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Notes on the common legend to the 1:100 000 digital geological map of southern West and South-West Greenland, 61°30' - 64°N

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Abstract

A seamless digital web-based 1:100 000 scale geological map of southern West Greenland and South-West Greenland between 61°30′ – 64°N is produced on the basis of ten previously published 1:100 000 maps. This report describes the common legend for the whole area and the principles followed in its production.

Introduction

Aim of the project

This report presents results of the so-called '*Homogenisation project*', which is a joint project between the Greenland Bureau of Minerals and Petroleum (BMP) and the Geological Survey of Denmark and Greenland (GEUS). The main aim of the project is to generate a seamless digital web-based 1:100 000 scale geological map of southern West Greenland and South-West Greenland between 61°30′ and 64° N. As a natural part of this task, a common legend has been constructed for the geology of the area. The geological data concerning geochronology, structural geology, metamorphic petrology, geochemistry, locality descriptions, and photographs will become available on the web. The currently available geological observations are conceptually modernised and updated with recent field work in selected areas. In order to display the complete Tartoq Group, which straddles the 61°30′N latitude line, the northern part of the Ivigtut map sheet (61 V1 Syd, Henriksen, 1968) is included.

The area covers the crystalline Archaean basement of southern West Greenland and South-West Greenland. It is part of the North Atlantic craton. The exposed rocks are of middle to lower crustal origin, although supracrustal rocks outcrop locally. In the southernmost part of the area, Palaeoproterozoic rocks of the Ketilidian Border Zone (Midternæs & Grænseland) are described. These rocks are included on the map and in the legend, but are otherwise not part of the project.

The area was first mapped in the 1950–1970s and published as a series of maps at 1:100 000 scale in the 1960–1980s by the Geological Survey of Greenland (GGU) and mapping teams from the University of Exeter, UK. The petrographical characterisation of the rocks on the original 1:100 000 scale maps is generally very good. The area is not remapped within the scope of this project, which aimed at increasing the understanding of the area. Instead, the project focused on key localities where processes are most clearly observed.

As a first step for the seamless digital map of southern West and South-West Greenland, it was necessary to produce a common legend for the whole area. The aim of this legend is to show as much information from the original ten map sheets as possible, but in a manner that is consistent for the whole area. Here, we discuss the rational for this common legend. This text is intended as a precursor to a map sheet description.

Basis for the geology and the legend

The basis of the digital seamless map of southern West and South-West Greenland consists of the 10 geological maps at a scale of 1:100 000 that were published between 1968 and 1985 (see Figure 1). These 10 map sheets are:

- Ivigtut 61 V.1 Syd (part) *c.* 61°20´–61°30´N; 47°30´–49°09´W; N. Henriksen 1968.
- Neria 61 V.1 Nord 61°30´–62°00´N; 48°30´–50°00´W; S.B. Jensen 1975.
- Midternæs 61 V.2 Nord 61°30´–62°00´N; 47°00´–48°30´W; A.K. Higgins 1974.
- Nerutussoq 62 V.1 Syd 62°00´–62°30´N; 49°15´–50°45´W; S.B. Jensen 1976.
- Nigerdlikasik 62 V.2 Syd 62°00´–62°30´N; 47°45´–49°15´W; J.C. Escher & S.B. Jensen 1976.
- Bjørnesund 62 V.1 Nord 62°30´–63°00´N; 49°03´–50°48´W; J.C. Escher 1985.
- Grædefjord 63 V.1 Syd 63°00´–63°30´N; 50°15´–51°45´W; J.S. Myers 1982.
- Sinarssuk 63 V.2 Syd 63°00´–63°30´N; 48°45´–50°15´W; J.S. Myers 1980.
- Buksefjorden 63 V.1 Nord 63°30´–64°00´N; 50°42´–52°15´W; B. Chadwick & K. Coe 1983a.
- Kangiata nuna 63 V.2 Nord 63°30´–64°00´N; 49°00´–50°42´W; J.C. Escher 1981.

In addition to the above, map sheet descriptions were published for four of these maps:

- Ivigtut 61 V.1 Syd. A. Berthelsen & N. Henriksen 1975.
- Neria 61 V.1 Nord and Midternæs 61 V.2 Nord. A.K. Higgins 1990.
- Buksefjorden 63 V.1 Nord. B. Chadwick & K. Coe 1983b.

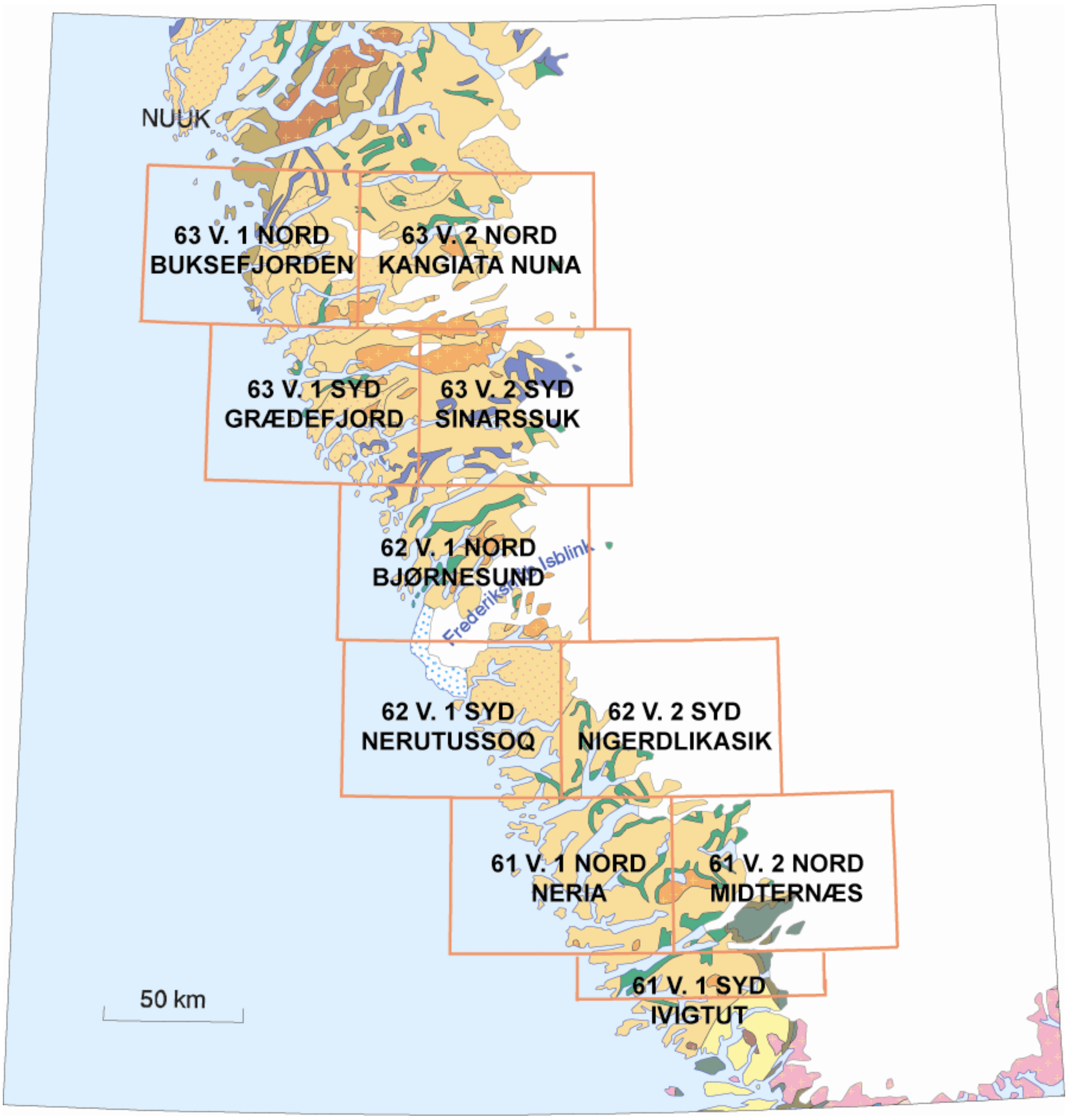

Figure 1: Overview of the ten published map sheets that form the basis for the digital map of southern West and South-West Greenland.

The area forms part of two smaller scale (1:500 000) map sheets with a descriptive texts:

Map sheets:

- Sheet 1: Sydgrønland. 59°30´–62°30´N; 42°00´–50°30´W. Second edition. A.A. Garde 2007.
- Sheet 2: Frederikshåb Isblink – Søndre Strømfjord. 62°30´–66°45´N; 49°00´–54°00´W; J.H. Allaart 1982.

Descriptive texts:

- Sheet 1: Sydgrønland. F. Kalsbeek, L.M. Larsen & J. Bondam 1990.
- Sheet 2: Frederikshåb Isblink – Søndre Strømfjord. F. Kalsbeek & A.A. Garde 1989.

Limitations

Even though an effort was made to keep to GGU standards, each of the 1:100 000 scale geological maps has its own style in representing the geology, depending partly on the compiler of the map, but mainly on the individual geologists who mapped out specific areas of the map sheet. Furthermore, the maps reflect an evolution in the understanding of the geology and, mainly, a change in the mapping philosophy between the publication of the first sheet (Ivigtut; Henriksen 1968) and the last sheet of the series (Buksefjorden; Chadwick & Coe 1983a).

The existing maps form the basis for the new digital map of the area. The limited amount of remapping prohibits major revision or reinterpretation of unit boundaries. Furthermore, the redefinition of a single rock unit into two separate units is only justified where relevant areas were revisited. Conversely, individual units can easily be merged, though this was avoided as much as possible to avoid loss of information.

Because the participants in the current *Homogenisation project* have not remapped the region, we cannot provide a homogenised map, only a homogenised legend. The quality of the digital map is thus for a large part dependent on the quality of the original ten maps. Therefore, mapping boundaries, both between and within maps, will to a large extent still remain visible.

Homogenisation procedure

The original printed maps were digitised. Each of the different rock units was entered in an Oracle-based database as polygons, where rock type, age, coordinates, colour on the map, legend description, and a map-unit abbreviation (gm-label) are recorded. All line data, like faults, unconformities and dykes, and all point data, such as inclusions and strike-dip signs, were also stored in this database.

As a first step, all labels were made unique. For example, Qgi has been used for the Qánguartoq tonalite, granodiorite and granite on the Grædefjord and Sinarssuk map sheets, but the same abbreviation has been used for the Qôrqut granite complex. Units that occur on different map sheets were merged into a single unit with a unique gm-label. The justification for these mergers is described in detail in the sections below.

Rock names in the legend were brought to IUGS standard as far as possible. These recommandations were published in three reports by the British Geological Survey: for igneous rocks (Gillespie & Styles 1999), sedimentary rocks (Hallsworth & Knox 1999), and metamorphic rocks (Robertson 1999). Since virtually all rocks in the area have been subject to variable grades of metamorphic overprinting, and are thus effectively metamorphic rocks, the prefix ‘meta’ has been dropped from the rock names. Here we follow the Surveys’ tradition rather than the IUGS recommendations. As an example, a metaleucogabbro is thus called a leucogabbro.

The classification of Le Maitre (1989) was used for igneous rocks. For example, individual map sheets use ultramafics or ultrabasics interchangeably for what are essentially the same rock types. These rocks are now listed as ultramafic rocks as their names are almost exclusively based on high M-values (i.e. > 90% mafic minerals).

We have also aimed for descriptive non-genetic terms. For example, rocks interpreted and described as sediments are usually based on the peraluminous nature of these rocks, rather than on the presence of sedimentary structures. These rocks are now relabelled as mica schists and gneisses. A detailed discussion of this topic follows below.

In general, generic names have been preferred to locality names. The latter are mainly used for areas that are widely discussed in the literature under their stratigraphic names, like the Fiskenæsset complex, and to separate out the different granites.

Obsolete names, such as Amîtsoq gneiss and Malene supracrustals, have been removed.

Integration of other map sheets

Many of the lithological units occurring on the ten printed map sheets are also found on the adjacent map sheets. Our current legend is partially based on previous integration of the Fiskefjord, Ivisârtoq, and Qôrqut map sheet legends for the area between 64º and 65ºN (J.A.M. van Gool, A.A. Garde & H.F. Jepsen, pers. comm. 2008), to the north of the current digital geological map. The defined lithological units on their joint legend and the current digital map can easily be merged. The intermediate map sheet near the inland ice, Kapisillit, is compiled with a legend that is very similar to the one discussed in this report (E.F. Rehnström, pers. comm. 2010). An extension to the north of the current digital map is therefore easily implemented. To the south of the current digital map many additional lithological units occur, which will require a major extension of the current legend, before these map can be integrated with the current digital geological map.

Geographical names and terms

Since the original mapping of the area was undertaken, a change in the spelling of the geographical names in Greenlandic has been implemented. This has led to a deviation in spelling of the geographical names on this digital map with respect to the original map sheets. However, map sheets, rock units and formation names always remain as they were originally defined, thus the old spelling is often applied for these names. Thus we use the obsolete spelling of Nuuk to describe the 'Nûk gneiss', while the capital of Greenland is spelled according to the new orthography.

Two fjords with the name 'Sermilik' occur within the area covered by this report, one north and one south of Frederikshåb Isblink. In the context of this report, these are referred to as 'northern Sermilik' and 'southern Sermilik'.

After the original mapping took place, GGU was merged with the Geological Survey of Denmark to form the Geological Survey of Denmark and Greenland (GEUS). GGU and GEUS are therefore referred to as 'the Survey'.

Radiometric ages, if not stated otherwise, are U/Pb zircon ages obtained by Secondary Ion Mass Spectrometry (SIMS; Ireland & Williams 2003) or by Laser Ablation Sector Field Inductively Plasma Mass Spectrometry (LA-SF-ICP-MS; Frei & Gerdes 2009). All quoted errors for age determinations are 2σ.

Metamorphic and igneous rocks of Eoarchaean to Palaeoarchaean age

A belt of Eoarchaean to Palaeoarchaean rocks extending from the Isukasia area in the north-east to Færingehavn in the south-west is exposed in the western part of the Buksefjorden map sheet. This belt is cut by a fault on its western side (Chadwick & Coe, 1983b); the westernmost Ravneøer are of the younger tonalitic orthogneiss (**gn**). The eastern boundary has been described as both intruded by younger orthogneiss (**gn**) and tectonically interleaved with these rocks (e.g. Bridgwater *et al.* 1974; Chadwick & Coe 1983b).

The three different gneiss types in this belt were formerly known as Amîtsoq gneisses and are now considered part of the Itsaq gneiss complex. Within these orthogneisses, enclaves of older, mainly supracrustal rocks were found for which McGregor & Mason (1977) coined the name 'Akilia association'.

Supracrustal rocks (formerly Akilia metasedimentary rocks) (Ams)

The supracrustal rocks consist of a highly variable assemblage of melanocratic to mesocratic amphibolites, with iron-rich rocks and quartz-rich feldspathic paragneisses (Nutman 1980; McGregor & Mason 1977). Nutman *et al.* (1993) report a SHRIMP zircon age of 3.87 Ga. This unit includes the metamorphosed sediments on the islands of Simiuttat and Qilanngaarsuit.

Amphibolite (formerly Akilia amphibolite) (Aa)

The amphibolite unit comprises thick sheets of leuco-amphibolite and gabbro that were intruded into the supracrustal rocks (McGregor & Mason 1977).

Ultramafic rocks (formerly Akilia ultramafic rocks) (Aub)

Ultramafic rocks and associated minor amphibolite occur as isolated enclaves in tonalitic gneiss, thus their age relationships with the amphibolite (**Aa**) and supracrustal rocks (**Ams**) is unknown. The rocks consist mainly of pyroxenite and peridotite (Chadwick & Coe 1983b).

Tonalitic and granodioritic gneiss (formerly Amîtsoq gneiss) (Agn)

Tonalitic and granodioritic orthogneiss are biotite- and hornblende-bearing multiphase grey banded gneisses with abundant deformed pegmatites and boudinaged Ameralik dyke fragments (**δA**, see below). A more detailed description is given by Nutman (1980) and for the more extensive outcrops farther to the north by McGregor (1993). Samples of the Eoarchaean and Palaeoarchaean tonalitic and granodioritic gneiss from the outer Ameralik fjord area were dated to 3.87–3.70 Ga (Nutman *et al.* 1993).

Granitic and ferrodioritic gneiss (formerly Amîtsoq gneiss) (Agi)

On the original Buksefjorden map sheet (Chadwick & Coe 1983a) the Amîtsoq augen granitic gneiss and the Amîtsoq ferrodioritic gneiss were mapped out separately. However, Nutman (1980) indicated that the pair forms a suite. In the map sheet description (Chadwick & Coe 1983b) and on the adjacent Qôrqut map sheet (see McGregor, 1993) both units are described together. On the current digital version of the map sheet, the units can be recognised by the augen signature on the granitic part of the gneisses. The granitic augen gneiss has been dated to 3.63–3.61 Ga (Nutman *et al.* 1993).

A detailed description of these gneisses can be found in Nutman (1980), Nutman *et al.* (1984), and the two map sheet descriptions named above.

Tonalitic gneiss (formerly Amîtsoq gneiss) (At)

These tonalitic to trondhjemitic grey orthogneisses are homogeneous and spatially confined to a few small islands north of Qilanngaarsuit, with the most extensive outcrop on the island of Akilia. The rocks are younger than the other two gneiss units named above, but are likewise cut by Ameralik dykes (Chadwick & Coe 1983b).

Ameralik amphibolitic dyke swarms (δ_A)

Ameralik dykes consist of massive, homogeneous amphibolite after medium-grained, mafic (doleritic) dykes that are discordant with respect to the layering and foliation of their host gneisses (McGregor 1968; Chadwick 1981). Due to intense deformation, the dykes usually occur as disrupted bodies of varying size. The dyke fragments and their intrusive relationships were commonly used to distinguish Eoarchaean and Palaeoarchaean gneisses from similar-looking Mesoarchaean tonalitic orthogneisses (McGregor 1966).

We follow Nutman *et al.* (2004a) and call these sets of dykes dyke swarms, since geochemistry and geochronology clearly shows that the dykes yield a variety of compositions. Dykes have so far been dated to two age groups of 3.50–3.45 Ga and *c.* 3.26 Ga (Nutman *et al.* 2004a).

Metamorphic and igneous rocks of Mesoarchaean to Neoarchaean age

Orthogneiss, undifferentiated, mainly tonalitic (gn)

Each map sheet is dominated by grey tonalite-trondhjemite-granodiorite (TTG) orthogneiss, which comprises 60–90 % of the exposed area. Although dominated by TTG-compositions, quartz-dioritic to more mafic and more granitic orthogneisses are also present. The mafic minerals in the orthogneiss are hornblende and biotite, and rarely, both minerals coexist. These mafic minerals occur as schlieren and streaks, in weakly- or well-developed bands, or as nearly homogeneous rocks. The nature of the mafic minerals is indicated on the digital map. The orthogneiss with abundant anorthosite inclusions on the original Ivigtut map sheet (labelled ga) and the now obsolete Nûk gneiss (including the Nûk gneiss of the Inugssuagssuaq nappe; labelled Ngn on the Buksefjorden map sheet, Chadwick & Coe 1983a) are merged with this lithological unit. The Ikkattoq gneiss, which was already included in the orthogneiss map unit on the original Buksefjorden map sheet, but is often discussed separately from the adjacent orthogneisses (e.g. Friend *et al.* 1996; 2009), is also included in this map unit.

Descriptions of the orthogneiss can be found in Kalsbeek (1976), Myers (1976a,b) and in Higgins (1990). The Nûk gneiss in the Buksefjorden area is described in detail by Chadwick & Coe (1983b). Abundant age data are available for the orthogneiss, particularly in the northern part of the digital 1:100 000 map area, which is also described as Tasiusarsuaq terrane: the orthogneiss ranges in emplacement age from 2824 ± 2 Ma in the north-western part of the area (Crowley 2002) to *c.* 2860 Ma (Nutman *et al.* 2004b) with older inclusions up to *c.* 2920 Ma (Schiøtte *et al.* 1989). Næraa & Scherstén (2008) describe an age of 2868 ± 4 Ma for a sample collected south of Kangerluarsunnguup Tasersua, and Friend & Nutman (2001) report 2878 ± 10 Ma for the orthogneiss near Ravn Storø. Kokfelt *et al.* (2010) show that the orthogneiss north of Frederikshåb Isblink decreases in age from Frederikshåb Isblink northwards, but with *c.* 3100 Ma orthogneiss in Fiskenæsfjorden. Emplacement ages for the orthogneiss protoliths south of Frederikshåb Isblink ranges from 2940 to 2830 Ma (Friend & Nutman 2001, Kokfelt *et al.* 2011).

Leucogabbro and anorthosite (an)

This lithological unit appears as ‘anorthosite complex’ or ‘anorthosite and leucogabbro’ on most of the northern map sheets. For the digital 1:100 000 geological map the legend text has been redefined to ‘leucogabbro and anorthosite’, since leucogabbro is more common than anorthosite *sensu stricto*. The most famous occurrence of leucogabbro and anorthosite, the Fiskenæsset complex, is discussed separately below. Apart from the Fiskenæsset complex, large leucogabbro and anorthosite outcrops are found in the Buksefjorden area between Ameralik and Tre Brødre (Chadwick & Coe 1983b; Owens & Dymek 1997). Some minor outcrops occur further to the south in the Neria area.

Fiskenæsset complex

The Fiskenæsset complex is widely described in the geological literature. However, such lithological units/rock types are not unique to this complex. Other Mesoarchaean anorthosites, leucogabbros, gabbros and ultramafic rocks occur in the region. Here we represent the Fiskenæsset complex in the same colours as its equivalent rocks outside the complex, but to emphasize this special and well-described area, the rocks in the complex received their own labelling (**Fα–Fδ**), following Myers (1980; 1982). A number of stratigraphies and detailed descriptions have been made for various parts of the complex, e.g. at Qeqertarsuatsiaq (Windley 1973; Windley *et al.* 1973), near the inner Bjørnesund (Walton 1973), at Majaqqap Qaava (Myers 1973; 1975), and at Annertusoq (Windley 1976). A good geological overview of the whole complex is given by Myers (1985). The description of the Fiskenæsset complex below is taken from these descriptions.

The rocks were intensively folded and recrystallised under high-grade metamorphic conditions after their formation, but relict igneous textures are locally preserved. The age of the Fiskenæsset complex, especially in relation to the surrounding orthogneiss, has received considerable attention. One of the first attempts was also one of the first ever Re-Os geochronology studies, which utilised molybdenite to obtain a *c.* 3.1 ± 0.1 Ga age (Herr *et al.* 1967). A whole-rock Sm-Nd isochron for the complex yielded a 2.86 Ga age (Ashwal *et al.* 1989). Recent results are more in line with Herr *et al.* (1967) and suggest that the Fiskenæsset complex is *c.* 2.95 Ga (Keulen *et al.* 2010a) to 2973 ± 28 – 2945 ± 36 Ma (Sm-Nd and Pb-Pb regression ages, respectively; Polat *et al.* 2010).

Fiskenæsset complex ultramafic and lower gabbro units (Fα)

The ultramafic unit consists of dunite, peridotite, pyroxenite and hornblende-rich rocks that are rich in magnetite. The lower gabbro lies stratigraphically below the ultramafic rocks and forms the lowest unit of the complex. It ranges in composition from melanogabbro to gabbro to leucogabbro. The lower gabbro unit outcrops as a massive amphibolite to mafic granulite.

Fiskenæsset complex middle gabbro and lower leucogabbro units (Fβ)

The lower leucogabbro unit is characterised by a dunite layer, which is only locally preserved and, where found, grades upward into a more leucogabbroic composition (peridotite, hornblendite, gabbro, leucogabbro); the leucogabbro forms the major part of this unit. The middle gabbro unit consists of two successions, each a thin sequence of ultramafic rocks overlain by massive uniform gabbro, followed by a third sub-unit of mainly gabbro, melanogabbro and leucogabbroic rocks.

Fiskenæsset complex anorthosite and upper leucogabbro units (Fγ)

The upper leucogabbro unit consists of a coarse-grained leucogabbro with minor layers of ultramafic rocks and chromite. The anorthosite unit is a thick, rather massive unit that dominates the complex. The anorthosite does not have a clear internal stratigraphy, but shows patches of leucogabbro and garnet-plagioclase amphibolite. Chromite horizons have been found within and on top of the anorthosite layer, consisting of chromite-enriched rock and locally of chromitite layers in a chromite-rutile-hornblende-biotite-plagioclase assemblage (e.g. Ghisler & Windley 1967; Ghisler 1976). Sapphirine (including ruby and sapphire) and kornerupine have been detected at various outcrops in the complex (e.g. Herd *et al.* 1969).

Fiskenæsset complex upper gabbro unit (Fδ)

The upper layer of the Fiskenæsset complex consists of gabbro interlayered with peridotite, dunite, melanogabbro, leucogabbro and anorthosite. Within these units sulphide- (e.g. Bishop *et al.* 1980), ilmenite- and magnetite-rich layers were described.

Amphibolite, undifferentiated (a)

Amphibolite and mafic granulite occur throughout the area and are, after the orthogneiss and granites, the most common rock type. These lithological units occur as bands and lenses in the orthogneiss. The original set of map sheets does not separate amphibolite-facies rocks from granulite-facies rocks, since no data were available at the time of compilation. Thus, no distinction can be made on the map legend between mafic granulite, amphibolite *sensu stricto*, and rocks of similar composition in upper greenschist facies.

The amphibolite units comprise both intrusive and extrusive rocks, which have been distinguished locally (see below), where pillow lavas, lithic and felsic tuffs, coarse-grained gabbros, metabasites, leuco-amphibolites and felsic volcanics are identified. Descriptions can be found in Andersen & Friend (1973), Chadwick & Coe (1983b), Wells (1976) and Higgins (1990). Kalsbeek & Leake (1970) give geochemical data on some of the supracrustal amphibolites from the Neria area. The Malene amphibolites (Ma on the original Buksefjorden map sheet) are merged into this lithological unit.

Amphibolite of extrusive origin (ae)

Amphibolites of extrusive origin were differentiated in the Kangiata nuna, Grædefjord, Sinarssuk and Bjørnesund map sheets. Usually the classification ‘extrusive’ was based on the fact that part of the outcrop was interpreted as pillow lavas or tuffs (both indicated on the digital map); in some locations the interpretation as extrusive amphibolites is based on the presence of a thin irregular compositional banding of the rocks. On the original Buksefjorden map sheet (Chadwick & Coe 1983a) sheets of leucocratic amphibolite (labelled **de**) were indicated. These are incorporated into the extrusive amphibolite unit on the new digital 1:100 000 map. A local description for Nunatak 1390 is given in Stendal & Scherstén (2007); Dawes (1970) described the extrusive rocks on the nunataks in Frederikshåb Isblink and Andersen & Friend (1973) describe the series in the Ravn Storø area (Ikkattup Nunaa).

Gabbro and leucogabbro (ai)

The amphibolite of intrusive origin, including mafic granulite, is indicated as gabbro and leucogabbro on the digital 1:100 000 map.

Diorite and tonalite, undifferentiated (d)

One major occurrence of diorite occurs south of the Bjørnesund in the east–west striking amphibolite-anorthosite belt. The diorite is a medium- to fine-grained, homogeneous orthogneiss that consists of predominantly feldspar, minor quartz and biotite, with rare hornblende. A sample collected by D. Schlatter in the western part of the outcrop yielded an age of 2919 ± 2 Ma (Keulen *et al.* 2010b).

Ultramafic rocks (ub)

This lithological unit consists of a range of different rock types of an ultramafic composition and includes serpentinised rocks, wehrlite, peridotite, hornblendite, pyroxenite, lherzolite (Keulen *et al.* 2009), harzburgite, and dunite (Chadwick & Coe 1983b). This map unit includes the Malene ultramafic rocks (Mub on the original Buksefjorden map sheet).

Mica schist and gneiss, undifferentiated (ms)

This map unit was described as 'metasedimentary rocks' on the five map sheets north of Frederikshåb Isblink, and as 'mica schist' south of Frederikshåb Isblink. On the digital 1:100 000 map the more generic expression 'mica schist and gneiss, undifferentiated, mainly biotite schist ± garnet, cordierite or silimanite' is used. This lithological unit includes sedimentary rocks, felsic volcanics, volcanoclastics and mica schists of unknown origin. Higgins (1990) gives a short description of the rocks south of Frederikshåb Isblink. The mica schists north of Frederikshåb Isblink were described in PhD theses (e.g. Stainforth 1977; Gibbs 1976) in a structural context, while Beech & Chadwick (1980) concentrated on their geochemistry.

Tartoq mixed volcanic and sedimentary rocks, greenschists (vs)

This lithological unit was described as "Greenschists, mixed metavolcanics and metasediments" on the original Midternæs map sheet (Higgins 1974) and on the Ivigtut map sheet as "metavolcanic rocks mixed with metasediments, e.g. 'greenschists'" (Henriksen 1968). Descriptions of the outcrops have been given by Higgins & Bondesen (1966), Higgins (1968) and van Hinsberg *et al.* (2010). Berthelsen & Henriksen (1975) and Szilas (2010) give some geochemical data. Nutman *et al.* (2004b) dated a schist from the southern part of the Tartoq Group area with relict volcano-sedimentary structures to 2842 ± 6 Ma. The sample included older grains of up to nearly 3.8 Ga. Nutman & Kalsbeek (1994) dated a sample of a tonalitic sheet cutting through supracrustal Tartoq Group rocks from an outcrop near Midternæs to 2944 ± 7 Ma.

Grey siliceous schist (qst)

Grey siliceous schist occurs within the greenschists of the Tartoq Group and consists locally of talc- and mica-bearing quartzites. Higgins (1990) explains that this schist was mapped originally as quartzitic or semipelitic sediments, but was later reinterpreted as, at least in part, felsic volcanic rocks. Appel & Secher (1984) give a short description of this lithological unit and the mixed volcanic and sedimentary rocks (**vs**) in the light of their gold potential.

Quartz-dioritic gneiss, Tartoq Group (Tgn)

Berthelsen & Henriksen (1975) give a description of this gneiss and discuss the contact relationship between this gneiss and the mixed volcanic and sedimentary rocks of the Tartoq Group.

Qáqatsiaq dyke (Qai)

Coe *et al.* (1976) defined two sets of dykes, the so-called 'Intra-Nûk dykes', in the Buksefjorden area. These dykes are folded and boudinaged by the regional main folding event that affected the orthogneiss (formerly named Nûk gneiss) in the area. Thus, Chadwick & Coe (1984) interpret the dykes as Archaean. These dykes are cut by granites, pegmatites and later dolerite dykes. The younger, broader type of Intra-Nûk dykes is called the Qáqatsiaq dykes. The second group is too narrow to be shown on the map. Chadwick & Coe (1983b) give some geochemical data and a longer description of both types of Intra-Nûk dykes.

Nukagpiarssuaq granite (Ngi)

The Nukagpiarssuaq granite was described by Williams (1973) in his PhD thesis, though without providing a name. The first use of the name Nukagpiarssuaq granite seems to be on the Bjørnesund map sheet (Escher 1985). The granite has been dated to 2.85 ± 0.01 Ga (Keulen *et al.* 2010b).

Ilivertalik granite (Igi) and Ilivertalik tonalite, diorite and gabbro (Idgi)

The Ilivertalik granite was described as 'Ilivertalik augen granite' on the Grædefjord, Sinarssuk and Kangiata nuna map sheets. The Ilivertalik granite is now described as a "dominantly K-feldspar augen granite, variably deformed, usually ortho-pyroxene bearing" rock in the new legend. The type locality for the Ilivertalik granite is its south-westernmost outcrop, the mountain of Ilivertalik (Kalsbeek & Myers 1973) on the Grædefjord map sheet, where the rock is charnockitic. The rock was dated to *c*. 2.80 Ga (Pidgeon & Kalsbeek

1978), and further work on other parts of the intrusion showed similar ages of 2799 ± 2 – 2793 ± 3 Ma (Næraa *et al.* 2010; Kokfelt *et al.* 2010).

The Ilivertalik granite consists of pyroxene, hornblende and biotite granites and charnockites. It typically has large (up to 5 cm) K-feldspar augen and is layered with sheets of diorite, tonalite and gabbro of up to 100 m thick. Further descriptions can be found in Wells (1979), Myers (1976) or Kalsbeek & Garde (1989).

The Ilivertalik granite is clearly younger than the orthogneisses into which it intruded. Its emplacement is contemporaneous to granulite facies metamorphism in the area, and the unit is locally intensively deformed by later tectono-metamorphic events at *c.* 2.71 Ga.

Marraq granite (Mgi)

One sample of Marraq granite (GGU 468755), collected at the mouth of the Grædefjord, was dated at 2653 ± 8 Ma (Kokfelt *et al.* 2010). The Marraq granite is a light coloured, coarse-grained inhomogeneous, locally deformed biotite-granite.

Taserssuatsiait granite (Tgi)

This granite occurs on the Buksefjorden map sheet, near outcrops of the Ilivertalik granite. The granite has never been described properly, nor has it been dated.

Qôrqut granite complex (Qgi)

The complex consists of (from bottom to top) leucogranites, grey biotite granite and composite granites (see Friend *et al.* 1985 for further details). The Qôrqut granite was first described by McGregor (1973) and later in more detail as the ‘Qôrqut granite complex’ by Friend *et al.* (1985). We follow the latter description for these granites and pegmatites, since large parts of the complex consist of up to 50% wall-rock (mainly Eoarchaean gneiss; Brown & Friend 1980) and the granites are cut by pegmatites. The granites were dated to 2.53 ± 0.03 Ga by Baadsgaard (1976) with U-Pb in zircons and by Moorbath *et al.* (1981) with Rb/Sr on a whole rock analysis. Friend *et al.* (2009) indicate an age of *c.* 2560 Ma. Crowley (2002) dated pegmatites associated with the granitic stock near Skinderhvalen to 2541 ± 2 Ma using U-Pb isotope analysis on zircons by SHRIMP. New zircon Pb/Pb dating (Næraa *et al.* submit.) gave an age of 2547 ± 4 Ma for the Qôrqut granite complex. Thus it seems likely that the granites near Skinderhvalen are also part of the Qôrqut granite complex.

Granite, undifferentiated (*sensu lato*) (gi)

This map unit comprises a series of smaller granite and granodiorite bodies scattered throughout the digital map sheet. Some of the bodies were dated: the series of granodiorites in the fjord north of Ikkattup Nunaa (Bjørnesund map sheet) that run parallel to the roughly east–west striking fold axes were dated to *c.* 2.85 Ga (Keulen *et al.* 2010b; Kokfelt *et al.* 2010). Different ages are expected for these granites in other parts of the area. This lithological unit includes the 'granite' on the Kangiata nuna map sheet (Escher 1981; labelled gr) and the 'granite' on the map sheets south of Frederikshåb Isblink (labelled g).

The Qánguartoq granite, granodiorite and tonalite gneiss unit (labelled Qgi on the Sinarssuk and Grædefjord map sheets) was merged into this unit. The Qánguartoq granite consists mainly of sheets and irregular shaped masses that cut through all other rock types in the region, locally including the Ilivertalik granite, and generally occurs as strongly deformed pegmatite-banded gneiss (Myers 1976).

The 'microgranodiorite, allochthonous' that occurs on the Neria map sheet (Jensen, 1973) was merged into this lithological unit on the digital 1:100 000 map.

Pegmatite, undifferentiated (P)

Pegmatites occur throughout the area, both as intrusive sheets, indicated as lines, and as small bodies, indicated in red. Chadwick & Coe (1983) specifically assigned (part of) these pegmatites to the Qôrqut granite complex on the Buksefjorden map sheet. Crowley (2002) dated pegmatites near Skinderhvalen to 2541 ± 2 Ma and other pegmatites a few kilometres further to the east to 2710 ± 2 Ma, both are indicated with the same colour on the Buksefjorden map sheet (Chadwick & Coe 1983). An age of *c.* 2.71 for pegmatites is very common throughout the whole studied area north of Frederikshåb Isblink (Kokfelt *et al.* 2010). On the digital web-based 1:100 000 scale geological map all pegmatites are merged into one lithological unit.

Palaeoprotorozoic

Most of the Palaeoprotorozoic rocks of the area covered by the digital 1:100 000 geological map occur in the south-easternmost part of the area on and around Midternæs and extend southwards to Grænseland (the Ketilidian Border Zone). The rocks include part of the Ketilidian supracrustal rocks that unconformably overlie the Archaean orthogneiss and the supracrustal rocks of the Tartoq Group. As opposed to most of the Archaean rocks, these supracrustal rocks have not been exposed to a higher grade of metamorphism than greenschist facies. The Ketilidian supracrustal rocks consist of a lower mainly sedimentary succession, the Vallen Group, and an upper mainly volcanic unit, called Sortis Group (Higgins, 1970). The two groups have a tectonic contact where the Sortis Group appears to be thrust over the Vallen Group (Garde *et al.* 2002). The exact age of the Ketilidian supracrustal rocks is unknown, but they are intruded and deformed by Ketilidian granites which were emplaced *c.* 1868–1796 Ma (Garde *et al.* 2002).

Sandstone, including chert and quartzite (qk)

The base of the Ketilidian succession is the sedimentary Vallen Group with a sandstone as the lowest unit, which locally, e.g. north-west of Birkesø, grades into conglomerate. In Grænseland this conglomerate locally contains a high concentration of opaque minerals mainly magnetite (Berthelsen & Henriksen 1975). Garde *et al.* (1998) reinterpreted this ore-conglomerate near Vallen Sø as banded iron formation. Units of intrusive rocks and extrusive volcanics are included within this sandstone unit and these contain lenticular layers of chert and cherty quartzite (Higgins, 1990).

Calcareous and dolomitic siltstone and shale (mk)

A group of calcareous sediments overlies the sandstone unit (Higgins 1990). These two units together are known as the ‘Zigzagland Formation’ (Bondesen 1970).

Pelitic siltstone and shale (spk)

The pelite siltstone and shale unit comprises a series of siliceous rocks that are represented in both the Vallen and Sortis Group and shows a large variety on a local scale. The most common rock types are banded siltstones and shales, but dark grey shale, thin greywacke, calcareous shale and dolomite have also been reported (Higgins 1970; 1990; Berthelsen & Henriksen 1975).

Shale and schist, dark pyritic (dsk)

Two small mappable outcrops of dark pyritic shale and schist occur north of Arsuk Bræ on the Ivigtut map sheet unit.

Greywacke (fk)

The greywacke lithological unit is part of the previous lithological unit, the 'pelitic siltstone and shale' (**spk**). It reaches a mappable thickness in south-west Midternæs north of Sioralik Bræ where it is mapped as greywacke (**fk**). On northern Midternæs the rock is developed as an arkose; in Grænseland it locally contains bands of pelite and conglomerate (Henriksen 1968; Higgins 1990).

Pelitic shale (pk)

A mainly black shale associated with carbonates and with abundant chert lenses and layers occurs east of Tordensø and south of Sioralik Bræ (Higgins 1990). In Grænseland the same unit appears in association with a thin rusty dolomite layer (Henriksen 1968).

Carbonate, mainly dolomite (ck)

The top part of the Vallen Group, in many localities, is a carbonate that is mainly dolomitic. It is includes graphitic and pyritic shales.

Pelitic schist, black, with dolomite and quartzite (qsk)

In areas where the upper part of the Vallen Group was not mapped in detail (e.g. on the southern side of Sioralik, east of Grænsesø) the undifferentiated siliceous sediments have been grouped into this unit labeled 'pelitic schist, black, with dolomite and quartzite'.

Mafic extrusive rocks, including pyroclastic rocks (aek)

Mainly pillow lavas, tholeiitic lavas (Henriksen 1969), agglomerates and volcanic breccias, tuffs and lapilli tuffs, some traceable for hundreds of metres or more have been reported for the mafic extrusive rocks of the Sortis Group. Chemical analyses are given in Higgins (1970) and Bondesen (1970). A more detailed description of the primary structures on Arsuk Ø can be found in Muller (1974).

Mafic intrusive rocks (aik)

A series of fine to coarse grained sills were intruded into the upper Vallen Group and throughout the extrusive mafic rocks of the Sortis Group (**aek**) (Higgins 1970, 1990).

Precambrian, undifferentiated

Dolerite dyke (δ, δ_P)

Several generations of dolerite dykes occur throughout the area covered by the 1:100 000 digital map. Although progress has been made recently, many dykes and dyke generations have not been dated so far. Attempts have been made to separate dyke generations by composition and orientation. Within the area covered by the digital 1:100 000 geological map at least six generations of dolerite dykes that post-date Archaean deformation are distinguished.

The early Proterozoic dykes are commonly labelled MD (metadolerite) since they were deformed in the Ketilidian orogeny in the area south of that currently covered by the digital 1:100 000 geological map. Within the map area, however, they are unmetamorphosed and the name is misleading. The MD dykes were mapped separately (as **ai**) from the later (Mesoproterozoic to Mesozoic) dolerite dykes on the five map sheets south of Frederikshåb Isblink. In the five map sheets north of Frederikshåb Isblink this distinction was not made. The dolerite dykes on the digital 1:100 000 geological map are labelled $\boldsymbol{\delta_P}$ for the MD dykes south of Frederikshåb Isblink and $\boldsymbol{\delta}$ for the younger dykes south of Frederikshåb Isblink and for all Palaeozoic dykes north of Frederikshåb Isblink.

The oldest set of dykes is east–west trending, but commonly only a few metres wide and therefore do not appear on the maps. They occur, for example, west of the southern Sermilik.

North–south trending dykes (MD_1) occur occasionally throughout the area. One prominent dyke can be observed south of Neria, continuing towards Arsuk Ø and south of the southern Sermilik. These dykes are commonly olivine-bearing (Bridgwater *et al.* 1976). Nilsson *et al.* (2010) dated baddeleyite from a dyke just north of 64º that was probably part of the MD_1 series to 2500 ± 2 Ma by TIMS. Yu & Wang (unpubl. data) dated baddeleyite from a north-south trending dyke, possibly the same dyke as Nilsson *et al.* (E.F. Rehnström, pers. comm. 2010), to 2541 ± 64 Ma.

NE-trending dykes (MD_2) are the most common dykes south of Frederikshåb Isblink, where they comprise more than one swarm. Their trends vary between NNE and ENE. Kalsbeek & Taylor (1985) dated one of the dykes to 2180 ± 100 Ma using Rb-Sr whole rock analysis.

SE-trending dykes (MD_3) are the most common dykes north of Frederikshåb Isblink. Their orientation varies between 90 and 140º. These dykes are petrographically similar to the MD_2 dykes. Some of the dykes show coarse-grained accumulations of plagioclase phenocrysts. Kalsbeek & Taylor (1985) dated two of the dykes to 2100 ± 85 Ma with Rb-Sr whole rock analyses, which provides within error an overlap with the MD_2 dykes. Nilsson *et al.* (2010) dated three dykes by TIMS to 2050 ± 2 Ma - 2029 ± 3 Ma with U/Pb on baddeleyite.

A further set of 120º-striking dykes is defined between Sioralik Bræ and the outer Kvanefjord. These dykes are feldspar-phyric, relatively narrow and occur closely spaced in a *c.* 9 km wide swarm. The dykes are tholeiitic in composition and were dated with whole rock K/Ar to *c.* 1630–1350 Ma (Bridgwater *et al.* 1976).

An additional series of NE to ENE trending dykes is interpreted as Gardar dykes (Higgins 1970). These broad (100–150 m) dykes have feldspar megacryst accumulates in some localities (Higgins 1970). These dykes are abundant around Sermiligaarsuk and south of the southern Sermilik, but not observed north of Frederikshåb Isblink.

Acid dyke (γ)

Acid dykes are mainly granophyric and occur in the vicinity of Pyramidefjeld. Berthelsen & Henriksen (1975) give a short description.

Trachyte dyke (σ)

The trachyte dykes are mainly very thin and are more abundant than shown on the map. Trachyte dykes are common on Midternæs and are interpreted to be of a Gardar age (*c.* 1250 Ma) (Higgins 1970).

Lamprophyric dyke (ω)

Lamprophyric dykes on Midternæs are of the same age as the trachyte dykes described by Higgins (1970, 1990). Larsen (2006) points out that the composition of the Sermiligaarsuk lamprophyric dykes suggest a Gardar age.

Mesozoic

Carbonatite (μ) and fenitisation associated with carbonatite (fen)

The Tikiusaaq carbonatite complex, discovered in 2005 by the Survey, was described by Steenfelt *et al.* (2007). It consists of massive carbonatite sheets, carbonatite veins and a swarm of ultramafic lamprophyre dykes. The carbonatite is of Jurassic age and was dated at 152 ± 2 Ma with U/Pb on zircon, and the ultramafic lamprophyre dykes at 162 ± 6 Ma with U/Pb on perovskite (S. Tappe in Steenfelt *et al.* 2007).

Kimberlitic dyke (χ)

A kimberlitic dyke at Nigerlikasik and intrusive sheets near Sioralik were described previously by Emeleus & Andrews (1975) and Andrews & Emeleus (1975). Larsen & Rex (1992) give geochemical data. P.W.U. Appel reinterpreted the dykes as a porphyritic peridotite dyke (Geisler 1972).

Lamprophyric dyke (ω)

Ultramafic lamprophyric dykes have been described near Færingehavn and near Paamiut (see Larsen & Rex, 1992). Lamprophyric dykes near Frederikshåb Isblink with a range of compositions were described in a number of publications and dated at *c.* 156–105 Ma with Rb-Sr and $^{40}Ar/^{39}Ar$ on whole rock by Hansen (1979, 1980, 1981, 1984).

Dolerite dyke (δ_M)

A set of coast-parallel (NNW-trending) alkali-basalt to transitional basaltic dykes is associated with the opening of the Labrador sea and can be found over a *c.* 30 km wide coastal zone stretching from South Greenland towards Grædefjord. The dykes are often described as TD (Trap Diabase) in the literature (Larsen 2006). Their age is determined as 140 ± 2 – 133 ± 1 Ma with $^{40}Ar/^{39}Ar$ on whole rock (Larsen *et al.* 1999; Larsen 2006).

Quaternary

Quaternary deposits can be found throughout the area, as the whole area was recently covered by ice except for the highest peaks. On the printed maps, as well as on the digital 1:100 000 geological map, only the areas with the most extensive Quaternary deposits are shown. Many detailed investigations were undertaken by Weidick (e.g. 1959, 1974, 1975) and show that many near-glacier Quaternary features developed between A.D.1600 and 1900, followed by a general retreat, with some notable exceptions, of the glaciers since the beginning of the previous century.

The legend

A folded inlay with the legend can be found in the pocket at the back of this report.

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Common legend to the 1:100 000 digital geological map of southern West and South-West Greenland, 61°30′ - 64°N

BUKSEFJORDEN 63 V. 1 NORD, KANGIATA NUNA 63 V. NORD, GRÆDEFJORD 63 V. 1 SYD, SINARSSUK 63 V. 2 SYD, BJØRNESUND 62 V. NORD, NIGERDLIKASIK 62 V. 2 SYD, NERUTUSSOQ 62 V 1 SYD, MIDTERNÆS 61 V. 2 NORD, NERIA 61 V. 1 NORD, IVIGTUT 61 V. 1 SYD

METAMORPHIC ROCKS OF EOARCHEAN TO PALAEOARCHAEAN AGE

- Ams — SUPRACRUSTAL ROCKS (formerly Akilia metasedimentary rocks), undifferentiated
- Aa — AMPHIBOLITE (formerly Akilia amphibolite), including metagabbro
- Aub — ULTRAMAFIC ROCKS (formerly Akilia ultramafic rocks)
- Agn — TONALITIC and GRANODIORITIC GNEISS, (formerly Amîtsoq gneiss)
- Agi — GRANITIC and FERRODIORITIC GNEISS, with K-feltspar augen, (formerly Amîtsoq gneiss)
- At — TONALITIC GNEISS, (formerly Amîtsoq gneiss)
- δA — AMERALIK AMPHIBOLITE DYKE SWARM

IGNEOUS AND METAMORPHIC ROCKS OF MESOARCHAEAN TO NEOARCHAEAN AGE

- gn — ORTHOGNEISS, undifferentiated, mainly tonalitic
- an — LEUCOGABBRO and ANORTHOSITE
- a — AMPHIBOLITE, undifferentiated, includes mafic granulite
  - Bands of amphibolite, undifferentiated
- ae — AMPHIBOLITE, of extrusive origin, includes mafic granulite
- ai — GABBRO and LEUCOGABBRO
- ub — ULTRAMAFIC ROCKS
  - Bands of ultramafic rocks, undifferentiated
- Fδ — FISKENÆSSET COMPLEX upper gabbro unit
- Fγ — FISKENÆSSET COMPLEX anorthosite and upper leucogabbro units
- Fβ — FISKENÆSSET COMPLEX middle gabbro ad lower leucogabbro units
- Fα — FISKENÆSSET COMPLEX ultramafic and lower gabbro units
- d — DIORITE and TONALITE, undifferentiated
- ms — MICA SCHIST and GNEISS, undifferentiated, mainly biotite schist ± garnet, ± corderite, ± silimanite
- vs — TARTOQ GROUP MIXED VOLCANIC and SEDIMENTARY ROCKS, mainly greenschist
- qst — GREY SILICEOUS SCHIST, locally talc- and mica-bearing quartzites
- Tgn — TARTOQ GROUP QUARTZ DIORITE GNEISS
- dgi — DIORITE, including biotite-bearing biotite
- Qai — QÁQATSIAQ DYKE
- Ngi — NUKAGPIARSSUAQ GRANITE
- Idgi — ILIVERTALIK TONALITE, DIORITE and GABBRO
- Igi — ILIVERTALIK GRANITE, dominantly K-feldspar augen granite, variably deformed usually orthopyroxene-bearing
- Tgi — TASERSSUATSIAIT GRANITE
- Mgi — MARRAQ GRANITE
- Qgi — QÔRQUT GRANITE COMPLEX, leucogranites, grey biotite granite and composite granites
- gi — GRANITE, undifferentiated (sensu lato)
- P — PEGMATITE, undifferentiated
  - P — Pegmatite, undifferentiated, mapped and schematic

PALAEOPROTEROZOIC

- qk — SANDSTONE, including chert and quartzite, locally with ore-bearing conglomerate
- SANDSTONE, with conglomerate
- mk — CALCAREOUS and DOLOMITIC SILTSTONE and SHALE
- spk — PELITIC SILTSTONE and SHALE, massive and banded, locally with greywacke bands
- dsk — SHALE and SCHIST, dark pyritic
- fk — GREYWACKE, with bands of conglomerate and pelite, locally arkose
- pk — PELITIC SHALE, with or without chert lenses
- ck — CARBONATE, mainly dolomite
- qsk — PELITIC SCHIST, black, with dolomite and quartzite
- aek — MAFIC EXTRUSIVE ROCKS, including pyroclastic rocks
- aik — MAFIC INTRUSIVE ROCKS
- δp — AMPHIBOLITE DYKE

PRECAMBRIAN, UNDIFFERENTIATED

- δ — DOLERITE DYKE, established, inferred
- σ — TRACHYTE DYKE
- ω — LAMPROPHYRE DYKE

MESOZOIC

- μ — CARBONATITE
- Fenitisation associated with carbonatite
- ω — LAMPROPHYRE DYKE
- χ — KIMBERLITE DYKE
- δM — DOLERITE DYKE, Jurassic and Cretaceous

QUATERNARY

- Ice and perennial snow
- Wind-blown sand
- Fluvio-glacial and lacustrine deposits
- Neoglacial moraine (younger than A D 1600) moraine
- Talus and alluvial cones
- Marine deposits and terrace
- Fluvio-glacial deposits and terrace
- Alluvial fan and delta
- Ice-dammed lake with periodic drainage
- Beach sand
- Undifferentiated cover, mainly prehistorical moraine

- Inclusions of calcareous schist
- Inclusions of calc-silicate
- Inclusions of amphibolite
- Inclusions of gneiss, mainly tonalitic
- Inclusions of gabbro-anorthosite
- Inclusions of ultramafic rocks
- Inclusions of mica schist
- Banded biotitic, with biotitic schlieren, streaks of biotite, inclusions of biotite
- Inclusions of chloritic rock
- Nebulitic gneiss, muscovite-bearing
- Biotite-bearing (in granite)
- Chromite-bearing
- Inclusions of quartzitic layers
- Inclusions of Tartoq Group volcanic and sedimentary rocks
- Inclusions of grey siliceous schist
- Inclusions of leucocratic amphibolite, formerly Akilia
- Inclusions of mafic amphibolite and ultramafic rocks, formerly Akilia
- Inclusions of mica schist, formerly Akilia
- Garnet-bearing
- Orthopyroxene-bearing

- Augen structure
- Pyroclastic rocks
- π — Pillow structure
- Foliation trend
- Amphibole defining foliation trend
- Migmatisation
- With net-veins of gneiss
- Boundary, established
- Boundary, inferred
- Boundary, transitional
- Boundary, Quaternary
- Fault or mylonite
- Thrust, established
- Thrust, inferred
- Fold axial trace
- 64 — Dip and strike of planar surface, inclined vertical, horizontal planar surface
- 32 — Direction and plunge of fold axis (plunge 32 ° SW, vertical and horizontal)
- 32 — Direction and plunge of mineral lineation (plunge 32 ° SW)
- Unconformity

GEUS