for one km and up to a couple of hundreds m wide.

Texture/Structure: No information

Ore mineralogy (principal and *subordinate*): Pyrite and *chalcopyrite.*

Gangue mineralogy (principal and *subordinate*): Quartz, muscovite and biotite.

Alteration: The fault zone is silicified and pyritized.

Weathering: Sulphide-rich parts are weathered to goehtite.

Ore controls: The east side of the valley has the most intensely pyrite-bearing zones especially where mica schist cuts the fault zone.

Genetic models: The occurrences are controlled by fault systems.

Analytical data:

The pyrite bearing samples yield 0.1% Cu, 0.05% Zn and 2.1% Mn. The gold content is detectable but only 11–13 ppb.

Exploration:

No exploration has been carried out in the area.

Photos, figures and maps:

Figure 40. *The fault valley at Attu 2 – rust zones are located with the valley, especially where mica schist cut the fault.*

References:

Compiler and date (dd-mm-yyyy):

HST 21-11-2003

Attu 3 (gold)   Type id. no. 70

Type locality id. no.: 70

Type locality for id. nos.: 66, 67, 68, 69, 70

Locality name: Attu (3)

Area: Kangaatsiaq

Genetic relation: Copper-gold in fault zone

GSC deposit type: 17 – Vein copper and hydrothermal alteration

Commodity group: Precious metals

Commodities (minor): Gold (copper)

Economic significance: 3

Geological characteristics:

Description of occurrence: A prominent shear zone in the southern Attu area is 100–330 m wide. This zone is complex and consist of three parallel fault systems, that strikes NNE and dips 60–70^o W. A gold-bearing mylonite and shear zone cut through granulite and/or high amphibolite facies gneisses. The shear zone is pegmatised with 30–40 cm wide veins consisting of red K-feldspar and quartz with occasional magnetite. The estimated relative volume of pegmatite in the shear zone varies from 1–10 % in the shear zone (Stendal *et al.* 2002).

Geotectonic setting: Archaean gneisses and amphibolites.

Depositional environment/Geological setting: The best gold-bearing zone is found in a coastal profile along the mylonite and shear zone.

Age of mineralisation: Probably Palaeoproterozoic as supposed for the NE-SW fault zones in the region.

Host/Associated rock types: The host rock is Archaean grey gneiss but close to an amphibolite contact.

Deposit form: The best site is a cliff exposure consisting of 5–20 cm wide bands of mylonite and a rusty band (10–20 cm) with pyrite, magnetite and some chalcopyrite. The fault zone can be followed along strike in northeasterly direction for several kilometres.

Texture/Structure: Pyrite and chalcopyrite replace magnetite. The magnetite is cataclastic but recrystallised magnetite does also occur.

Ore mineralogy (principal and *subordinate*): Magnetite, pyrite, *chalcopyrite and gold.*

Gangue mineralogy (principal and *subordinate*): Quartz, K-feldspar, muscovite, biotite and carbonates (calcite, dolomite or ankerite).

Alteration: The mylonite zone is silicified at the contact to the mineralised zone.

Weathering: Sulphide-rich parts are weathered to goehtite.

Ore controls: Mineralisation is within, or near, favourable mylonite/shear/fault zone. The gold is positively correlated with the sulphide and copper content.

Genetic models: The occurrences are controlled and occur in faults. In the fault systems vein and breccia zones occur.

Analytical data:
The main gold locality has reproducible gold values from 2.3 to 5.8 ppm. Other localities in the same type of fault structure have 90 ppb Au (id. no. 67) 2.24 ppm (id. no. 68) and 124 ppb Au (id. no. 69).

Exploration:
The site was found due to an Ujarassiorit sample delivered in 2000. GEUS has visited the locality during fieldwork in 2001 and in 2002.

Photos, figures and maps:

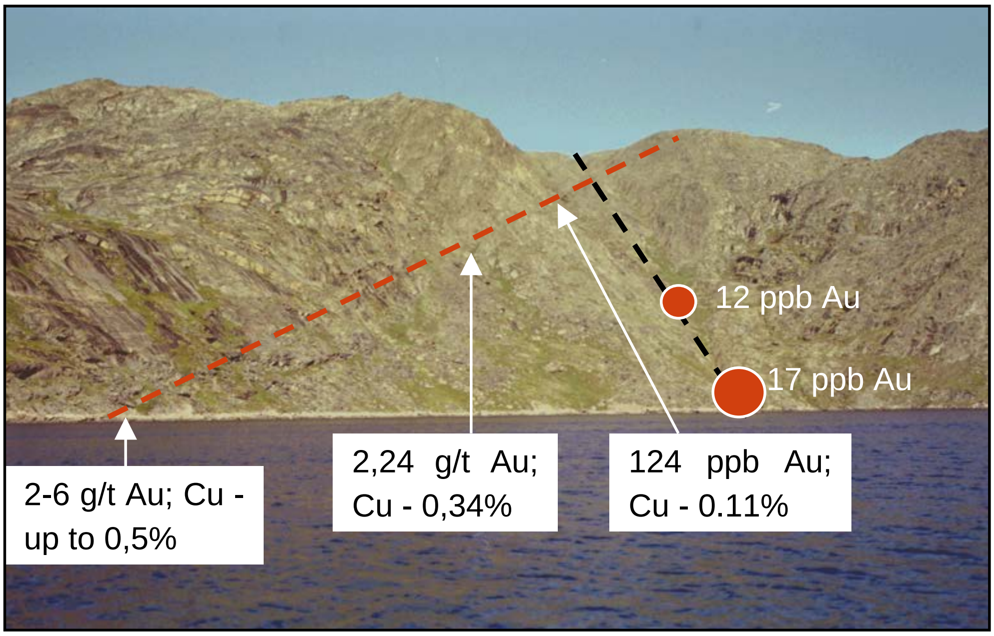

Figure 41. *The shear zone hosting the gold mineralisation south of Attu is indicated by the dashed red line. Gold and copper values in the white boxes are from rock samples. The red circles indicates locations for sampled stream sediments – and their gold content.*

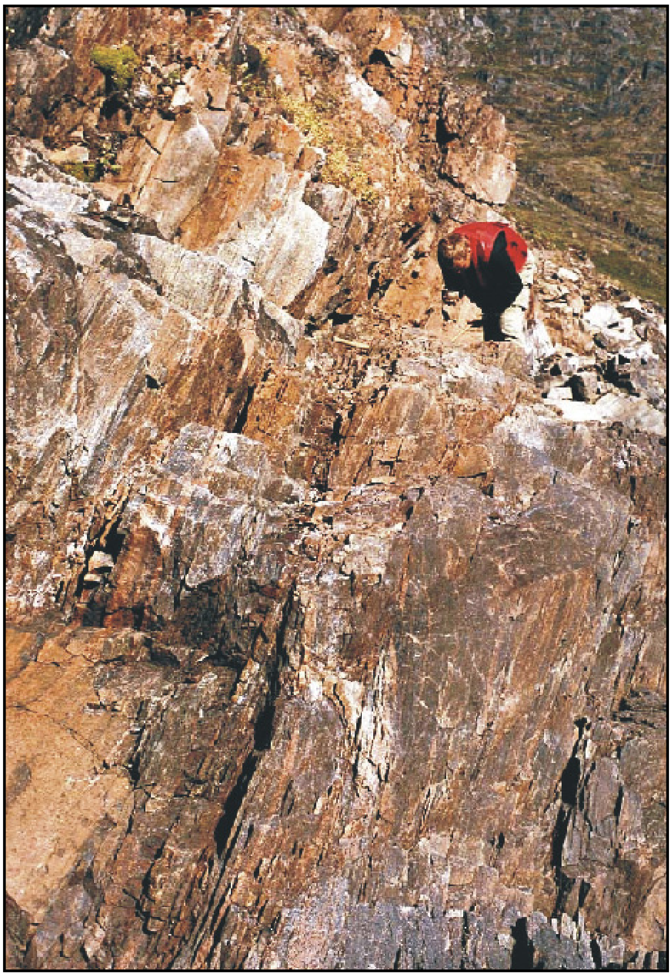

Figure 42. *The shear zone with mylonite and associated magnetite, pyrite and gold mineralisation, south of Attu.*

Figure 43. *Close-up of the gold bearing horizon in the shear zone with malachite staining (just above the white scale card, 5 cm wide).*

References:

Stendal, H., Blomsterberg, J., Jensen, S.M., Lind, M., Madsen, H.B., Nielsen, B.M., Thorning, L. & Østergaard, C. 2002: The mineral resource potential of the Nordre Strømfjord - Qasigiannguit region, southern central West Greenland. Geology of Greenland Survey Bulletin 191, 39–47.

Compiler and date (dd-mm-yyyy):

HST 20-11-2003

Ataneq 1 (copper) **Type id. no. 71**

Type locality id. no.: 71

Type locality for id. nos.: 71, 72, 73, 74, 75

Locality name: Ataneq (1)

Area: Kangaatsiaq

Genetic relation: Volcanic-associated massive sulphide

GSC deposit type: 6.3 – Volcanic-associated massive sulphide base metals

Commodity group: Base metals

Commodities (minor): Copper, zinc

Economic significance: 3

Geological characteristics:

Description of occurrence: Semi-massive pyrrhotite lenses occur in the area between Giesecke Sø and Ataneq over a strike length of about 22 km (Madsen 2003; Platou 1967; Platou 1968). The supracrustal rocks in the area have an overall strike of 265° and dip 60°N, parallel to the Nordre Strømfjord steep belt. Massive to semi-massive pyrrhotite occurs in a supracrustal sequence composed of foliated amphibolite, biotite garnet ± graphite ± sillimanite gneiss and skarn a ± sulphide mineral (Stendal *et al.* 2002). The metamorphic grade is upper amphibolite facies.

Geotectonic setting: The volcano-sedimentary sequence is part of the Nordre Srømfjord associations believed to have been a volcanic arc formed during the subduction around 1920 Ma.

Depositional environment/Geological setting: Sedimentary and submarine volcanic sequences with pelitic sediments, exhalites and volcanic mafic rocks. A difference from the Naternaq deposit is more graphite and less carbonate in the Ataneq occurrences.

Age of mineralisation: The volcanic-associated massive sulphide base metal at Ataneq is probably Palaeproterozoic in age and the volcanic rocks are related to the subduction environment formed together with the Arfersiorfik complex around 1920 Ma (Kalsbeek *et al.* 1987). The sedimentation took place around 1950–1920 Ma and the subduction from 1920–1870 (van Gool 2002).

.

Host/Associated rock types: The semi-massive sulphide lenses are hosted in pelitic sediments (paragneisses), leucocratic garnet biotite gneisses, mafic rocks and Fe-Mn rich exhalites.

Deposit form: Platou (1967, 1968) divide the 22-km long belt into eight sulphide occurrences. Madsen (2003) describes the same linear belt but divide it into three sub-areas named (from West to East) Simiutannguaq, Maligiaq, and Illuarssuit. The pyrrhotite occurrences form two parallel layers up to one metre thick and with varying length (10–100 m). The most common host rocks to the pyrrhotite lenses are skarn, amphibolite, biotite garnet gneiss and some altered silicified lithologies, which occasionally contain notable amounts of graphite. In some places skarn minerals enclose the pyrrhotite.

Texture/Structure: Pyrrhotite occurs as hypidioblastic grain in mm-size and a granoblastic texture. The pyrrhotite shows 'bird's eye' texture with pyrite and marcasite as alteration products. Chalcopyrite is often interstitial in the pyrrhotite. Sphalerite occurs always associated with chalcopyrite (Madsen 2003).

Ore mineralogy (principal and *subordinate*): Pyrrhotite dominates with minor amounts of *pyrite, chalcopyrite, sphalerite and arsenopyrite.* The oxide minerals are *ilmenite, magnetite, rutile and goethite (and lepidocrocite).*

Gangue mineralogy (principal and *subordinate*): Calc-silicates.

Alteration: No distinct alteration pattern.

Weathering: Sulphide-rich lenses produce significant gossans.

Ore controls: The mineralisation is formed within exhalite-formations.

Genetic models: Precambrian volcanic-associated massive sulphide base metal occurrences are common in greenstone belts. The Palaeoproterozoic Ataneq occurrences are low in base metals. The best volcanic-associated massive sulphide analogy is the Besshi-type semi-massive sulphide deposits.

<u>Analytical data:</u>

Chip samples of 17 semi-massive pyrrhotite lenses within the 22 km long linear belt:

Semi-massive sulphide	Cu %	Ni %	Zn %	Mn %	Ag ppm	Au ppb
Chip samples (average 17)	0.06	0.03	0.1	0.07	2	23
Chip samples (max. value)	0.32	0.06	0.35	0.27	3.3	44

The exhalites are in general enriched in Ba and Mn (Madsen 2003). Earlier chemical data of the pyrrhotite mineralisation gave similar results as those obtained by Madsen (2003) (Car 1996; Geyti & Pedersen 1991; Gothenborg 1980; Platou 1968).

<u>Exploration:</u>

Platou (1967) discovered the sulphide occurrences. Exploration activities have been carried out by the mining companies Kryolitselskabet Øresund (Gothenborg 1980), Nunaoil A/S (Geyti & Pedersen 1991) and Inco Ltd. (Car 1996).

Photos, figures and maps:

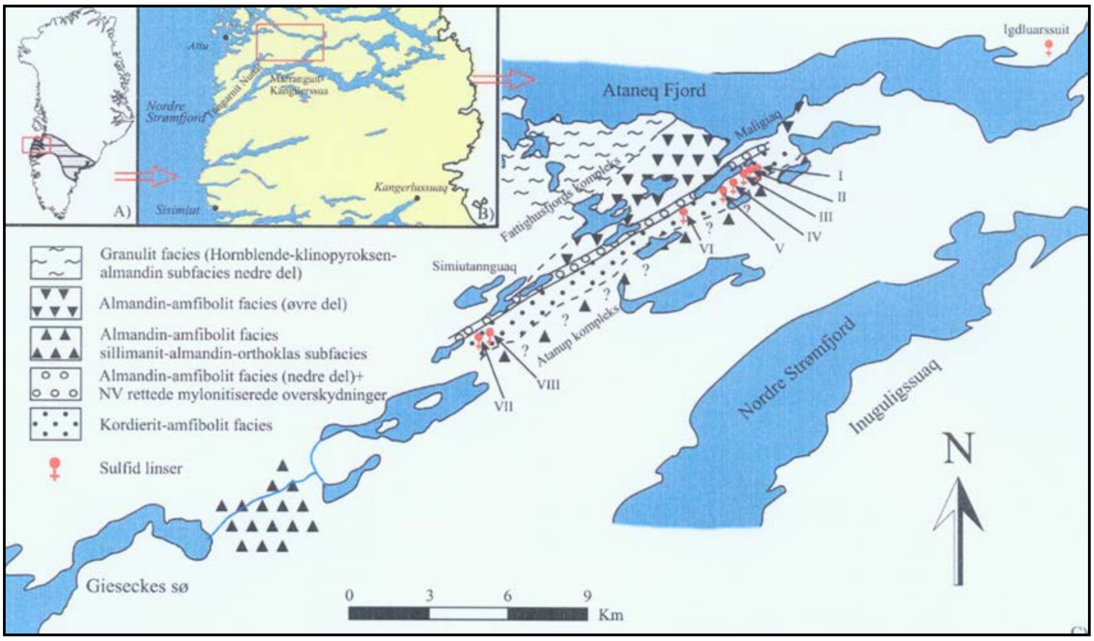

Figure 44. *Geological sketch map of the Ataneq area with indication of sulphide lenses (red dots). From Madsen (2003).*

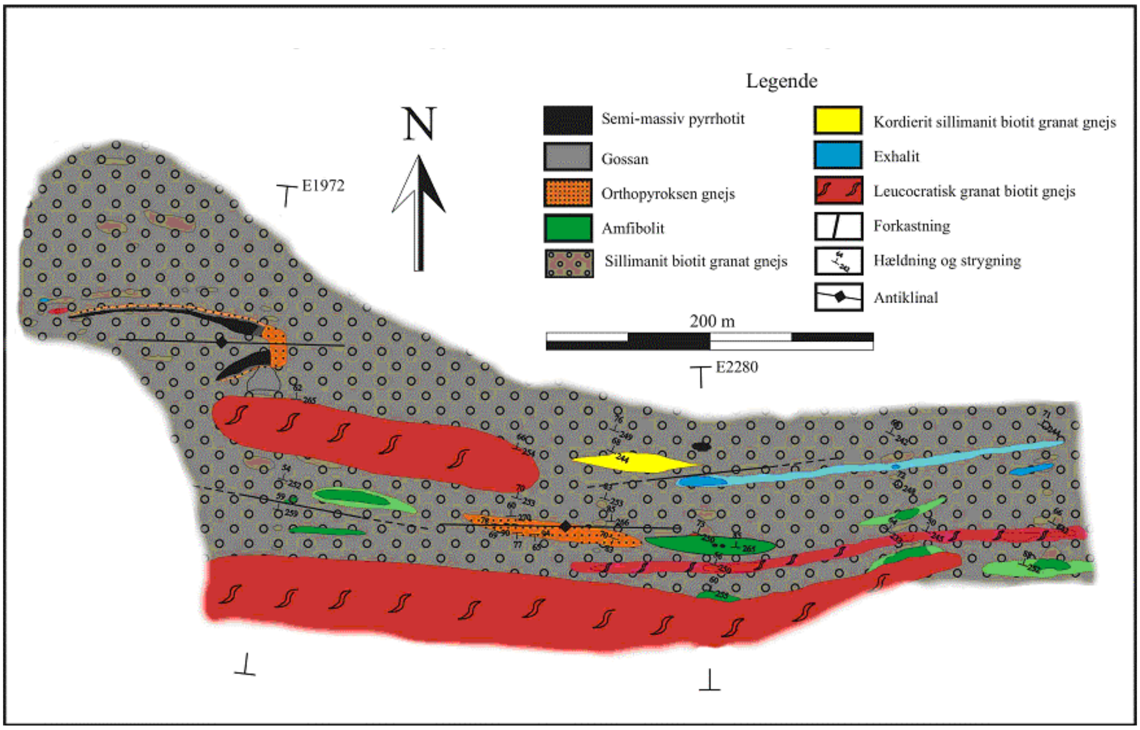

Figure 45. *Geological map of the massive to semi-massive pyrrhotite occurrences at Simiu-tannguaq – a part of the occurrences just south of Ataneq (see location on map above). Map in Danish from Madsen (2003).*

Figure 46. *Pyrrhotite lenses at Ataneq 1. Figure from Madsen (2003) – text in Danish.*

References:

Car, D. 1997: Assessment report for exploration licence 16/96, West Greenland, Volume I: 14 pp., 14 figures, Appendix A-E, Volume II: 8 plates, Volume III: 4 plates. Unpublished report, Inco Limited, Copper Cliff, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 21473).

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Platou, S.W. 1967: Foreløbig rapport om Kobbermineraliseringerne ved Ataneq, 11pp. Unpublished report, Århus, Danmark.

Platou, S.W. 1968: Petrografiske beskrivelser af bjergarterne ved Ataneq, 14pp. Unpublished report, Århus, Danmark.

Stendal, H., Blomsterberg, J., Jensen, S.M., Lind, M., Madsen, H.B., Nielsen, B.M., Thorning, L. & Østergaard, C. 2002: The mineral resource potential of the Nordre Strømfjord - Qasigiannguit region, southern central West Greenland. Geology of Greenland Survey Bulletin 191, 39–47.

Compiler and date (dd-mm-yyyy):

HST 20-11-2003

Arfersiorfik 1 (copper) Type id. no. 84

Type locality id. no.: 84

Type locality for id. nos.: 76, 78, 79, 81, 82, 83, 84, 85, 87, 88, 89, 90, 91

Locality name: Arfersiorfik 1

Area: Arfersiorfik

Genetic relation: Massive sulphide

GSC deposit type: 6.3 – Volcanic-associated massive sulphide base metals

Commodity group: Base metals

Commodities (minor): Copper, zinc

Economic significance: 3

Geological characteristics:

Description of occurrence: Occurrences of disseminated to massive pyrrhotite horizons and lenses are located in the eastern extension of the 150km supracrustal belt hosting the pyrrhotite lenses between Giesecke Sø and Ataneq (Madsen 2003; Platou 1967; Platou 1968). The supracrustal rock sequences have an overall strike of 245° in the area and with a dip of 60° to 80° towards the south.

Disseminated to massive sulphide occurrences are associated with strongly foliated amphibolite, mafic biotite ± garnet ± graphite ± sillimanite schist-paragneiss. The sulphide occurrences are either found as dm thick horizons or as lenticular bodies or pods. The mineralisations are often associated with silicification. At one-exposure possible volcanic pillow structures was observed. The occurrence can often be found in separated sub-parallel horizons with a total thickness of less than 10 m –15 m.

In the inner part of Arfersiorfik fjord are the sulphide occurrences, both disseminated and more massive forms, often found in tectonic contact with the Arfersiorfik quartz diorite complex. Sulphide stringers are locally observed in zones, which are crushed and fractured.

Geotectonic setting: The supracrustal rocks and the volcanic-associated massive sulphide have been deposited within a volcanic arc environment related to the Nagssutoqidian subduction.

Depositional environment/Geological setting: The occurrences are deposited in an environment dominated by submarine volcanic-sedimentary sequences with mafic pelitic sediments and amphibolites. Sulphide mineralisation concentrated in small fold-closures and hydrothermal activity in fault zones cross-cutting or within the sulphide horizons indicate later hydrothermal activity. It is possible that hydrothermal activity and deformation in the Nordre Strømfjord shear zone and in the contact to the Arfersiorfik quartz diorite have caused the remobilisation and hydrothermal activity.

Age of mineralisation: The volcanic-associated massive sulphides in Ataneq-Arfersiorfik is probably Palaeoproterozoic in age and the volcanic rocks are related to the subduction environment formed together with the Arfersiorfik quartz diorite complex around 1920 Ma.

Host/Associated rock types: The sulphide occurrences are hosted in mafic pelitic schist-paragneisses. As for the occurrences further to the west an elevated content of graphite is often associated with the occurrences.

Deposit form: The occurrences can be found as disseminated to massive sulphides in mafic pelitic schist horizons. The sulphide content is 10 – 20 vol.%. The disseminated horizons are mostly up to 1 m thick, however 2–4 m thick horizons occur. The horizons can be followed for hundreds of meters, though with variable sulphide content. The semi-massive to massive sulphide horizons are often less than ½ m thick and can be followed for tens of meters.

Texture/Structure: Pyrrhotite and pyrite occurs as grain in mm-size. Magnetite as smaller grains is observed.

Ore mineralogy (principal and *subordinate*): Pyrrhotite are the predominating ore mineral with minor amounts of *pyrite, chalcopyrite and magnetite*

Gangue mineralogy (principal and *subordinate*): Quartz, mica, amphiboles, *chlorite*.

Alteration: None.

Weathering: The sulphide occurrences are often associated with a distinct rusty or orange gossan.

Ore controls: The sulphide occurrences and mafic schist lithologies with a high content of graphite may have acted as 'lubricant' for the tectonic actions, and consequently have focused the movements in these contact zones. Remobilsation of the sulphides have probably played an important role in the formation of the present occurrence.

Genetic models: Syngenetic volcanic-associated exhalative massive sulphides.

Analytical data:
The highest analytical values obtained from samples of disseminated sulphides in mafic pelitic schist, which yield the following maximum values:

38 ppb Au, 45 ppm As, 497 ppm Zn, 3813 ppm Cu and 456 ppm Ni. All samples have furthermore elevated Mn content, up to 2,9 % ppm Mn.

Exploration:

The sulphide occurrences east of Ataneq fjord and in the inner part of Arfersiorfik fjord was first recorded during helicopter reconnaissance undertaken by Kryolitselskabet Øresund A/S in 1962 and 1977 (Gothenborg & Keto 1980; Keto 1963a). However, no detailed follow-up on the occurrences was carried out. Inco Ltd. discovered several other sulphide occurrences (Car 1997) during exploration for Thompson Nickel Belt and Voisey Bay analogies.

No detailed work has been carried out on the occurrences east of Ataneq fjord and in the inner part of Arfersiorfik fjord.

Photos, figures and maps:

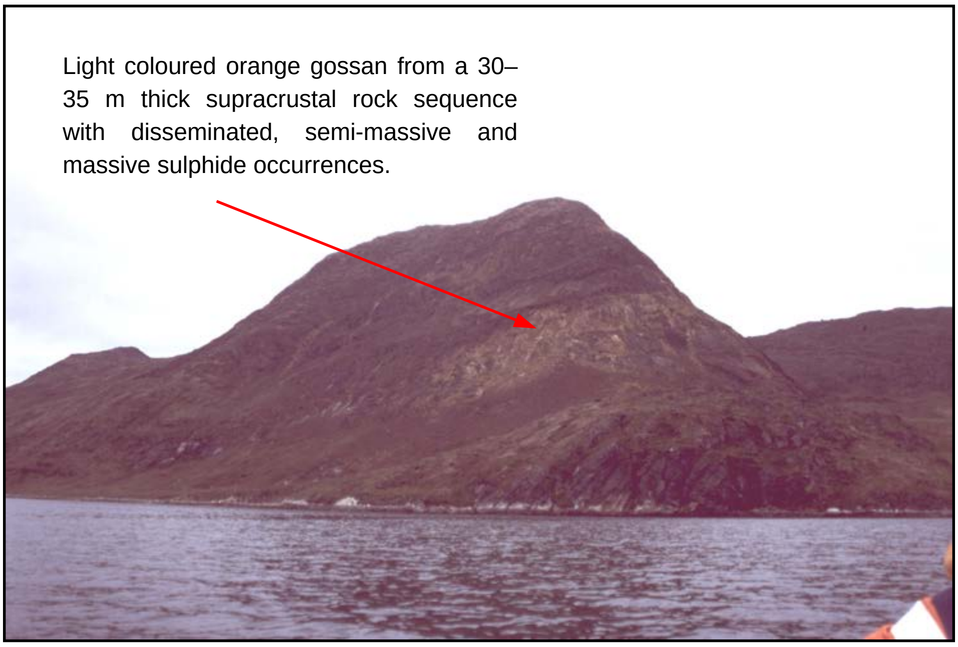

Figure 47. *Supracrustal rock sequence dominated by mafic pelitic schist and amphibolite from the inner part of Arfersiorfik fjord. The sequence hosts several semi-massive to massive sulphide occurrences.*

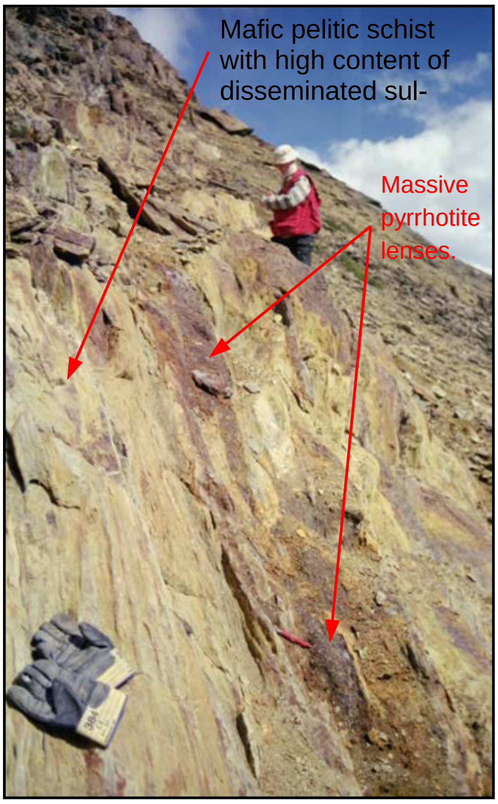

Figure 48. *Pelitic schist with high content of disseminated sulphides and massive pyrrhotite lenses.*

References:

Car, D. 1997: Assessment report for exploration licence 16/96, West Greenland, Volume I: 14 pp., 14 figures, Appendix A-E, Volume II: 8 plates, Volume III: 4 plates. Unpublished report, Inco Limited, Copper Cliff, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 21473).

Gothenborg, J. & Keto, L. 1980: Report on the aerial reconnaissance between Sukkertoppen Ice Calot and Nordenskiölds Gletscher. 1977. [KØ/190], 84 pp., 12 plates. Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20071).

Keto, L. 1963: Aerial prospecting between Holsteinsborg and Umanak, West Greenland 1962 (including a minor area east of Sukkertoppen). [KØ/34], 65 pp., 15 plates. Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20154).

Madsen, H.B. 2003: Besshi-type vulkansk associeret semi-massive sulfid forekomster i Ataneq området, Vestgrønland, 141. M.Sc. Thesis, University of Aarhus.

Platou, S.W. 1967: Foreløbig rapport om Kobbermineraliseringerne ved Ataneq, 11pp. Unpublished report, Århus, Danmark.

Platou, S.W. 1968: Petrografiske beskrivelser af bjergarterne ved Ataneq, 14pp. Unpublished report, Århus, Danmark.

Compiler and date (dd-mm-yyyy):

BMN 24-11-2003

Arfersiorfik 2 (copper) Type id. no. 86

Type locality id. no.: 86

Type locality for id. nos.: 77, 80, 86

Locality name: Arfersiorfik 2

Area: Nassuttooq– Arfersiorfik

Genetic relation: Hydrothermal mineralisation

GSC deposit type: 17.0 – Vein copper and hydrothermal alteration

Commodity group: Base metals

Commodities (minor): Copper

Economic significance: 4

Geological characteristics:

Description of occurrence: Several prominent sulphide mineralised faults cut through this region. The dominating directions of the near vertical faults are NNE, but several other directions are observed. The fault and associated fracture zones have often related alteration zones in the host rock with moderate to intense silicification. In many cases are the wall rock characterised by malachite staining.

Locally a general zonation is observed. The zone around the fault plans is intensely crushed with a high degree of silicification, high content of red feldspar and some green epidote. In general it seems that the alteration and hydrothermal activity in the fault zones increases towards the east in the region. Sulphide mineralisation and malachite is observed in the inner part of the fault zone.

Geotectonic setting: Palaeoproterozoic fault zone, which has the regional strike (prominent NNE) of regional fault zones.

Depositional environment/Geological setting: Hydrothermal formation.

Age of mineralisation: Palaeoproterozoic, however fault zones can have been reactivated during later uplift.

Host/Associated rock types: The host rock is Archaean and Paleoproterozoic gneisses and supracrustal rocks.

Deposit form: Disseminated to semi-massive forms generally with less than 5 % sulphide. In some places are sulphide stringer zones developed in the inner part of the fault zones.

The linear fault zones can often be followed tens of km. The mineralisation occurs typically in the inner part of the fault zone.

Texture/Structure: Disseminated to semi-massive.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, pyrite, magnetite, hematite, malachite.

Gangue mineralogy (principal and *subordinate*): Quartz, feldspar, epidote, chlorite. In one case rhodochrosite have been observed in a fault zone in the interior part of Arfersiorfik fjord.

Alteration: Silicification, chloritisation, pyritization and oxidation.

Weathering: The fault zones have often a rust colouring.

Ore controls: Structural lineaments. The increased hydrothermal activity and a more brittle nature of the zones towards the east in the region could reflect the eastward tilting suggested for the region (Bak *et al.* 1975a; Bak *et al.* 1975b).

Genetic models: The genetic model is unsure, but might correspond to hydrothermal vein type occurrences.

Analytical data:
No information.

Exploration:
GEUS have investigated fault zones in the region in 2001 and 2002.

Photos, figures and maps:

References:

Compiler and date (dd-mm-yyyy):
BMN 24-11-2003

Kuup Akua (magnesite) Type id. no. 93

Type locality id. no.: 93

Type locality for id. nos.: 93

Locality name: Kuup Akua

Area: Nassuttooq

Genetic relation: Magnesite replacement occurrence

GSC deposit type: 28.0 – Mafic/ultramafic

Commodity group: Industrial minerals

Commodities (minor): Magnesium

Economic significance: 3

Geological characteristics:

Description of occurrence: A 300–400 m thick supracrustal sequence with garnet gneisses, marble with calc-silicate minerals, magnesite horizon and sheets of Arfersiorfik quartz diorite. The strike of the magnesite horizon is 86° and the dip is 68° NW.

To the north is the magnesite horizon in contact (presumably tectonic) with Arfersiorfik quartz diorite. To the south the magnesite horizon is bounded by garnet gneisses (probably paragneisses) which further to the south are succeed by quartz diorite. 150 m further to the south is the supracrustal sequence bounded by a 10 m wide marble calc-silicate zone (with green mica, muscovite, diopside, apatite and rhodochrosite), where the northern and southern edge is in tectonic contact with the Arfersiorifik quartz diorite. The foliation of the marble zone is 80°.

Geotectonic setting: The supracrustal rock sequence and intercalated magnesite horizon may represent continental margin or volcanic arc.

Depositional environment/Geological setting: The magnesite horizon are may represent faulted and metasomatically altered ultramafic rocks that are tectonically in contact meta-sediments.

Age of mineralisation: The age of the Arfersiorfik quartz diorite is determined to be around 1920 Ma. The sedimentation took place around 1950 Ma to 1920 Ma and the subduction from 1920 Ma to 1870 Ma. The alteration forming the magnesite horizon probably took place under the regional peak metamorphism and related deformation around 1850 to 1870 Ma.

Host/Associated rock types: The magnesite occurrence is situated in a supracrustal rock sequence of garnet paragneiss, marble with calc-silicates and sheets of the Arfersiorfik quartz diorite.

Deposit form: The magnesite horizon is 2 m – 3 m thick and can be followed along strike 86° for at least 200 m. Sulphides in the horizon are either found as disseminated or as stringer sulphides.

Texture/Structure: The magnesite (incl. gangue minerals) horizon is massive to schistose

Ore mineralogy (principal and *subordinate*): Magnesite, *pyrrhotite* and *pyrite*.

Gangue mineralogy (principal and *subordinate*): Calc-silicates, calcite, ankerite, quartz, light coloured mica.

Alteration: Metasomatic alteration.

Weathering: The magnesite horizon has a distinct light brown colouring.

Ore controls: Primary control in the presence of a magnesium-rich silicate rock to act as a source of magnesium.

Genetic models: It is possibly that the occurrence is formed by metasomatic processes (carbonatisation and hydration) where circulating fluids along the tectonic contact have altered ultramafic rocks, possibly during peak metamorphism in the Nagssugtoqidian orogen. The model is supported by the elevated Ni and Cr content and lack of sedimentary trace elements. However, more detailed work should be performed in order to confirm this model.

Analytical data:
24% Mg, 0.25% Ni and 0.2% Cr.

Exploration:
GEUS discovered the magnesite occurrence during fieldwork in 2002. No detailed work or exploration has been carried out.

Photos, figures and maps:

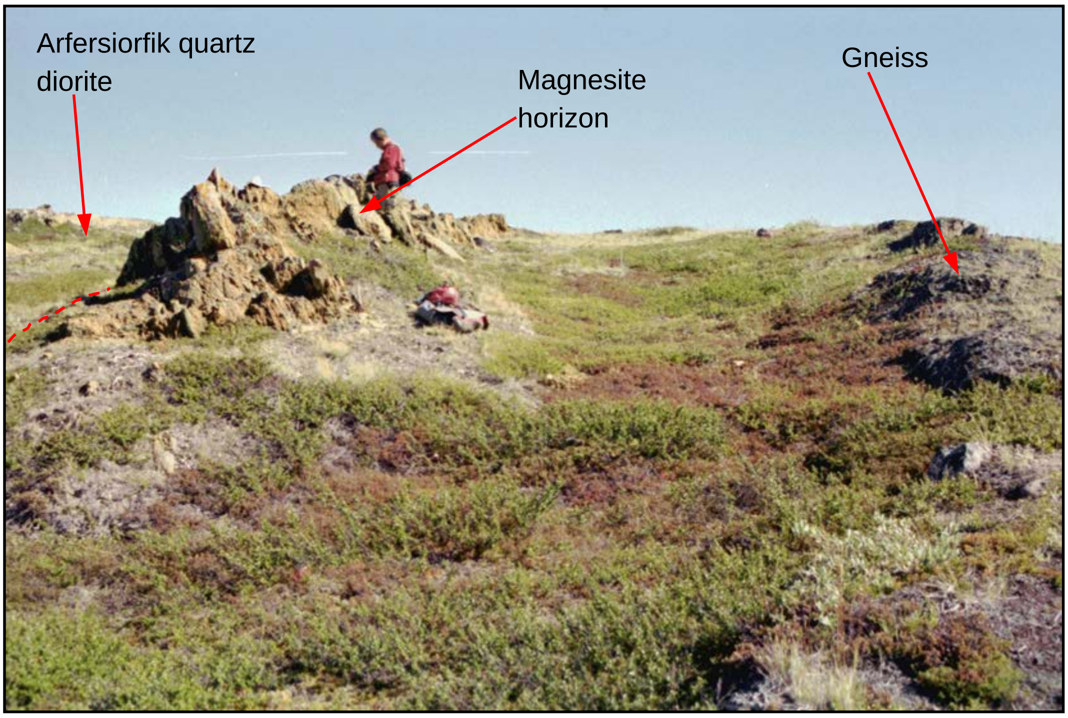

Figure 49. *Magnesite horizon stands out as a ridge in the local topography. To the north (left) is the horizon bounded by Arfersiorfik quartz diorite; to the south is the horizon bounded by paragneiss (contact not exposed).*

References:

Compiler and date (dd-mm-yyyy):
BMN 25-11-2003

Ussuit 1 (copper) Type id. no. 94

Type locality id. no.: 94

Type locality for id. nos.: 92, 94, 95

Locality name: Ussuit (1)

Area: Nassuttooq

Genetic relation: Hydrothermal mineralisation

GSC deposit type: 17.0 – Vein copper and hydrothermal alteration

Commodity group: Base metals

Commodities (minor): Copper

Economic significance: 4

Geological characteristics:

Description of occurrence: Several distinct faults zones occur in the area, orientated NNE and cutting through all lithologies in the region. Some of the fault zones are mineralised with iron sulphides. The wall rocks of the fault zones are in variable degree altered by hydrothermal fluids and intensely silificified. Many of the faults in the area are characterised by intense reddish and greenish colouring caused by unusual high content of red K-feldspar and green epidote.

Geotectonic setting: Steep Palaeoproterozoic fault zones with a regional NNE strike. From aeromagnetic data a dextral displacement of several kilometres can be deducted.

Depositional environment/Geological setting: Hydrothermal formation in a fault zone probably during peak metamorphism under granulite facies conditions (and in middle to deep crustal levels).

Age of mineralisation: Palaeoproterozoic

Host/Associated rock types: The host rock is grey basement gneisses and supracrustal rocks.

Deposit form: The fault zones can be followed for teens of kilometres. Mineralisation can often be observed in the fault planes for more than hundred meters. However, it seems that mineralisation within the fault zones is discontinuous.

Texture/Structure: The ore minerals are either found as disseminated or as semi-massive sulphides in the central zone of the fault zone or in the adjacent wall rock.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, pyrite, *malachite*, *magnetite, hematite* and *chalcopyrite.*

Gangue mineralogy (principal and *subordinate*): Quartz, feldspar, epidote, *chlorite* and *graphite*.

Alteration: The fault zone is silicified and pyritised (locally also chloritised).

Weathering: Some of the fault zones have a distinct rusty colouring.

Ore controls: Fault zone mineralisation controlled by crustal level.

Genetic models: Hydrothermal activity in structurally low pressure zones during peak metamorphism and orogenic deformation.

<u>Analytical data:</u>

Variable, Cu up to ca 1000 ppm.

<u>Exploration:</u>
GEUS described and sampled the sulphide occurrences in the fault zones during fieldwork in 2001 and 2002. No other exploration focusing on the fault zones have been carried out.

<u>Photos, figures and maps:</u>

Figure 50. *Crushed fault plane with intense malachite staining. The blocky jointing of the fault plane can be followed for several hundreds of meters.*

Figure 51. *Red K-feldspar and green epidote in the zone of intense silicification. This is a characteristic feature of faults in the region.*

References:

Compiler and date (dd-mm-yyyy):
BMN 23-11-2003

<u>Ussuit 2 (diopside)   Type id. no. 96</u>

Type locality id. no.: 96

Type locality for id. nos.: 96, 97

Locality name: Ussuit (2)

Area: Nassuttooq

Genetic relation: Skarn mineralisation

GSC deposit type: 20.0 – Skarn

Commodity group: Industrial minerals

Commodities (minor): Diopside

Economic significance: 4

Geological Characteristics:

Description of occurrence: Light green diopside is the most abundant calc-silicate mineral, commonly occurring as rather massive lenses in metasediments. Marble and calc-silicate units occur in the inner parts of Nassuttooq and Ussuit. They are composed of varying proportions of calcite, dolomite, diopside, humite(?), garnet, phlogopite, fluorite and graphite.

The largest accumulation of diopside is located in a narrow strip of coastal exposure at id no. 97. It constitutes part of a complex N–S-trending zone of supracrustals wedged between Archaean gneisses to the east and Arfersiorfik quartz diorite to the west. From west to east, the supracrustal sequence consists of a 40 m wide zone of silicified mafic metavolcanics, a 1.5 m wide quartz vein, 4–5 m of ultramafic rocks, and 10 m of nearly pure diopside.

Fluorite often occurs in minor amounts in the marble and calc-silicate rocks, especially near the contacts to quartzo-feldspathic country rocks. Graphite is a common accessory mineral, and tends to be concentrated near the contacts to the country rocks. Discrete grains of yellow-orange accessory humite is a common constituent of the marble units.

Geotectonic setting: The protolith for the marbles and calc-silicates are carbonate rocks possibly deposited in continental margin or marine platform settings.

Depositional environment/Geological setting: The protholith is deposited in a marine environment.

Age of mineralisation: The diopside occurrences (marble and calc-silicate) are formed during the regional metamorphism and related deformation around 1860 to 1840 Ma

Host/Associated rock types: The marbles and calc-silicates are hosted in supracrustal rocks which consists of mafic pelitic garnet-biotite schist, amphibolites and ultramafic bodies.

Deposit form: The diopside can be found either as massive lenses or horizons. Lenses are up to 1–2 m thick and up to 10 m long. The horizons are found as up to 10 m thick layers.

Texture/Structure: The diopside occur as crystalline masses.

Ore mineralogy (principal and *subordinate*): Calcite, dolomite, diopside, *humite(?), garnet, phlogopite, fluorite* and *graphite.*

Gangue mineralogy (principal and *subordinate*): Pelitic schist with biotite, amphiboles, quartz and graphite.

Alteration: None.

Weathering: None.

Ore controls: Primary control is the presence of a carbonate bearing rocks as a source for the formation of diopside.

Genetic models: The dioside occurrences represents skarn alterations of carbonate protholiths. The main processes have been metasomatism and metamorphism of the protholith.

Analytical data:
Not available.

Exploration:
GEUS discovered the diopside occurrence during fieldwork in 2001. No detailed work or exploration has been carried out.

Photos, figures and maps:

References:

Compiler and date (dd-mm-yyyy):
BMN 25-11-2003

Eqalussuit (graphite) Type id. no. 99

Type locality id. no.: 99

Type locality for id. nos.: 98, 99

Locality name: Eqalussuit

Area: Nassuttooq

Genetic relation: Graphite schist with iron sulphides

GSC deposit type: 6.3 – Volcanic-associated massive sulphide base metals

Commodity group: Industrial minerals

Commodities (minor): Graphite

Economic significance: 1

Geological characteristics:

Description of occurrence: Graphite accumulations occur in a supracrustal sequence composed of foliated biotite garnet ± graphite ± sillimanite gneiss, locally interlayered with amphibolites, ultrabasics and marble bands. The metamorphic grade is upper amphibolite facies. The supracrustal rocks in the area have an overall strike of 265° and dip 60°N, parallel to the Nordre Strømfjord (Nassuttooq) steep belt. Graphite schists are known from observations further inland to the east, but apparently without substantial accumulation of graphite.

Geotectonic setting: In "greenstone belts" believed to be developed in the transition platform/volcanic environment.

Depositional environment/Geological setting: Sedimentary and submarine volcanic sequences with pelitic sediments, exhalites and mafic rocks.

Age of mineralisation: The graphite rich schist is probably Palaeoproterozoic in age, but precise data are not available.

Host/Associated rock types: Graphite, together with pyrite/pyrrhotite lenses is hosted in pelitic sediments (paragneisses).

Deposit form: The occurrences are found within two parallel schist layers (supracrustals), up to 20 m thick and traceable for tens of kilometres along strike. Individual graphite rich lenses may reach 1 x 20 m, and are found scattered within the schist. Horizons, where the graphite accumulation is observed, are locally due to shearing and internal folding (Platou 1969; Bondam, 1992).

Texture/Structure: The graphite occurrences are generally of a disseminated type of fine-grained flake graphite, and locally developed in lenses with more or less massive graphite, interlayered with pyrrhotite/pyrite, quartz, biotite and garnet. Foliation-parallel pegmatites contain minor amounts of coarse-grained flake graphite (Pedersen 1992).

Ore mineralogy (principal and *subordinate*): Graphite. Associated *pyrite and pyrrhotite*.

Gangue mineralogy (principal and *subordinate*): Quartz, biotite, garnet.

Alteration: Distinct limonitisation.

Weathering: Graphite sequences are creating gossans and rust zones due to weathering of the sulphides.

Ore controls: Graphite is considered to represent a primary carbon content within the supracrustals.

Genetic models: Metamorphosed counterpart to primary bituminous sediments.

Analytical data:
Not applicable.

Exploration:
Exploration of the graphite deposits in the area has been carried out since the beginning of the 20th century (Ball 1923). Graphite attracted economic interest as one of the first commodities in West Greenland, and the activity increased around 1900, partly because of the demand from the growing electrical industry and partly from the use in the foundry and moulding industry. In the actual area the activity in 1903, 1912 and again in1916 went as far as to primitive exploitation on a pilot scale. In 1916 a complete plant layout including a miner's accommodation village was presented by the Grønlands Minedrift A/S. However, proper exploitation was not brought to the practical step (Lindås 1916).

id. no. 99 Eqalussuit West, (Two adits, 1903/1916)
id. no. 98 Eqalussuit East, (Trenching, 1916)

The activity was based on a licence granted in 1904 and later extended to 1933. The locality was later renamed 'Akuliaruseq' and was a target for renewed evaluation from 1982–86 by the Kryolitselskabet Øresund A/S. Geophysical surveys, drillings and flotation tests were carried out during this campaign (Keto et al, 1987). In 1992–93 NunaOilA/S undertook additional investigations (Pedersen 1992). The exploration has at the time of writing ceased.

Resource estimates are primarily based on the data from the Kryolitselskabet Øresund A/S. According to these data the total volume of graphite ore, calculated down to 40 m below surface, is 5.3 million t with an average C-content of 9.5% as flake graphite. At least 1.6 million t of this resource is representing an average of 14.8% C. About 50 wt% of the flake graphite are in the +100 mesh category (Pedersen 1992).

Photos, figures and maps:

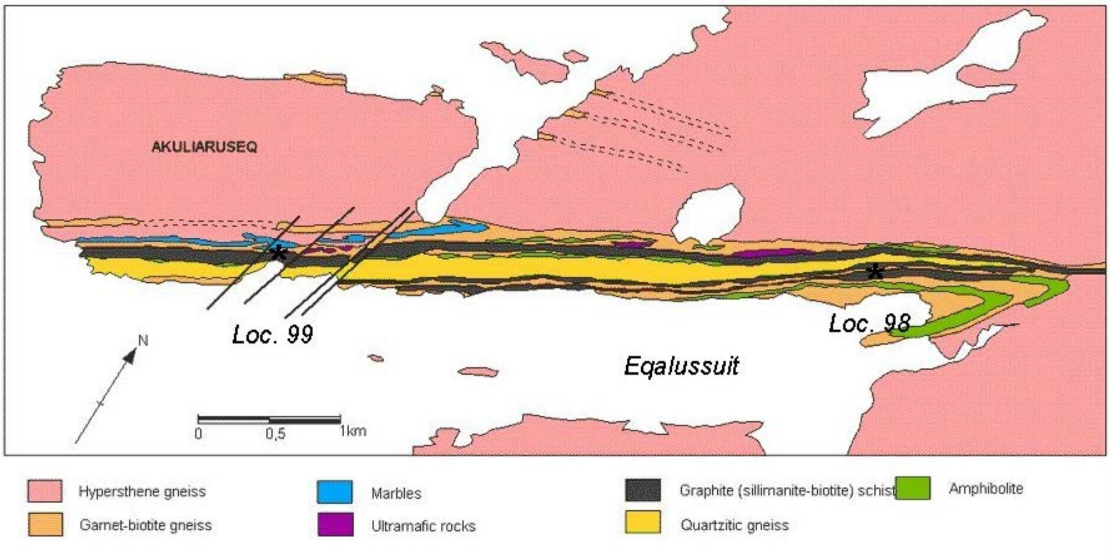

Figure 52. *Geological map of the Eqalussuit area.*

Figure 53. *Old pits from graphite mining at id no. 99, Eqalussuit.*

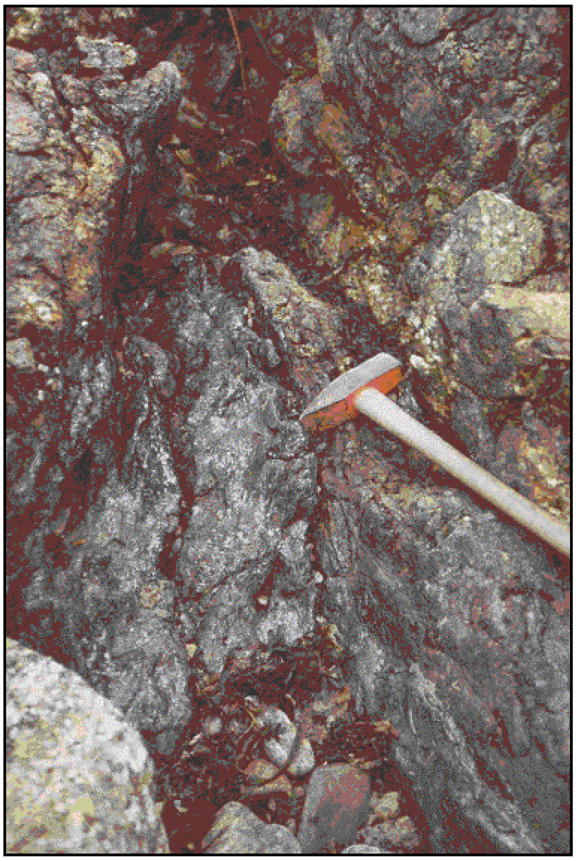

Figure 54. *Massive graphite (left of hammer head) in mafic metasediments.*

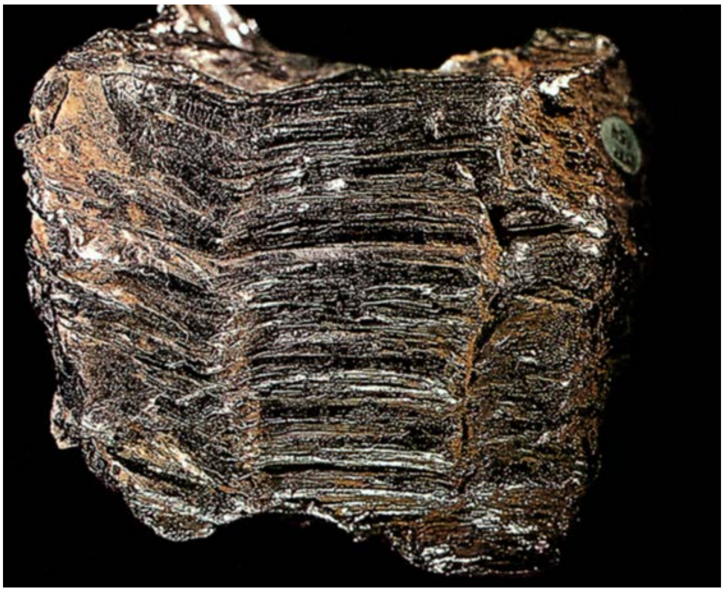

Figure 55. *Close-up of graphite ore sample (scale is indicated by green label to the right, 1 cm)*

References:

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Bondam, J. 1992: Graphite occurrences in Greenland - A review. Open File Series Grønlands Geologiske Undersøgelse **92/6**, 1–32.

Keto, L., Morthorst, P., & Hansen, P.S. 1987: Undersøgelser af grafitforekomsten ved Akuliaruseq 1982-1986, 15 pp. Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20222).

Lindås, G. 1916: Rapport over Expedition til Holsteinsborg og Egedesminde distrikt, sommeren 1916, 33pp. Unpublished report, Grønlands MinedriftA/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20486).

[Pedersen, J.L.]1992: The Akuliaruseq graphite deposit Nordre Strømfjord, central West Greenland. 18 pp. Unpublished report, NunaOil A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 21081).

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Compiler and date (dd-mm-yyyy):

KSE 04-12-2003

Inussuk (copper) Type id. no. 101

Type locality id. no.: 101

Type locality for id. nos.: 100, 101

Locality name: Inussuk

Area: Nassuttooq

Genetic relation: Volcanic-associated massive sulphide mineralisation

GSC deposit type: 6.3 – Volcanic-associated massive sulphide base metals

Commodity group: Base metals

Commodities (minor): Copper, zinc

Economic significance: 4

Geological characteristics:

Description of occurrence: Silicified horizons intercalated in biotite-garnet-graphite schist are mineralised with pyrite and pyrrhotite.

At id. no. 101 the supracrustal rocks are folded and both flanks of the fold are exposed c. 20 m. apart. At id. no. 100 similar host lithologies and mineralisation are described, however, the mineralised horizons are mylonitized at this locality and no folding is reported (Car 1997).

Geotectonic setting: The supracrustal rocks and the volcanic-associated massive sulphide are of similar type as the occurrences at id. no. id. no. 84 and id. no. 71. They are interpreted to be Palaeoproterozoic volcanic arcs (back-arc) formed in a subduction environment contemporaneously together with the formation of the Arfersiorfik quartz diorite complex around 1920 Ma.

Depositional environment/Geological setting: The occurrences are deposited in an environment dominated by submarine volcanic sedimentary sequences with mafic pelitic sediments and amphibolites.

Age of mineralisation: The volcanic-associated massive sulphides south of Nordre Strømfjord is probably Palaeoproterozoic in age and the volcanic rocks are related to the subduction environment formed together with the Arfersiorfik quartz diorite complex around 1920 Ma. The sedimentation took place around 1950–1920 Ma and the subduction from 1920–1870.

Host/Associated rock types: The sulphide occurrences are hosted in biotite-garnet-graphite schist, which are intercalated in coloured mica-garnet paragneiss.

Deposit form: Three mineralised horizons are found. These can be followed for ca 100 m and are 20 cm – 30 cm thick. The sulphide volume content varies from 5 vol.% to 30 vol.%. The sulphides are either found as disseminated forms or as sulphide stringers.

Texture/Structure: Sulphides are either disseminated or semi-massive. Pyrrhotite and pyrite occurs as grains in mm-size.

Ore mineralogy (principal and *subordinate*): Pyrrhotite and pyrite.

Gangue mineralogy (principal and *subordinate*): Quartz, mica, amphiboles, graphite, garnets, *chlorite*.

Alteration: None.

Weathering: The sulphide horizons have a distinct rusty colouring.

Ore controls: Syngenetic volcanic-exhalative environment.

Genetic models: Volcanic-associated massive sulphide base metals. The Ataneq-Arfersiorfik volcanic-associated exhalative massive sulphides, however, are low in base metals.

Analytical data:

None.

Exploration:

Besides the sulphide occurrence reported by Car (1997) no other sulphide occurrences have been reported from the area south of the inlet to Nassuttooq.

Photos, figures and maps:

Figure 56. *Semi-massive to massive iron sulphide occurrences in metasediments at Inussuk. The horizons are 20–30 cm thick.*

References:

Compiler and date (dd-mm-yyyy):

BMN 24-11-2003

Isortuarsuk (garnet sand) Type id. no. 106

Type locality id. no.: 106

Type locality for id. nos.: 102, 103, 104, 105, 106, 107

Locality name: Isortuarsuk

Area: Nassuttooq–Kangerlussuaq

Genetic relation: Beach placer

GSC deposit type: 1.2 – Placer

Commodity group: Industrial minerals

Commodities (minor): Garnet sand

Economic significance: 4

Geological characteristics:

Description of occurrence:
Id. nos. 106 & 107 Isortuarsuk: Garnet sand from a pebbly 20 m x 100 m beach with 30 cm "massive" layer of garnet sand and millimetre-thick garnet layers and garnet sand from shore face on 5 m – 10 m x 100 m beach with 1 m thick sand layer.

Id. no. 102 - Akuliaruseq garnet sand: Beach (15 m x 60 m) in a cove by the old graphite mines. At this locality the garnet sand layer is 30 cm – 50 cm thick. An uplifted terrace extends approximately 50 m inland and has a 30 cm – 50 cm thick layer of garnet sand.

Id. no. 103 - North coast of Eqalussussuit: Garnet sand in upper tidal zone. The sand field is up to 1m thick; and alternating layers with and without garnet are 1 cm – 5 cm thick. The beach is rather stony on the lower shore face. The beach with relatively pure garnet rich sand is 5 m x 100 m. Similar stretches can be found along the fjord.

Id. no. 104 - Inussuk: Garnet sand in a small cove with 20 % – 30% garnet. The pebble content in the sand is 10% – 20%. The layer of garnet sand is up to 1.5 m thick, and the beach is 15 m x 25 m. Above the tidal zone the garnet sand can be followed inland on an elevated beach. However, 20 m inland the thickness decreases to 30 cm.

Id. no. 107 - Utoqqaat: The size of the beach with garnet sand is approximately 10 000 m^2. The upper 20–30 cm of the beach consists of garnet rich sand. The locality has not been systematically investigated.

Geotectonic setting: The garnet placer occurrences occur at beaches and river outlets, often in close proximity to the sources of the garnets. The source rocks are often garnet-rich metasediments.

Depositional environment/Geological setting: The placers are deposited along shore-lines or nearshore environments, often where smooth water or tidal conditions are present. They occur both along present beaches and in preserved elevated shore terraces.

Age of mineralisation: Recent, present day occurrences.

Host/Associated rock types: Well to moderately sorted, medium to coarse-grained sands in coastal and river occurrences; in some cases with pebbles and boulders.

Deposit form: Beach placers. The garnet sand occurrences are in most cases of restricted sizes – seldom are they more than 100 x 25 m.

Texture/Structure: Granular sorted beach sand.

Ore mineralogy (principal and *subordinate*): Garnet.

Gangue mineralogy (principal and *subordinate*): Quartz, feldspar, amphiboles, pyrox-enes, mica, *magnetite*.

Alteration:

Weathering:

Ore controls: The presence of placers seems to be controlled by the presence of stable shorelines in areas with smooth water; often seems tidal conditions to play an important role. The size and quality of the occurrences are controlled by the bedrock sources and its extent and composition.

Genetic models: Beach placer accumulation.

Analytical data:
Not available.

Exploration:
A.H. Clark & Associates have investigated the garnet sand at Isortuarsuk. The first estima-tions indicated a resource of 10 Mt of sand with at least 20% garnet. The garnet sand has been tested for waterjet cutting purposes and its properties were found according to stan-dards. GEUS investigation included sampling of the different garnet occurrences in 2002 (Sørensen 2003).

Photos, figures and maps:

Figure 57. *Garnet sand in beach exposure at Inussuk, id no. 104.*

References:

Sørensen, J.B. 2003: Investigation for garnet sand in Sioraq, South West Greenland, and analyses of garnet sand from central West Greenland. Danmark og Grønlands Geologiske Undersøgelse Rapport **2003/7**, 27.

Compiler and date (dd-mm-yyyy):

BMN 26-11-2003

Nordre Isortoq (copper) Type id. no. 108

Type locality id. no.: 108

Type locality for id. nos.: 108, 109, 110, 111

Locality name: Nordre Isortoq

Area: Sisimiut

Genetic relation: Iron-formation-hosted base metals

GSC deposit type: 3.2 – Algoma-type iron-formation

Commodity group: Base metals

Commodities (minor): Copper

Economic significance: 4

Geological characteristics:

Description of occurrence: Supracrustal suite comprising marble, garnet quartzite and amphibolite (51°/54°SE) crosscut by a crushing zone. The crushed zone is rust stained (3-m) and includes graphite-sulphide rocks. Outside the crush zone quartzites (± garnet) has some disseminated pyrrhotite.

Id. no. 109: 2–3m wide shear zone forming the contact between marble and garnet-mica schist. The zone carries disseminated pyrrhotite and graphite.

Id. no. 110: Garnet-amphibolite sequence (50°/23°SE) with 0.5–1 m wide rust layers and lenses (up to 10-m long). Within the rust layers/lenses up to 20-cm wide bands consists of massive pyrrhotite and quartz bands. Outside the massive pyrrhotite layers disseminated pyrrhotite occurs.

Id. no. 111: Garnet amphibolite (30 m wide) folded with two rusty flanks (1.5 m wide) with quartz, calc-silicate and 5–10 vol% disseminated to semi-massive pyrrhotite.

Geotectonic setting: Part of a supracrustal sequence with marble and quartzites.

Depositional environment/Geological setting: Sedimentary and submarine volcanic sequences.

Age of mineralisation: Probably Palaeoproterozoic.

Host/Associated rock types: The supracrustal rocks are hosted in gneiss and char-nockites.

Deposit form: Stratiform zones within the supracrustal rocks. Host strata have been folded and deformed. The folding probably caused thickened and remobilized ore.

Texture/Structure: Sulphide minerals in stratiform appearance as semi-massive bodies and disseminated ore.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, *pyrite and chalcopyrite.*

Gangue mineralogy (principal and *subordinate*): Calc-silicates and quartz (chert).

Alteration: Sulphidisation (pyrrhotitisation) is common in wall rocks in shear zones.

Weathering: Sulphide-rich parts are rust weathered.

Ore controls: Mineralisation is settled within the supracrustal sequence. Most deposits occur adjacent to prominent regional structural and stratigraphic "breaks" and mineralisation is often related to local structures such as folds and shear zones where remobilization of the sulphides can occur.

Genetic models: The iron-suphides may come from hydrothermal fluids in a basin (shallow water?). Thus, the geological environment is syngenetic in an active submarine exhalative system and association with chemical sedimentary strata. Replacement and vein features are due to deformation.

Analytical data:

Analytical results of pyrrhotite rich samples yield maximal 900 ppm Cu, 0.3% Mn, 687 ppm Ni, 187 ppm Zn and the gold content varies from 8 to 36 ppb.

Exploration:

No exploration has been carried out.

Photos, figures and maps:

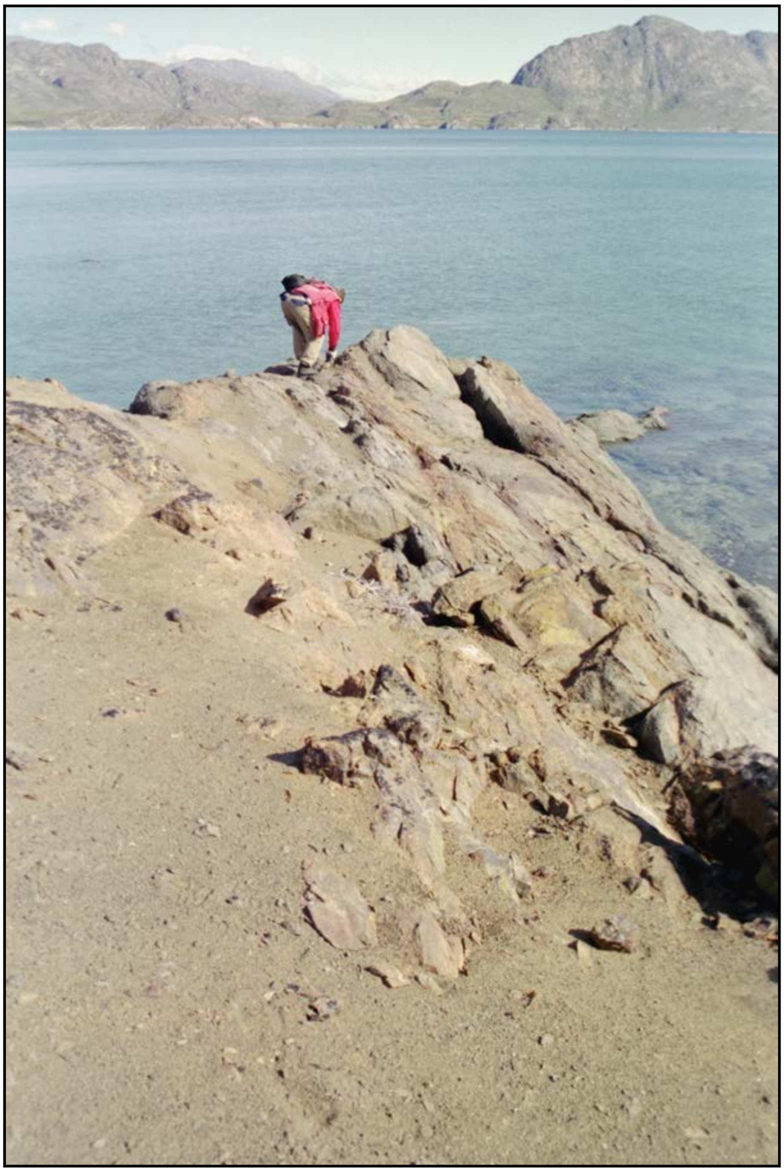

Figure 58. *Disseminated to semi-massive iron sulphide occurrence in Nordre Isortoq fjord.*

References:

Compiler and date (dd-mm-yyyy):

HST 26-11-2003

<u>Utoqqaat (graphite)   Type id. no. 113</u>

Type locality id. no.: 113

Type locality for id. nos.: 112, 113, 114

Locality name: Utoqqaat

Area: Sisimiut

Genetic relation: Graphite schist with iron sulphides

GSC deposit type: 6.3 – Volcanic-associated massive sulphide base metals

Commodity group: Industrial minerals

Commodities (minor): Graphite

Economic significance: 3

<u>Geological characteristics:</u>

Description of occurrence: Graphite accumulations occur in a supracrustal sequence composed of foliated biotite garnet ± graphite ± sillimanite gneiss, locally interlayered with amphibolites. The metamorphic grade is upper amphibolite facies. Graphite schists are known from observations at several localities in the adjacent areas, but apparently without substantial accumulation of graphite.

Geotectonic setting: Believed to a volcanic arc environment.

Depositional environment/Geological setting: Sedimentary and submarine volcanic sequences with pelitic sediments, exhalites and mafic rocks.

Age of mineralisation: No isotope data available.

Host/Associated rock types: The graphite, together with pyrite/pyrrhotite lenses is hosted in pelitic metasediments. The proportion of garnet in the gneiss may reach up to 50% of the rock volume.

Deposit form:
Id. no. 113 (Utoqqaat): The occurrences are found in two E–W striking shear zones in the country schist layers (supracrustals), 10–15 m apart, each up to 20 m thick and traceable a few kilometres along strike. The two graphite rich layers are 1.7m and 3.3m wide respectively. Horizons, where the graphite accumulation is observed, are locally due to shearing and internal folding (Ball 1914; Bondam, 1992).

Id. no. 112 (Sungog): Graphite rich lenses, up to 4m wide. Some lenses demonstrate crystalline, dense masses of pegmatitic graphite.

Id. no. 114 (Nipisat): Several lenses of graphite rich schist scattered on the island, typically with 5–20 % pyrite as accessory; up to 3m wide.

Texture/Structure: The graphite occurrences are generally of a disseminated type of fine-grained flake graphite, and locally developed in lenses with more or less massive graphite, interlayered with pyrrhotite/pyrite, quartz, biotite and garnet.

Ore mineralogy (principal and *subordinate*): Graphite. Associated *pyrite and pyrrhotite*.

Gangue mineralogy (principal and *subordinate*): Quartz, biotite, garnet.

Alteration: Distinct limonitisation.

Weathering: Graphite rich sequences appear rusty due to weathering of the sulphides.

Ore controls: Graphite is considered to represent a primary organic rich sediment within the supracrustals.

Genetic models: Metamorphosed counterpart to organic rich sediments in a volcanic arc environment.

Analytical data:

Average C content 21% and S content 5,5% (Høeg 1915).

Exploration:

Exploration of the graphite deposits in the area has been carried out since the beginning of the 20th century (Ball 1923). Graphite attracted economic interest as one of the first commodities in West Greenland, and the activity increased around 1900, partly because of the demand from the growing electrical industry and partly from the use in the foundry and moulding industry. In the actual area the activity in 1914 went as far as to primitive exploitation on a pilot scale, and a complete plant layout was presented by the GrønlandsMinedriftA/S, however, eventually without being brought to the practical step (Lindås 1914).

The activity was based on a licence granted in 1904 and later extended to 1933. In 1992–93 NunaOilA/S undertook additional prospecting, but the activity was eventually dropped (Pedersen 1992).

Resource estimates are primarily based on the data from Ball (1914), who report of the richest part of the graphite lenses as traceable for at least 150 m and carrying 8000 to 9000 t of (pure) graphite for each 30 m of depth. 80 t of ore was collected in 1914 and shipped to Copenhagen for analyses.

Photos, figures and maps:

Figure 59. *Old mine excavation at Utoqqaat graphie prospect. From Ball (1914).*

Figure 60. *A 2001 look at the Utoqqaat graphite mine prospect.*

References:

Ball, S.H. 1914: Report on the mining concession of the Gronlandsk Minedrifts Aktieselskab and its copper mine at Josva. New York, Grønlands MinedriftA/S, 67 pp. Internal report, (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 21164).

Ball, S.H. 1923: The mineral resources of Greenland. Meddelelser om Grønland **63,1**, 1–60.

Bondam, J. 1992: Graphite occurrences in Greenland - A review. Open File Series Grønlands Geologiske Undersøgelse **92/6**, 1–32.

Høeg, E. 1915: Grafitforekomsterne i Grønland samt nogle undersøgelser af de fra Nanortalik, Holsteinsborg og Upernavik i 1914 hjemsendte grafitertse, 17 pp. Unpublished report, Grønlands Minedrifts A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20292).

Lindås, G. 1914: Rapport over grafitexpeditionen til Holstensborg-distriktet. Sommeren 1914. København, GrønlandsMinedrifts A/S, 7 pp. Internal report, (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 21170).

[Pedersen, J.L.] 1992: The Akuliaruseq graphite deposit Nordre Strømfjord, central West Greenland. 18 pp. Company report, København, NunaOil A/S, (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 21081).

Compiler and date (dd-mm-yyyy):

KSE 04-12-2003

Sarfartoq (pyrochlore) Type id. no. 115

Type locality id. no.: 115

Type locality for id. nos.: 115

Locality name: Sarfartoq

Area: Kangerlussuaq region

Genetic relation: Magmatic deposit (hydrothermal)

GSC deposit type: 24.0 – Carbonatite-associated deposits

Commodity group: Speciality metals

Commodities (minor): Niobium and tantalum (uranium)

Economic significance: 1

Geological characteristics:

Description of occurrences: The pyrochlore deposit was formed during one of several magmatic phases of the Sarfartoq carbonatite intrusion (Secher & Larsen 1980). The pyrochlore is accumulated late in the igneous history as vein shaped bodies in a marginal zone surrounding a central carbonatite mass. The mineralisation is located in a tangential set of cataclastic fractures believed to be generated during the emplacement of the intrusion. Several of these fractures are later mineralised and those in the south-eastern part of the complex are the most prominent examples. However, only two occurrences (named 'Sarfartoq 1' and 'Sarfartoq 2') seem at present to be of economic interest. Unlike other known carbonatite complexes, the Nb content of the main Sarfartoq carbonatite is very low, thus explaining the late stage accumulation and precipitation of pyrochlore.

Geotectonic setting: The Sarfartoq carbonatite, together with kimberlitic rocks from the region, belongs to the well-known and widespread 'North Atlantic alkaline rock province', which has representatives in both eastern Canada and Scandinavia (Secher & Larsen 1980). It is believed that this province was formed in a rift system during the opening of the Iapetus Ocean (Larsen *et al.*1983; Larsen & Rex 1992).

Depositional environment/Geological setting: The Sarfartoq carbonatite complex is emplaced in the transition zone between the Archaean granulite facies craton to the south and the Palaeoproterozoic Nagssugtoqidian orogen to the north (Secher 1986). The complex is ellipsoidal at the surface and covers about 90km^2, of which 10km^2 are intrusive carbonatites (Secher & Larsen 1980).

Two major stages of igneous activity introduced Fe/Mg-carbonatite rocks, leading to the formation of a steeply dipping conical body (the core) of concentric sheets of carbonatite, followed by a series of concentric and radial dykes and agglomerates emplaced in the surrounding marginal shock-zone. Hydrothermal activity gave rise to several phases of Nb and REE- mineralisation in carbonate veins and shear zones. The accompanying fenitisation is of the Na-type.

The carbonatite core is divided into three zones based on the proportion of carbonatite to fenite. The inner core (>50% carbonatite) is only approximately 1 km^2 in area; the outer core (<50% carbonatite) forms a 1–3 km broad ring, occupying around 9 km^2. A narrow rim of fenite (about 5 km^2) surrounds this.

Age of mineralisation: The age of the Sarfartoq carbonatite complex is around 600 Ma, based on K/Ar age determinations (Larsen *et al.* 1983; Larsen & Rex 1992). The complex is thus of late Proterozoic age

Host/Associated rock types: The dolomitic magmas of the carbonatite intrusion were poor in SiO_2, Al_2O_3 and K_2O, as well as Nb compared to other carbonatites. There is a marked trend in the increasing Nb content during the progress of the emplacement with a late stage culmination of the pyrochlore deposition. The host rock is gneiss with amphibolite schlieren, altered by a slight K-feldspar fenitisation and hematite staining.

Deposit form: The occurrence is located on the southern mountain slope of the valley Arnangarnup kua in an altitude of 640 m a.s.l. ('Sarfartoq 1'). The pyrochlore-mineralised structure is a steep to vertical dipping lens measuring 10 x100 m. The mineralisation strikes roughly E-W and has a sharp contact to the hosting gneiss. The western part of the mineralised lens has been displaced approximately 17 m towards NE by a 132° striking fault. The lens is pinching out laterally and gradually fading out into the host rock. The radiometric map is based on cps-values (counts per second) measured by a SPP-2 Saphymo Stel scintillometer in a 5 m grid. The very steep gradient in cps-values indicates, as shown by the mapping, a mineralisation with sharp contacts (Secher 1986).

Other known pyrochlore showings in the area ('Sarfartoq 2') of the same type are found to be much smaller and with lower grades.

Texture/Structure: Pyrochlore is typically deposited as granular to dense aggregates with size of individual grains in the range of 0.1–2 mm. Modal compositions of mineralised lenses shows up to 70 % pyrochlore. Single grains are often euhedral with a pronounced zonarity due to compositional variations. An accumulation of U and Ta in grain cores is not unusual. Cavities occur within the aggregates and can locally be up to walnut size. Hematite and mm-sized octahedrons of pyrochlore are observed in the cavities.

Ore mineralogy (principal and *subordinate*): The central part of the lens consists of 95 vol% pyrochlore giving the occurrence a nearly monomineralic character. The remaining 5 vol% comprises hematite, K-feldspar and aegirine. Thin section studies show that pyrochlore is strongly zoned generally with an irregular and inclusion filled core surrounded by alternating layers of fresh looking pyrochlore in varying shades of yellow brown. No sign of metamictisation has been observed.

The Nb-content varies from 40 % (table 1) in the central part of the lens to 5 % at the contact to the host rock. In general it is estimated that the lens averaging approximately 10 % Nb equivalent to 15 % Nb_2O_5.

Analyses of pyrochlore are shown in table 1. The Nb/Ta ratio increases from core to rim in the grains, whereas LREE seems to decrease. It is estimated that the high Ta-U cores of the pyrochlore represent 5–10 vol% of the mineralisation. The cores are probably remnants of earlier formed pyrochlore.

Gangue mineralogy (principal and *subordinate*): The main rock-forming minerals are dolomite, ankerite, calcite, apatite, phlogopite, richterite-arfvedsonite and magnetite. Important accessories are *pyrochlore, zircon and niobian rutile*.

Alteration: None.

Weathering: None.

Ore controls: Tangential cataclastic zones as well as the fenitisation within the marginal area around the Sarfartoq i complex is probably generated during the emplacement. Pre-hydrothermal Nb-deposition is observed only as Nb-rutile within the carbonatite proper. The initial pyrochlore crystals of the mineralised veins were deposited as open space fillings in cataclastic zones as isolated euhedral grains. During successive pyrochlore deposition the earlier deposited pyrochlore crystals were partly digested and U, Ta and REE redistributed. Together with fractionation of the fluid, this created changes in composition of later deposited pyrochlore.

Genetic models: The Nb-enriched hydrothermal phase terminating the carbonatite magma activity resulted in several stages of pyrochlore deposition in veins and shear zones within the fenitised zone of the marginal part of the complex (Secher 1986, 1987, 1989).

The described pyrochlore occurrence is of an extremely unique type, so far not observed elsewhere. The geochemical, spatial and chronological evolution observed in the Sarfartoq complex is outlining a typical trend for carbonatite complexes, where the deposition of pyrochlore has developed into an extremely rich type of mineralisation here (Secher & Larsen 1980; Wolley 1987).

Analytical data:

Sam -ple	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	P_2O_5	Nb_2O_5	RE_2O_3	UO_2	Ta_2O_5	ThO_2	Volat.	Sum
1	8.32	2.57	0.63	3.10	0.63	1.11	12.50	5.27	0.36	0.11	58.20	1.67	0.92	0.58	0.01	5.28	100.67
2	1.07	3.10	n.d.	n.d	n.d.	n.d	13.24	5.29	0.06	0.11	63.49	0.79 *	1.72	0.64	0.27	-	88.95

Table 4. *Chemical analyses (Secher 1987). 1 Rock: GGU No 253678, from the central part of mineralised zone. Chemical analyses based on XRF (GEUS/GGU) supplemented by results from EDX and INAA (RISØ-NL), recalculated and matrix corrected with heavy elements. 2 Mineral: Geometric mean based on 70 point analyses, representing several pyrochlore grains within the mineralisation. Analyses obtained by microprobe (University of Copenhagen) on single mineral grains. *Includes only Ce and La.*

Exploration:

The exploration of the Sarfartoq carbonatite complex has been based on the use of airborne gamma-ray spectrometry (Secher 1976). Stream sediment geochemistry has assisted in localising the Nb-enriched sections. The first showing ('Sarfartoq 1'), discovered in 1978, demonstrates a high grade, low tonnage type of deposit. There is an expected minimum of 0.1 x 10^6 ton of mineralised rock, calculated to a depth of 50 m, carrying 15 %, Nb_2O_5 and 0.18 %, Ta_2O_5. Maximum values are as high as 58 % Nb_2O_5 and 0.58 % Ta_2O_5. This calculation is based only on surface observations.

Even as a low tonnage deposit it must be considered one of its kind in economic geological terms. The maximum grade values are close to the content of commercial pyrochlore concentrate (60 %, Nb_2O_5). The average ore, if exploited, has only to be upgraded by a factor of four to meet the demands of the known type of concentrate. The market situation, size of tonnage, content of radioactive materials, political, technical and environmental conditions will determine the economy of this probably exploitable deposit.

The pyrochlore potential within the Sarfartoq complex has been evaluated and drilled by two companies: In 1989 Hecla Mining Company drilled 568 m of core at the occurrence 'Sarfartoq 1', and based on that the company estimated 25,000 t –30,000 t of ore with a cut off at 10% Nb_2O_5. The company concluded that the mineralisation pinched-out laterally as well as at depth and accordingly ceased exploration at the licence (Druecker 1990). In 1998 New Millennium carried out 800 m of diamond drilling and after that calculated a measured resource at 35,000t at 11.3 % Nb_2O_5 and additional 100,000 tonnes at 4.6% Nb_2O_5 in the indicated category. At the time of writing the licence is still active, according to the web page of New Millenium Resources N.L. (www.new-millennium.com.au).

Photos, figures and maps:

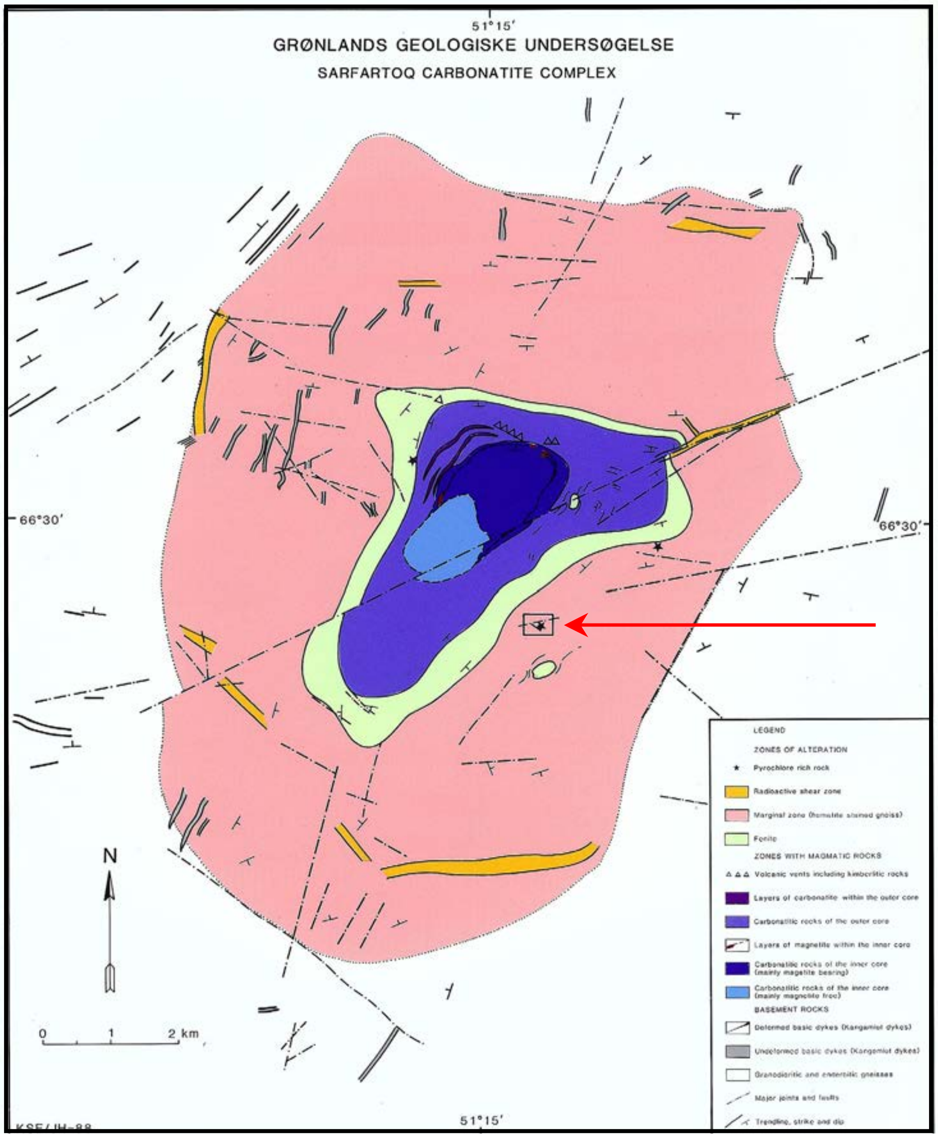

Figure 61. *Geological map of the Sarfartoq carbonatite complex . The pyrochlore mineralisation ("Sarfartoq 1") is outlined by a box (end of red arrow). After Secher (1986).*

Figure 62. *Close-up of pyrochlore lens at the southern margin of the Sarfartoq complex.*

References:

Druecker, M.D. (1990): Sarfartoq Carbonatite Complex ,Summary report; 9 pp. Unpublished report, Hecla Mining Company, Idaho, USA (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20337).

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Woolley, A. R. (1987): Alkaline rocks and carbonatites of the world. Part 1: North and South America. British Museum, London, 73–96.

Compiler and date (dd-mm-yyyy):

KSE 27-11-2003

Sarfartoq (Phosphate) Type id. no. 116

Type locality id. no.: 116

Type locality for id. nos.: 116

Locality name: Sarfartoq

Area: Kangerlussuaq region

Genetic relation: Magmatic deposit

GSC deposit type: 24.0 – Carbonatite-associated deposits

Commodity group: Industrial minerals

Commodities (minor): Phosphate

Economic significance: 2

Geological characteristics:

Description of occurrence: Apatite is found within a carbonatite intrusion as megacrysts or disseminated in magmatic carbonatite sheets, 2–30 m wide and may be traced for a distance of up to 200–500 m along the strike.

Geotectonic setting: The Sarfartoq carbonatite, together with kimberlites from the region, belong to the well-known and widespread 'North Atlantic alkaline rock province' which has representatives in both eastern Canada and Scandinavia (Secher & Larsen, 1980;). It is believed that this province was formed in a rift system during the opening of the Iapetus Ocean (Larsen *et al.*1983; Larsen & Rex 1992).

Depositional environment/Geological setting: The Sarfartoq carbonatite complex is emplaced in the transition zone between the Archaean granulite facies gneiss complex to the south and the Palaeoproterozoic Nagssugtoqidian orogen to the north (Secher1986). The complex is ellipsoidal at the surface and covers about 90 km^2, of which 10 km^2 are intrusive carbonatites (Secher & Larsen, 1980).

Two major stages of igneous activity introduced Fe/Mg-carbonatite rocks, leading to the formation of a steeply dipping conical body (the core) of concentric sheets of carbonatite, followed by a series of concentric and radial dykes and agglomerates emplaced in the surrounding marginal shock-zone. An accompanying fenitisation surrounding the core is of the Na-type.

The carbonatite core is divided into three zones based on the proportion of carbonatite to fenite. The inner core (>50% carbonatite) is only approximately 1 km^2 in area, the outer core (<50% carbonatite) forms a 1–3 km broad ring, occupying around 9 km^2. A narrow rim of fenite (about 5 km^2) surrounds this. The predominantly carbonatite type in the core is rauhaugite (dolomite-rich); søvite (calcite-rich) occurs only sporadically in the outer core as schlieren, and as discrete layers in the inner core. The foliation and layering are accentuated by the streaky occurrence of dark minerals such as phlogopite and magnetite which are sometimes concentrated in lenses of glimmerite and bands in which magnetite constitutes up to 80% of the rock, by volume. (Secher, 1986; Secher and Larsen, 1980)

Age of mineralisation: The age of the Sarfartoq carbonatite complex is around 600 m.y., based on K/Ar age determinations (Larsen *et al.*, 1983, Larsen & Rex, 1992). The complex is thus of late Proterozoic age

Host/Associated rock types: The dolomitic magmas were poor in SiO_2, Al_2O_3 and K_2O in relation to other carbonatites. The main phosphate-carrying carbonatite is characterised by a CaO/MgO ratio of 1.8–2.8, i.e. rather uniform rauhaugite. Increasing CaO/MgO ratio (2.8 to 8.2) separates three successive phases of søvite with decreasing P_2O_5 content, ending with nearly phosphate-free rocks.

Deposit form: The søvite of the inner core invariably has a low P_2O_5 content, 0.1–2.0-wt %. The rauhaugite of the outer core has a P_2O_5 content varying from 0.5 to 8.0 wt %, with a mean value of approximately 3.5 wt %. Values up to 12-wt % P_2O_5 are found in few narrow layers of søvitic rauhaugite. While any single rauhaugite sheet has a relatively constant apatite content, there are large variations between sheets and adjacent sheets may show maximum differences. However, there is a general increase in P_2O_5 content in the outer parts of the core (Secher 1989).

Texture/Structure: The apatite grains are usually euhedral and occur as disseminations, clusters and rosettes or large single crystals.

Ore mineralogy (principal and *subordinate*): The phosphate mineral is fluorapatite, which is from light green to brown and pink, the variation in colour being ascribed to variations in the contents of Mn and REE. The existence of an unidentified, probable Th-REE-phosphate in the marginal zone is insignificant from a phosphate resource point of view.

Gangue mineralogy (principal and *subordinate*): The main rock-forming minerals are dolomite (ankerite), calcite, apatite, phlogopite, richterite-arfvedsonite and magnetite. Important accessories are *pyrochlore, zircon and niobian rutile*.

Alteration: Alteration of the apatite is actually not developed in the subarctic arid climate.

Weathering: Highly variable. Apparently dissolution of the carbonate rich host rock is the general process, thereby releasing apatite mineral grains to the soil cover. Luxurious vegetation at the valley floor is expected to be based on a phosphate surplus within the soil. Part of the dissolved carbonate is redeposited as coatings of hydrous carbonate minerals (monohydrocalcite). Secondary accumulation or development of residual deposits of phosphate is not observed, probably because of pronounced glacial erosion.

Ore controls: Apatite accumulation within the host rock is a result of primary crystallisation from the carbonatite magma. Apatite grains are locally broken and bent, and possibly concentrated locally by post-crystallisation deformation in the magma. Separate phases of magma may represent another explanation of increased apatite content.

Genetic models: Apatite accumulation is a result of primary magmatic crystallisation into a rather uniform rauhaugite, characterised by an even CaO/MgO ratio of 1.8–2.8. Increasing CaO/MgO ratio (2.8 to 8.2) separates successive phases of søvite with decreasing P_2O_5 content, ending with nearly phosphate-free rocks, thus explaining generally low apatite contents within the inner core and accordingly general increase in P_2O_5 content in the outer parts of the rauhaugite dominated core.

Analytical data:

La (ppm)	Y (ppm)	Sr (ppm)	Mn (ppm)
800	190	5700	420

Table 5. *Average trace elements in apatite from rauhaugite.*

Exploration:

The exploration of the Sarfartoq carbonatite complex has been based on the use of airborne gamma-ray spectrometry (Secher 1976). Stream sediment geochemistry has assisted in localising the apatite carrying carbonatitic rocks. Economic calculations have not been carried out nor has any dedicated apatite exploration. The heterogeneous distribution of the apatite grains and the size of individual deposits have so far not created an exploitable source (Secher 1986).

The phosphate potential of the complex is related to the conical body of concentric carbonatite sheets situated in the outer core (9 km^2). On the basis of data available, resources of carbonatite may be roughly estimated at 1000 million tonnes averaging 3.5 wt % P_20_5, to depths of 100 m and 200 m, respectively (Secher 1989). Possible minor commodities from the processing of the apatite-rich carbonatite could be strontium and magnetite.

Photos, figures and maps:

Figure 63. *View (facing north) of the Sarfartoq carbonatite complex core area.*

Figure 64. *Close-up of apatite crystals in the carbonatite host rock, Sarfartoq. Scale-bar 2 cm.*

References:

Larsen, L.M., Rex, D.C. & Secher, K. (1983). The age of carbonatites, kimberlites and lamprophyres from southern West Greenland: recurrent alkaline magmatism during 2500 million years. Lithos, **16**, 215–21.

Larsen, L.M., & Rex, C. 1992: A review of the 2500 Ma span of alkaline-ultramafic, potassic and carbonatite magmatism in West Greenland. Lithos **28**, 367–402.

Secher, K. 1976: Airborne radiometric survey between 66° and 69°N, southern and central West Greenland. Rapport Grønlands Geologiske Undersøgelse **80**, 65–67.

Secher, K. (1986). Exploration of the Sarfartoq carbonatite complex, southern West Greenland. Rapp. Grønlands geol. Unders.,**128**, 89–101.

Secher, K. 1989: Phosphate resources in the Sarfartôq Carbonatite Complex, southern West Greenland. In: Notholt, A. J. G., Sheldon, R. P., and Davidson, D. F. (eds.): Phosphate deposits of the world, **2** (Phosphate rock resources): Cambridge Cambridge University Press, 87–89.

Secher, K.. & Larsen, L.M. (1980). Geology and mineralogy of the Sarfartoq carbonatite complex, southern West Greenland. Lithos, **13**, 199–212.

Compiler and date (dd-mm-yyyy):

KSE 20-11-2003

Sarfartoq (REE) Type id. no. 117

Type locality id. no.: 117

Type locality for id. nos.: 117

Locality name: Sarfartoq

Area: Kangerlussuaq

Genetic relation: Magmatic deposit (hydrothermal)

GSC deposit type: 24.0 – Carbonatite-associated deposits

Commodity group: Speciality metals

Commodities (minor): REE (Thorium)

Economic significance: 3

Geological characteristics:

Description of occurrence: REE accumulations was formed during one of several magmatic phases of the Sarfartoq carbonatite intrusion (Secher & Larsen 1980). The HREE is deposited late in the igneous history as hydrothermal products in the marginal alteration zone surrounding a central carbonatite mass. The mineralisation is located in veins and in cataclastic fractures and zones of varying orientation and often associated with elevated Th-contents. LREEs are selectively enriched in pyrochlore vein occurrences as described (id. no. 115).

Geotectonic setting: The Sarfartoq carbonatite, together with kimberlitic rocks from the region, belongs to the well-known and widespread 'North Atlantic alkaline rock province' which has representatives in both eastern Canada and Scandinavia (Secher & Larsen 1980). It is believed that this province was formed in a rift system during the opening of the Iapetus Ocean (Larsen *et al.*1983; Larsen & Rex 1992).

Depositional environment/Geological setting: The Sarfartoq carbonatite complex is emplaced in the transition zone between the Archaean granulite facies craton to the south and the Palaeoproterozoic Nagssugtoqidian orogen to the north (Secher 1986). The complex is ellipsoidal at the surface and covers about 90km^2, of which 10km^2 are intrusive carbonatites (Secher & Larsen 1980).

Two major stages of igneous activity introduced Fe/Mg-carbonatite rocks, leading to the formation of a steeply dipping conical body (the core) of concentric sheets of carbonatite, followed by a series of concentric and radial dykes and agglomerates emplaced in the surrounding marginal shock-zone. Hydrothermal activity gave rise to several phases of Nb and

REE-mineralisation in carbonate veins and shear zones. The accompanying fenitisation is of the Na-type.

The carbonatite core is divided into three zones based on the proportion of carbonatite to fenite. The inner core (>50% carbonatite) is only approximately 1 km^2 in area; the outer core (<50% carbonatite) forms a 1–3 km broad ring, occupying around 9 km^2. A narrow rim of fenite (about 5 km^2) surrounds this.

Age of mineralisation: The age of the Sarfartoq carbonatite complex is around 600 Ma, based on K/Ar age determinations (Larsen *et al.* 1983). The complex is thus of late Proterozoic age

Host/Associated rock types: The dolomitic magmas of the carbonatite intrusion show REE contents, which are consistent with those reported from a number of world carbonatites. The host rock is gneiss with amphibolite schlieren, altered by a slight K-feldspar fenitisation and hematite staining, and characteristically together with strong limonitisation (Secher & Larsen 1980).

Deposit form: The accumulation of HREEs is observed in two groups of occurrences within the marginal zone of the carbonatite complex. A) Radioactive shear zones of varying orientation, 50–200 m wide and 1–3 km long are frequent and very visible in the terrain, due to pronounced limonite staining. B) Veinfillings of dolomite-REE carbonate -(sulphide), 5–20 cm, and traceable rarely more than 10 m.

Texture/Structure: The radioactive shear zones are characterised by rusty coloured fine grained matrix, locally with infillings of carbonate rich material and often with pseudomorphs after a prismatic mineral very much like ancylite. Probe analyses have shown that REE and Th are contained in semioppaque Ca-rich 'pigmentary' material around the pseudomorphs. The dolomite-REE carbonate veins are irregular, but locally developed with a symmetric structure with dolomite crystals in sheaf like bundles perpendicular to either contacts. Fine grained mixed carbonate material is the matrix between bundles and in the central part of the vein structure (Secher 1980b; Secher & Larsen 1980).

Ore mineralogy (principal and *subordinate*): REE-carbonate, dolomite and *pyrite*.

Gangue mineralogy (principal and *subordinate*): The main vein forming minerals are dolomite and calcite.

Alteration: Alteration of the radioactive shear zones is pronounced with development of limonite and/or hematite.

Weathering: Not discernible from the alteration.

Ore controls: Cataclastic zones as well as the alteration within the marginal area around the Sarfartoq carbonatite complex is probably generated early in the emplacement history, and reactivated a couple of times during the emplacement period. Hydrothermal products have later settled in breccias and cracks/veins along with further alteration under oxidising conditions. At the same time a fractionation of REEs into LREE (pyrochlore occurrences) and HREE (in carbonate veins) is developed.

Genetic models: The REE-enriched hydrothermal phase terminating the carbonatite magma activity resulted in several stages of deposition in veins and shear zones within an alteration zone of the fenitised marginal part of the complex, which are also known from similar veins in the United States (Secher 1980a+b;1986, 1987, 1989). As in other places abroad these veins are enriched in intermediate REE and with a specific peak at Eu (table).

Analytical data:

Type	La (ppm)	Ce (ppm)	Eu (ppm)	Tb (ppm)	Yb (ppm)	Σ (ppm)
A: Rad. shear zone	1200–1860	1680–3300	200-236	18-44	3-126	3286-5381
B: Dolomite vein	20000–30000	–	20–50	–	–	40000–70000

Table 6. *REE analyses (Secher 1980b; Secher & Larsen 1980)*

Exploration:
The exploration of the Sarfartoq carbonatite complex has been based on the use of airborne gamma-ray spectrometry (Secher 1976). Stream sediment geochemistry has assisted in localising the REE-enriched sections. Radiometric ground mapping based on cps-values (counts per second) measured by a SPP-2 Saphymo Stel scintillometer has locally been used in order to outline details of radioactive shear zones.

The radioactive shear zone show noteworthy concentrations of LREE of up to 0.5% with peak values of Eu at 236 ppm. Showings of that kind are so far only observed at few localities and have limited extend. Resources estimation will need more field information. Dolomite/REE-carbonate veins can carry up to 7 % REE, mainly La and Ce. These veins are scattered through out the marginal zone, however, demonstrating a limited resource, based on accessible knowledge. No exploration directed at REE occurrences have been conducted.

Photos, figures and maps:

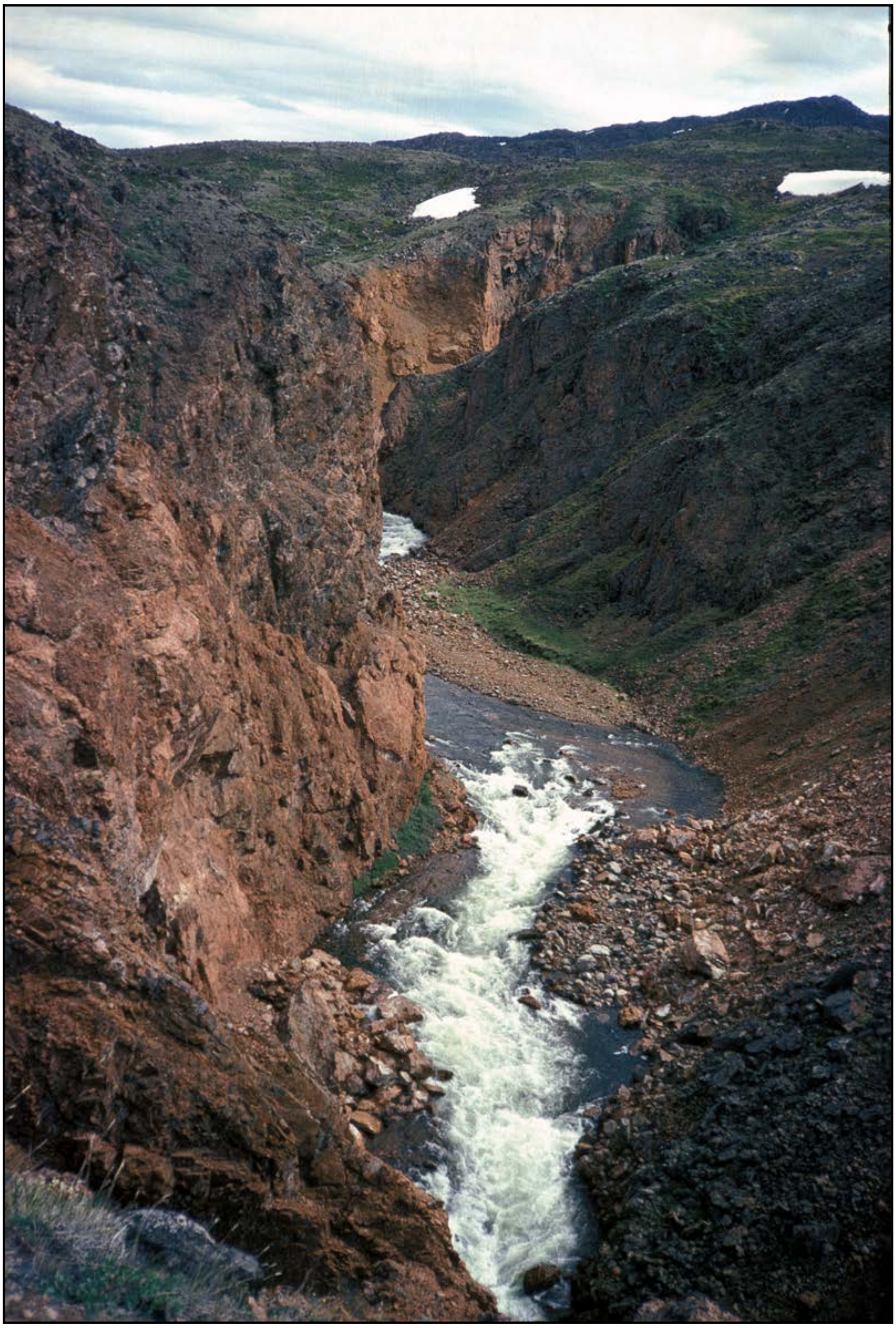

Figure 65. *Field view of a radioactive shear zone located along a gully close to the southern margin of the Sarfartoq complex.*

Figure 66. *Vein-filling of REE carbonate and dolomite within a radioactive shear zone. Arrow head indicates the centre of the vein.*

References:

Larsen, L.M., Rex, D.C. & Secher, K. (1983). The age of carbonatites, kimberlites and lamprophyres from southern West Greenland: recurrent alkaline magmatism during 2500 million years. Lithos, **16**, 215–21.

Secher, K. 1976: Airborne radiometric survey between 66° and 69°N, southern and central West Greenland. Rapport Grønlands Geologiske Undersøgelse **80**, 65–67.

Secher, K. 1980a: Distribution of radioactive mineralisation in central West Greenland. Rapport Grønlands Geologiske Undersøgelse **100**, 61–65.

Secher, K. 1980b: Indhold af lanthanider i karbonatitbjergarter fra Sarfartôq karbonatitkomplekset, centrale Vestgrønland, bestemt ved instrumentel neutronaktiveringsanalyse (INAA). 1–13, Unpublished GGU report, Copenhagen, Denmark.

Secher, K. (1986). Exploration of the Sarfartoq carbonatite complex, southern West Greenland. Rapport Grønlands Geologiske Undersøgelse,**128**, 89–101.

Secher, K. (1987): Pyrochlore mineralisation within the Sarfartoq carbonatite complex. 15 pp. GGU int. report, Copenhagen, Denmark.

Secher, K. & Larsen, L.M. (1980). Geology and mineralogy of the Sarfartoq carbonatite complex, southern West Greenland. Lithos, **13**,199–212.

Compiler and date (dd-mm-yyyy):

KSE 28-11-2003

Qaqortorssuaq (anorthosite) Type id. no. 119

Type locality id. no.:	119
Type locality for id. nos.:	119
Locality name:	Qaqortorssuaq
Area:	Kangerlussuaq
Genetic relation:	Anorthosite
GSC deposit type:	26.0 – Mafic intrusion
Commodity group:	Industrial minerals
Commodities (minor):	Aluminium
Economic significance:	2

Geological characteristics:

Description of occurrence: The Qaqortorssuaq mountain reaches 1300 m in altitude and constitutes of a large body of white anorthosite. The strike direction of the long axis is WSW-ENE. Around 90 vol. % of the deposit is homogeneous anorthosite which is predominantly composed of white bytownitic plagioclase. Patches of anorthosite-gabbro occur locally in limited amounts. Chunks of metamorphosed Kangamiut dyke rocks with the direction 66°E are observed as inclusions in the anorthosite. (Ellitsgaard-Rasmussen & Mouritzen 1954; Gothenborg & Keto 1977).

Geotectonic setting: The anorthosite occurrence is situated in the southern border zone of the Nagssugtogidian orogen, which is characterised by regional shearing under amphibolite facies conditions. This border is defined as the southern boundary of Palaeoproterozoic reworking of the Archaean basement gneisses.

Depositional environment/Geological setting: Emplacement and subsequent metamorphism of an anorthositic gabbro body intrusion, which is composed of white bytownitic plagioclase (77 vol. %) and hornblende (23 vol. %). The rock is medium-grained and shows locally gradual transitions into pure anorthosite.

Age of mineralisation: The age of the anorthosite is uncertain. Based on inclusions of metamorhosed Kangamiut dyke fragments it is obvious that the anorthosite is emplaced post Kangamiut dyke, which are dated to 2040 Ma.

Host/Associated rock types: Granulite facies and amphibolite facies basement rocks of tonalitic to granodioritic composition.

Deposit form: The deposit covers app. 45 km^2 and has an oval shaped outline (5x15 km) with rather sharp contacts.

Texture/Structure: The anorthosite is a small to medium grained, white xenoblastic rock, locally with cm-large idioblastic phenocrysts, and with scattered irregular aggregates of mafic minerals. Xenomorphic grains of plagioclase with a mean grain size of 0.7 mm (max. 5 mm) are the dominating mineral, constituting 84.5–98.4 vol. % of the rock. Polysyntetic twinning is well-developed in larger grains, but usually they may be surrounded by a dense granular matrix of plagioclase without twinning. The anorthite content of the plagioclase is varying between values of 81–88 % An, corresponding to bytownite (Ellitsgaard-Rasmussen & Mouritzen 1954; Gothenborg & Keto 1977).

Ore mineralogy (principal and *subordinate*): Plagioclase.

Gangue mineralogy (principal and *subordinate*): No gangue.

Alteration: No alteration.

Weathering: None.

Ore controls: Intrusive body.

Genetic models: Primary magmatic intrusion.

Analytical data:
Chemical assays on Al, Ca, Mg, Na, K/and Fe have been carried out on 12 specimens of anorthosite (Gothenborg & Keto 1977). The Al_2O_3 content is in the range 32.2–35.9wt. % and has a mean value of 33.7 wt.%.

Exploration:
Exploration has been carried out Kryolitselskabet ØresundA/S, who estimated that the Qaqortorssuaq anorthosite deposit represents an important resource of aluminium in the order of 100 million tonnes per metre depth with an average Al_2O_3 content of 33.7% (equivalent to c.18 % Al). The estimate is based on a profile sampling and chemical analyses of 52 samples from two profiles (total length is 2.3km).

Photos, figures and maps:

Figure 67. *Arial view of the 1300 m a.s.l. Qaqortorssuaq mountain from south.White dashed line indicate the border between the anorthosite (top area) and the basement.*

References:

Ellitsgaard-Rasmussen, K., & Mouritzen, M. 1954: An anorthosite occurrence from West Greenland. Meddelelser fra Dansk Geologisk Forening **12**, 436–442.

Gothenborg, J., & Keto, L. 1977: Report on the areal reconnaissance between Sukkertoppen Ice Calot and Nordenskiölds Gletscher, 2–8, Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20071).

Compiler and date (dd-mm-yyyy):

KSE 02-12-2003

Kangâmiut dykes (malachite) **Type id. no. 120**

Type locality id. no.: 120

Type locality for id. nos.: 120

Locality name: Angujaartorfik

Area: Kangerlussuaq

Genetic relation: Mafic intrusion (Kangamiut dyke)

GSC deposit type: 27.0 – Magmatic nickel-copper-platinum group elements

Commodity group: Base metals

Commodities (minor): Copper (nickel)

Economic significance: 4

Geological characteristics:

Description of occurrence: The Kangamiut dyke swarm is consisting of normal or hornblende dolerites, characterised by a marked ophitic texture and little or no internal structure. Most of the dykes are between 10 and 50 m wide. They are traceable for several hundred metres and often can be traced for tens of kilometres along strike. Individual dykes may show sudden changes in strike, and intersections between different generations within the same set are common. Two major sets are observed; an E-W oriented and a NNE trending set.

Geotectonic setting: Emplaced during extension related to continental breakup (van Gool *et al.* 2002), which probably took place before or early in the development of the Palaeoproterozoic Nagsugtoqidian orogen. Reworking and reorientation of the dykes are pronounced (Escher *et al.*1975; Korstgaard 1979).

Depositional environment/Geological setting: Emplacement of swarms of doleritic dykes in the Archaean basement. The Kangamiut dykes are continental tholeiites (Nielsen 1987).

Age of mineralisation: The Kangamiut dykes are emplaced around 2040 Ma (Nutman *et al.*1999).

Host/Associated rock types: Granulite facies and amphibolite facies basement rocks of tonalitic to granodioritic composition.

Deposit form: Disseminated Cu-bearing sulphides occur in limited amount, generally barely visible. However, weathering and development of malachite and azurite staining are observed at several places along Kangerlussuaq and Ikertoq fjords and has early in the exploration history gained attention (Ball 1922; Nielsen 1973). Spectacular outcrops with malachite staining are developed in patches covering several square metres.

Texture/Structure: Disseminated sulphides in ophitic dolerite.

Ore mineralogy (principal and *subordinate*): Chalcopyrite and pyrrhotite (malachite and azurite).

Gangue mineralogy (principal and *subordinate*): Dolerite matrix with plagioclase and hornblende.

Alteration: No distinct alteration pattern.

Weathering: Development of malachite and azurite in patches.

Ore controls: The mineralisation is disseminated in the dolerite dykes.

Genetic models: Primary accumulation/dispersion of magmatic sulphides in dolerite rocks.

Analytical data:

Analyses are carried out by GEUS and show the following metal contents: Cu, Ni and Zn each in the range 130–140 ppm.

Exploration:

Exploration has been carried out at several occasions by Grønlands Minedrifts A/S and Kryolitselskabet Øresund A/S earlier in the history of the Greenland mineral exploration (Ball 1922; Nielsen 1973). However, it has been recognised that the content of Cu (and Ni, Zn) is very low and probably without economic interest.

Photos, figures and maps:

Figure 68. *Malachite staining on Kangâmiut dyke slope exposure (green arrow indicates the stained surface).*

References:

Escher, A., Escher, J.C., & Watterson, J. 1975: The reorientation of the Kangâmiut dike swarm, West Greenland. Canadian Journal of Earth Sciences **12**, 158–173.

Ball, S.H. 1922: The mineral resources of Greenland. Meddelelser om Grønland **63,1**, 1–60.

Nielsen, B.L. 1973: A survey of the economic geology of Greenland. Rapport Grønlands Geologiske Undersøgelse **56**, 1–45.

Nielsen, T.F.D. 1987: Mafic dykes swarms in Greenland: a review. in: Halls, H. C., and Fahrig, W. F., eds.: Mafic dyke swarms. **34**, Special Paper Geological Association of Canada 349–360.

Compiler and date (dd-mm-yyyy):

KSE 02-12-2003

Kangerlussuaq (diamonds) **Type id. no. 136**

Type locality id. no.: 136

Type locality for id. nos.: 118, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139

Locality name: Sarfartoq

Area: Kangerlussuaq

Genetic relation: Hypabyssal intrusion (kimberlitic rocks)

GSC deposit type: 25.0 – Primary diamond deposits

Commodity group: Gemstones

Commodities (minor): Diamond

Economic significance: 3

Geological characteristics:

Description of occurrence: Diamonds have been found within some of the many kimberlitic dykes in the area. The dykes commonly contain numerous mantle xenoliths ranging in size from a few millimetres to several decimetres. A majority of the xenoliths have peridotitic or pyroxenitic composition. Kimberlitic or lamproitic boulders in sizes from a few centimetres to 2 metres across are ubiquitous often concentrated in clusters or trains several hundreds of metres long.

Geotectonic setting: Alkaline ultramafic dykes in the Sisimiut–Kangerlussuaq and Sarfartoq areas intrude the border zone between the Archaean craton and the Palaeoproterozoic Nagssugtoqidian orogen (Secher & Larsen 1980). The alkaline rocks were indeed intruded along the Archaean border zone during continental rifting following the opening of the Iapetus sea at the dawn of the Cambrian (Secher & Larsen 1980).

Depositional environment/Geological setting: The region hosts several clusters of kimberlitic dykes and sills (more than 200 outcrops), which appear to be controlled by pre-existing joint systems or concordant with the enclosing gneiss. A large number of dykes are located in the vicinity of the Sarfartoq carbonatite complex. A genetic relation between the kimberlitic dykes and the carbonatite magma source is suggested (Larsen 1980). The Kangerlussuaq region has the largest concentration of Kimberlitic dyke and boulder occurrences within the West Greenland alkaline province (Larsen 1991, Jensen *et al.* 2002).

Age of mineralisation: Kimberlitic dykes occur in swarms and have been interpreted as cone-sheets centred on the 0.6 Ga Sarfartoq carbonatite complex (Larsen 1980). Lamproitic dykes in the adjacent Sisimiut region are around 1.2 Ga old, and the kimberlitic dykes in both the Sarfartoq and Sisimiut regions have ages of around 0.6 Ga (Larsen & Rex 1992). A new age dating programme involving the kimberlitic rocks is in progress at GEUS.

Host/Associated rock types: Southern West Greenland hosts an alkaline province with a variety of ultramafic alkaline rocks, including swarms of dykes traditionally described as kimberlites and lamproites. The classification of these rocks has been disputed and they are considered to be ultramafic lamprophyres. The term 'kimberlitic', however, is still in common use in Greenland and is applied here.

Deposit form: In total around 500 diamonds (microdiamonds and a few macrodiamonds) are found in outcropping dykes. The dykes are often subvertical, 1–2 m wide, and traceable for many hundreds of metres. Others are shallow dipping, rarely over 1 m wide, and exposed over tens of metres.

Texture/Structure: Two clusters of dykes have been recognised within the region in the last 20–30 years (Scott 1977, 1981; Larsen 1980, 1991). Dykes of the Sisimiut swarm (20 x 60 km), consisting mainly of 1287 Ma lamproites and 587 Ma kimberlites, generally have vertical E–W/SE–NW striking orientation. The Sarfartoq swarm with mainly 615 Ma kimberlites was described as a cone-sheet structure centred on the 600 Ma Sarfartoq carbonatite (80 x 80 km).

The cone-sheet model for kimberlitic dykes around the Sarfartoq carbonatite complex was largely based on measurements of dyke orientations in a broad east–west valley transecting the core of the complex. With recent knowledge of many additional dyke occurrences in the region, it appears that other structural elements in addition to the cone-sheet model have controlled the emplacement of dykes (Jensen *et al.* 2003b).

For example, many kimberlitic dyke orientations follow the trends of the Palaeoproterozoic Kangâmiut dolerite dykes in reworked as well as unreworked parts of the Archaean basement. Another example is an apparent predominance of north–south kimberlitic dykes in a corridor reaching far beyond the Sarfartoq complex. Information from magnetic field data lend support to the hypothesis that kimberlitic dyke emplacement may be controlled by such structures of more regional character.

Ore mineralogy (principal and *subordinate*): Diamond. Kimberlite indicator minerals: pyrope garnet (G10 and eclogitic), chrome diopside, ilmenite, chromite, olivine and phlogopite.

Gangue mineralogy (principal and *subordinate*): Kimberlitic rock.

Alteration: Not existent, or rarely observable.

Weathering: Development of secondary monohydrocalcite coating on boulders and cliff surfaces. On a local scale kimberlite indicator minerals from till samples are distributed due to complex glacial dynamics having characterised the formation of till deposits. The most diamond-favourable indicator minerals are distributed far beyond the areas with known diamonds. This observation, together with the postulated regional structural control, suggests that the potential for diamonds is not restricted to the known occurrences.

Ore controls: Not applicable.

Genetic models: Diamond are transported from the mantle's diamond stability field (180–200 km's depth) to the recent position during kimberlite dyke intrusion.

Analytical data:
Not applicable.

Exploration:
The kimberlites have been a target for commercial diamond exploration since the mid-1990s. The first (micro)diamonds recorded from the area were collected from stream sediments in the valley of Sarfartoq in 1973 (Jensen *et al.* 2003). Since the mid 1990s exploration companies have reported in situ micro and macro diamonds in kimberlitic dykes and sills from several localities within the area (reviewed by Jensen et al 2003). Indicator minerals from till are reported from 8000 localities within the area. The study of indicator minerals is regarded as a key method for localising kimberlitic rocks. Company exploration is ongoing.

Photos, figures and maps:

Figure 69. *Typical diamondiferous kimberlitic dyke exposure in the Kangerlussuaq region.*

References:

Jensen, S.M., Hansen, H., Secher, K., Steenfelt, A., Schjøth, F. & Rasmussen, T.M. (2002): Kimberlites and other ultramafic alkaline rocks in the Sisimiut-Kangerlussuaq region, southern West Greenland. Geology of Greenland Survey Bulletin **191**, 57–66.

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Scott, B.H. 1981: Kimberlite and lamproite dykes from Holsteinsborg, West Greenland. Meddelelser om Grønland, Geoscience **4**, 24 pp.

Secher, K. & Larsen, L.M. (1980): Geology and mineralogy of the Sarfartôq carbonatite complex, southern West Greenland. Lithos **13**, 199–212.

Compiler and date (dd-mm-yyyy):

KSE 02-12-2003

Nassuttooq (cordierite) Type id. no. 140

Type locality id. no.:	140
Type locality for id. nos.:	140
Locality name:	Nuuk
Area:	Nassuttooq
Genetic relation:	Pegmatite
GSC deposit type:	21 – Granitic pegmatite
Commodity group:	Gemstones
Commodities (minor):	Cordierite
Economic significance:	4

Geological characteristics:

Description of occurrence: Biotite-rich micaceous layers within quartzo-feldspathic gneisses locally contain garnet and sillimanite or cordierite. Individual cordierite grains within pegmatic sections may reach a size of 5 cm. Cordierite has been observed at several places in the Sisimiut-Nassuttooq region (Ramberg 1948).

Contact relationships with the surrounding grey orthogneissic rocks and their relative ages are uncertain.

Geotectonic setting: Unknown.

Depositional environment/Geological setting: Quartzo-feldspathic gneisses are interpreted as meta-psammitic rocks.

Age of mineralisation: Unknown.

Host/Associated rock types: Quartzo-feldspathic gneisses are grey, medium-grained paragneisses and are rather homogeneous, often quartz-rich and poor in biotite, and may contain abundant small (1-2 mm) garnets. The quartzo-feldspathic paragneisses are interlayered with 5-100 cm wide amphibolite layers, which are probably of volcanic origin. Rare, biotite-rich micaceous layers locally contain garnet and sillimanite.

Deposit form: Cordierite locally develops as cm large violet grains/augens, transparent and locally with only few cracks. Details of deposit size are not available.

Texture/Structure: Augen and/or granoblastic texture. The grey, medium-grained paragneisses are rather homogeneous, often quartz-rich and poor in biotite, and may contain abundant small (1–2 mm) garnets.

Ore mineralogy (principal and *subordinate*): Cordierite.

Gangue mineralogy (principal and *subordinate*): Not applicable.

Alteration: No alteration observed.

Weathering: None.

Ore controls: Chemical composition and metamorphic grade of meta-sedimentary rocks.

Genetic models: Cordierite carrying quartzo-feldspathic gneisses are interpreted as meta-psammitic rocks.

Analytical data:
None.

Exploration:
No exploration has been done concerning gemstones. The cordierite (var. dichroite) has been cut and polished as a test with an acceptable result (Ellitsgaard-Rasmussen, pers. com). No information of available resources.

Photos, figures and maps:
None

References:
Ramberg, H. 1948: On the petrogenesis of the gneiss complexes between Sukkertoppen and Christianshaab, West-Greenland. Preliminary report. Meddelelser fra Dansk Geologisk Forening **11**, 312–327.

Compiler and date (dd-mm-yyyy):
KSE 28-11-2003.

Nassuttooq (monazite) Type id. no. 144

Type locality id. no.:	144
Type locality for id. nos.:	121, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157
Locality name:	Hyttefjeld
Area:	Nassuttooq
Genetic relation:	Pegmatite
GSC deposit type:	21.0 – Granitic pegmatites
Commodity group:	Speciality metals
Commodities (minor):	Monazite (cerium)
Economic significance:	3

Geological characteristics:

Description of occurrence: Monazite is found as 0.5–5 mm orange coloured crystals accumulated in white plagioclase-biotite pegmatites clustered in the Nassuttooq region. The white pegmatites are generally concordant (locally discordant) to the foliation of the surrounding granulite facies gneiss (Secher 1980).

Geotectonic setting: Unknown.

Depositional environment/Geological setting: The pegmatites are intrusive both into gneisses and supracrustal rocks.

Age of mineralisation: Palaeoproterozoic in age close to 1800 Ma (Pb isotope dating of discrete monazite grains).

Host/Associated rock types: Granulite facies gneiss

Deposit form: The size of individual bodies varies, 5–10 m wide and traceable for 50–200 m often with gradual contacts to the host rock.

Texture/Structure: Monazite crystals are euhedral and accumulated in lens shaped layers accompanied by biotite, set in a granoblastic matrix of primarily plagioclase.

Ore mineralogy (principal and *subordinate*): Monazite and *garnet, zircon, ilmenite, molybdenite*.

Gangue mineralogy (principal and *subordinate*): Plagioclase and *biotite.*

Alteration: None.

Weathering: None

Ore controls: Accumulation of accessory minerals in pegmatitic intrusions.

Genetic models: Unknown.

Analytical data:

The rare earth elements contents are: La 1–2%, Ce 2.5–4%, Nd 5–7%;. Other element contents are Zr 1–1.5%, Y 500 ppm, ppm, and Th 5–10%. The monazite type is dominated by Nd.

Exploration:

The investigation of pegmatites has used airborne and ground gamma-ray spectrometry (Secher 1976). No company exploration has been carried out concerning monazite carrying pegmatites. No resource estimates are available.

Photos, figures and maps:

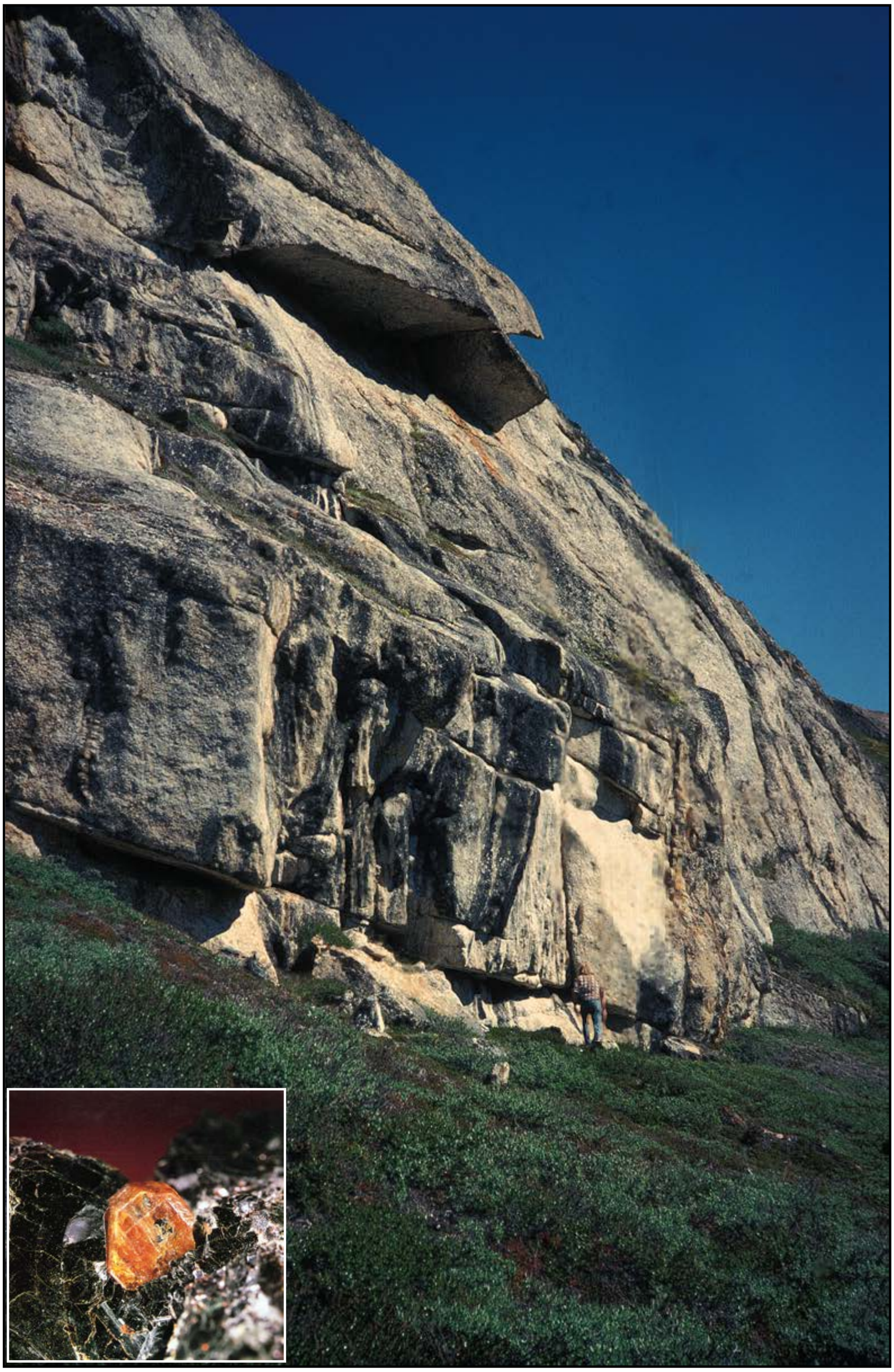

Figure 70. *Field view of concordant white pegmatite (radioactive) exposed parallel to the cliff wall. Inset: close-up of a 2 mm monazite crystal.*

References:

Secher, K. 1976: Airborne radiometric survey between 66° and 69°N, southern and central West Greenland. Rapport Grønlands Geologiske Undersøgelse **80**, 65–67.

Secher, K. 1980: Distribution of radioactive mineralisation in central West Greenland. Rapport Grønlands Geologiske Undersøgelse **100**, 61–65.

Compiler and date (dd-mm-yyyy):

KSE 01-12-2003

Itilliarsuk (iron) Type id. no. 159

Type locality id. no.: 159

Type locality for id. nos.: 159

Locality name: Itilliarsuk

Area: Nuussuaq

Genetic relation: Banded iron-formation

GSC deposit type: 3.2 – Algoma-type iron-formation

Commodity group: Iron and iron alloys

Commodities (minor): Iron

Economic significance: 2

Geological characteristics:

Description of occurrence: Banded iron-formation occurs 200 m above a 'rust zone' within the supracrustals. The thickest succession of supracrustal rocks north of Torsukattak occurs in the Itilliarsuk area. The supracrustal sequence is at least 2.5 km thick. The contact between the supracrustal rocks and the underlying gneisses is strongly tectonised and a basal unconformity has not been located (Garde & Steenfelt 1999c). The sedimentary pile is of presumed Archaean age, and is intruded by gabbroic sills and thin felsic dykes. The lower 400 m of the succession consist of amphibolite with sheared lenses of ultramafic rocks.

Within and on the top of this succession a polymict conglomerate with felsic and mafic clasts occurs. The felsic clasts resemble the underlying gneisses indicating that the supracrustal succession rest unconformably on the Nuussuaq gneiss (Garde & Steenfelt 1999c). The amphibolite succession is overlain by a more than 2-km thick sequence of siliciclastic rocks dominated by mica-garnet schists. Locally the siliciclastic succession is interlayered with up to 100-m thick amphibolite and metagabbro, and in the middle part very thin BIF horizons also occur. Several hundred metres of felsic volcanic rocks conclude the supracrustal succession. Lower amphibolite facies metamorphism and at least two phases of deformation have affected all rocks (Garde & Steenfelt 1999b; Garde & Steenfelt 1999c).

Geotectonic setting: The geotectonic setting of the Archaean supracrustal rocks of the area north of Torsukattak represent a rift or continental margin environment with more metasediments intercalated in the volcanic sequences than in the island arc setting towards south (Eqi and Arveprinsen Ejland) (Garde & Steenfelt 1999b).

Depositional environment/Geological setting: The banded iron-formation is an approximately 200 m wide sequence of 2–10cm magnetite-rich cherty bands alternating with quartz-mica schists. The gradual transition zone between the iron-formation and the adjacent rocks in the sequence is characterised by a garnet-hornblende-magnetite bed. Laterally the iron rich strata grade into clastic sediments with accessory amounts of magnetite. The iron-rich beds gradually become poorer in magnetite and richer in garnet and hornblende. Cyclic repetition occurs between the magnetite-bearing bed and the occurrence of garnet and hornblende in distinct beds can be traced over 500 m along strike. This indicates that the transition from iron oxide to iron silicates reflects a primary chemical gradation in the sediment.

Age of mineralisation: The age is of the mineralisation is uncertain but syngenetic with the Archaean host rocks.

Host/Associated rock types: The host rocks are acid and mafic volcanic rocks.

Deposit form: Stratiform beds.

Texture/Structure: Cm-banding between magnetite, garnet and hornblende and quartz.

Ore mineralogy (principal and *subordinate*): Magnetite.

Gangue mineralogy (principal and *subordinate*): Quartz, garnet and hornblende.

Alteration: None.

Weathering: None.

Ore controls: Syngenetic banded iron-formation.

Genetic models: Algoma-type banded iron-formation. The cyclic repetition indicates that the transition from iron oxide to iron silicates reflects a primary gradation in the chemical sediment.

Analytical data:

Averaging 20% Fe.

Exploration:

Kryolitselskabet Øresund A/S initiated exploration in the Itilliarsuk area (Gothenborg & Keto 1986; Gothenborg & Morthorst 1981; Gothenborg & Morthorst 1982). NunaMinerals A/S later carried out some exploration in the area (Nunaminerals 2000). The Kryolitselskabet Øresund A/S has estimated that the best mineralised part covering an area of 130 x1000 m contains a resource of 150–200 million t of ore grading 20% Fe (Gothenborg & Morthorst 1981).

Photos, figures and maps:

Figure 71. *Banded iron formation from Itilliarsuk. Photo Nunaminerals A/S.*

See also Figure 2 under type locality id. number 7.

References:

Garde, A.A. & Steenfelt, A. 1999a: Precambrian geology of Nuussuaq and the area north-east of Disko Bugt, West Greenland. Geology of Greenland Survey Bulletin **181**, 7–40.

Garde, A.A. & Steenfelt, A. 1999b: Proterozoic tectonic overprinting of Archaean gneisses in Nuussuaq, West Greenland. Geology of Greenland Survey Bulletin **181**, 141–154.

Gothenborg, J. & Keto, L. 1986: Exploration in the Atâ area, Jakobshavn, 1980-1985, 12 pp., Unpublished report, Kryolitselskabet Øresund A/S, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20220).

Gothenborg, J. & Morthorst, J. 1981: Report on the ore exploration in Atâ area, Jakobshavn, 1980, 80 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20325).

Gothenborg, J. & Morthorst, J. 1982: Report on the ore exploration in the Atâ area, Jakobshavn, 1981, 88 pp., Unpublished internal report Kryolitselskabet Øresund, Copenhagen, Denmark (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 20202).

Nunaminerals 2000: An overview of the Company and its prospects, 8 pp., Nunaminerals A/S.

Compiler and date (dd-mm-yyyy):

HST 03-12-2003

<u>Kakilisattoq (sulphides)   Type id. no. 160</u>

Type locality id. no.: 160

Type locality for id. nos.: 160

Locality name: Kakilisattooq

Area: Kangerlussuaq

Genetic relation: Mafic intrusion

GSC deposit type: 27.1 - Nickel-copper sulphides

Commodity group: Base metals

Commodities (minor): Copper (nickel, PGE)

Economic significance: 3

<u>Geological characteristics</u>:

Description of occurrence: The sulphide mineralisation is located in a sequence of amphibolites within grey, quartz rich banded basement gneiss. The mineralisation is confined to layers within the amphibolite and can be followed discontinuously over c. 4 m. At its best the mineralisation contains up to 30 vol% sulphides, mainly pyrrhotite. The mineralisation is not outcropping and is accordingly located by means of geophysical measurements.

Geotectonic setting: The mineralisation is located within the Palaeoproterozoic Nagssutoqidian orogen close to the boundary of the Archaean craton. It is speculative whether or not the amphibolite represents a part of a system of gabbro-anorthosite intrusions into the basement during Palaeoproterozoic reworking processes. (See also id. no. 119).

Depositional environment/Geological setting: The sulphides are confined to amphibolite layers.

Age of mineralisation: The age is unknown, however, the Archaean rocks in the area is generally accepted to be in the interval 2600–2900 Ma with the Palaeoproterozoic reworking around 1750–1950 Ma.

Host/Associated rock types: Amphibolite within basement rocks of tonalitic to granodioritic composition.

Deposit form: The precise form of the mineralisation is unknown and the only information is gathered from a 45º plunging drillcore of 107m. Sulphide rich intersections with massive sulphide (30% over 7 cm; >50% over 7 cm; 20% over 20 cm and 115% over 110 cm) within a 4 m section of amphibolite (Ferguson 2002).

Texture/Structure: Sulphide stringers streaking parallel to amphibolite foliation.

Ore mineralogy (principal and *subordinate*): Pyrrhotite, chalcopyrite (*pentlandite and rare millerite*)

Gangue mineralogy (principal and *subordinate*): Hornblende, biotite and quartz.

Alteration: Locally violarite is developed in Ni-rich areas of the sulphide patches.

Weathering: Not reported.

Ore controls: Foliation within the ampibolite.

Genetic models: Primary accumulation/dispersion of magmatic sulphides in basic rocks.

Analytical data:

Analyses carried out by Ciation Resources report values up to 0.67% Ni and 0.1% Co, 0.7g/t PGE over 7 cm and 2.56% Cu over 7 cm in an adjacent intersection (Ferguson 2002).

Exploration:

Exploration has been carried out by Citation Resources Inc in 2000–2002, comprising air-borne and ground (MaxMin) electromagnetic surveys. These surveys located an oval shaped target of 150 x 300 m, inside which a 107m drillhole was carried out. The area has otherwise been covered by several kimberlite exploration campaigns by other companies since 1996.

Photos, figures and maps:

No illustrations.

References:

Ferguson, J. 2002: Geological report on work conducted in 2001 on the Kakilisattooq exploration licence (EL 2001/12), 5 pp. Unpublished report, Citation Resources Inc. for Dia Met Minerals Ltd., Kelowna, British Columbia, Canada (in archives of Geological Survey of Denmark and Greenland, GEUS Report File 21788).

Compiler and date (dd-mm-yyyy):

KSE 15-01-2004