DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2003/24

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A review and new data

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GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
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Abstract

The Disko Bugt region of central West Greenland is located within Palaeoproterozoic mobile belts: the Rinkian mobile belt to the north and the Nagsssugtoqidian mobile belt to the south. Well-preserved Palaeoproterozoic supracrustal rocks overlie Archaean supracrustal rocks and granitoids (c. 2800 Ma). The Archaean supracrustal rocks of the region may once have formed a continuous belt, but are now segmented into several blocks.

The types of mineral occurrences are:

(a) Archaean iron formations are widespread in the supracrustal rocks. They form layers of both banded iron formation (BIF) and mixed oxide and sulphide horizons within the greenstone-dominated successions.
(b) Archaean massive sulphides are found either as pyrite or pyrrhotite occurrences. The massive pyrite (e.g. at Eqi) occurs in 50-200 m thick rusty zones associated with rhyolite. Massive pyrite occurs as fine-grained pyrite in cm- to dm-thick massive layers with quartz, and as large pyrite grains within highly strained rims in a quartz-sericite matrix. The massive pyrrhotite (e.g. Saqqaq area) occurs in a thick package of Archaean metasediments, basic and ultrabasic volcanic rocks. Mineralised chemical sediments occur in several horizons as stratiform quartz/chert and massive-sulphide layers. These pyrrhotite-mineralised horizons are associated with chalcopyrite and can be followed along 15-20 km´s strike length.
(c) Gold mineralisation is hosted in the c. 2800 Ma old bimodal metavolcanic succession (greenstone unit) and the deposition of gold took place in several steps: (1) syngenetic gold in the massive sulphides, (2) pervasive mineralisation during carbonate alteration, and (3) epigenetic gold.
(d) Mineralisation in the Palaeoproterozoic supracrustal rocks is scarce but a pronounced regional albitization post-dates the regional Palaeoproterozoic deformation.

The Archaean syngenetic massive sulphides of the greenstone succession are likely formed in an island-arc environment. North of the island-arc, volcanic rocks occur together with clastic sediments in a back-arc setting with an initial rifting of an older Craton and the creation of a continental margin basin.

Pb-Pb isotopic compositions confirm two distinct episodes of mineralisation. The first episode resulted in syngenetic massive sulphides in the greenstone succession (~2800 Ma); the second episode was contemporaneous with the regional Palaeoproterozoic peak metamorphism in the region (~1900 Ma). An extensive hydrothermal episode of albitization occurred after the regional metamorphism but this event has no associated mineral occurrences.

The potential to find an economic massive sulphide deposit in the Disko Bugt region is present, but the size might be small due to the relative small volume of volcanic rocks. The Disko Bugt region has the right environment for formation of mesothermal gold occurrences but the small volume of the greenstone succession might again be a disadvantage. The

stratiform metachert horizon at Saqqaq hosts a good candidate for a potential gold deposit and possibly massive sulphide mineralisation.

The geological setting, geochemistry and formation of mineral occurrences in the Disko Bugt region have many similarities with the ~100 Ma younger Abitibi greenstone belt in Canada.

Contents

Introduction

The Disko Bugt area is located in central West Greenland of the North Atlantic region (Fig. 1). The northern flank of the North Atlantic Craton in southern Greenland (Nain Province in Canada) consists in Greenland of the Nagssugtoqidian Orogen representing a deeply eroded Palaeoproterozoic tectonic belt and the northern part of the belt includes the Rinkian Orogen (van Gool 2002). Between the two orogenic belts the Archaean Disko Craton is located (Fig. 2), which plays a central part of this paper. To the east (trans-Atlantic) the Palaeoproterozoic collision orogen extends to the Lapland-Kola Belt in the northern part of the Baltic Shield. To the west (Canada) the Torngat orogen is similar in development and age as the Nagssugtoqidian Orogen (van Gool *et al.* 2002; Fig. 2).

The Palaeoproterozoic mobile belts were the site of orogenic activity in the period 1.95 – 1.65 Ga. In the Disko Bugt region an enclave of Archaean supracrustal rocks (Disko Craton) is enveloped in the Palaeoproterozoic mobile belts. This enclave includes supracrustal rocks and intrusives dated at c. 2.8 Ga (Kalsbeek & Taylor 1999) and comprises 265 km^2. This small greenstone belt is an interesting target for gold and massive sulphide deposits. Palaeoproterozoic sedimentary rocks unconformably overlie Archaean rocks.

In the Disko Bugt region, regional mineral exploration has been carried out by Kryolitselskabet Øresund A/S in 1980-1982 (Gothenborg & Keto 1986), Platinova Resources Ltd/Rayrock-Yellowknife Resources Inc. in 1988 (Blackwell 1989) and the Geological Survey of Greenland (GGU) 1987 - 1991. Following a GGU gold discovery at Eqi in 1988, this area was further explored by Platinova Resources Ltd./Faxe Kalk A/S in 1989-91 (Knudsen & Nielsen 1992) and GGU in 1991 (Stendal *et al.* 1999). The area has in the 1990's been explored by Nunaminerals A/S, especially targets at Saqqaq, Itilliarsuk, and Eqi (Nunaminerals 2000).

Mineralisation is known as widespread and small occurrences in supracrustal rocks of Archaean and Palaeoproterozoic age in the Disko Bugt region (Blackwell 1989; Gothenborg & Keto 1986; Knudsen *et al.* 1990; Knudsen *et al.* 1988). The aim of this paper is to give an overview of the current knowledge of mineral occurrences and mineralising events in the Disko Bugt region and evaluate the Archaean and Palaeoproterozoic supracrustal rocks for their base metal and gold potential.

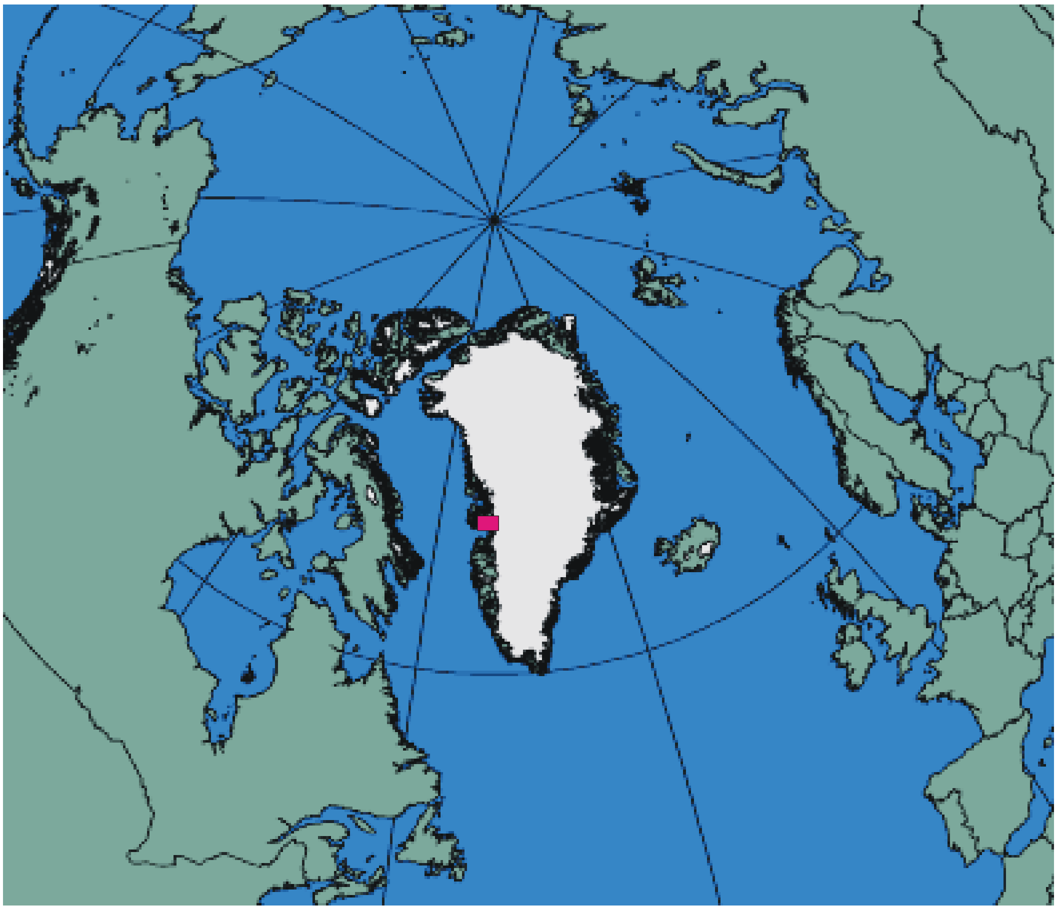

Figure 1. *Greenland located within the northern Polar region. The study area is shown with a Red Square.*

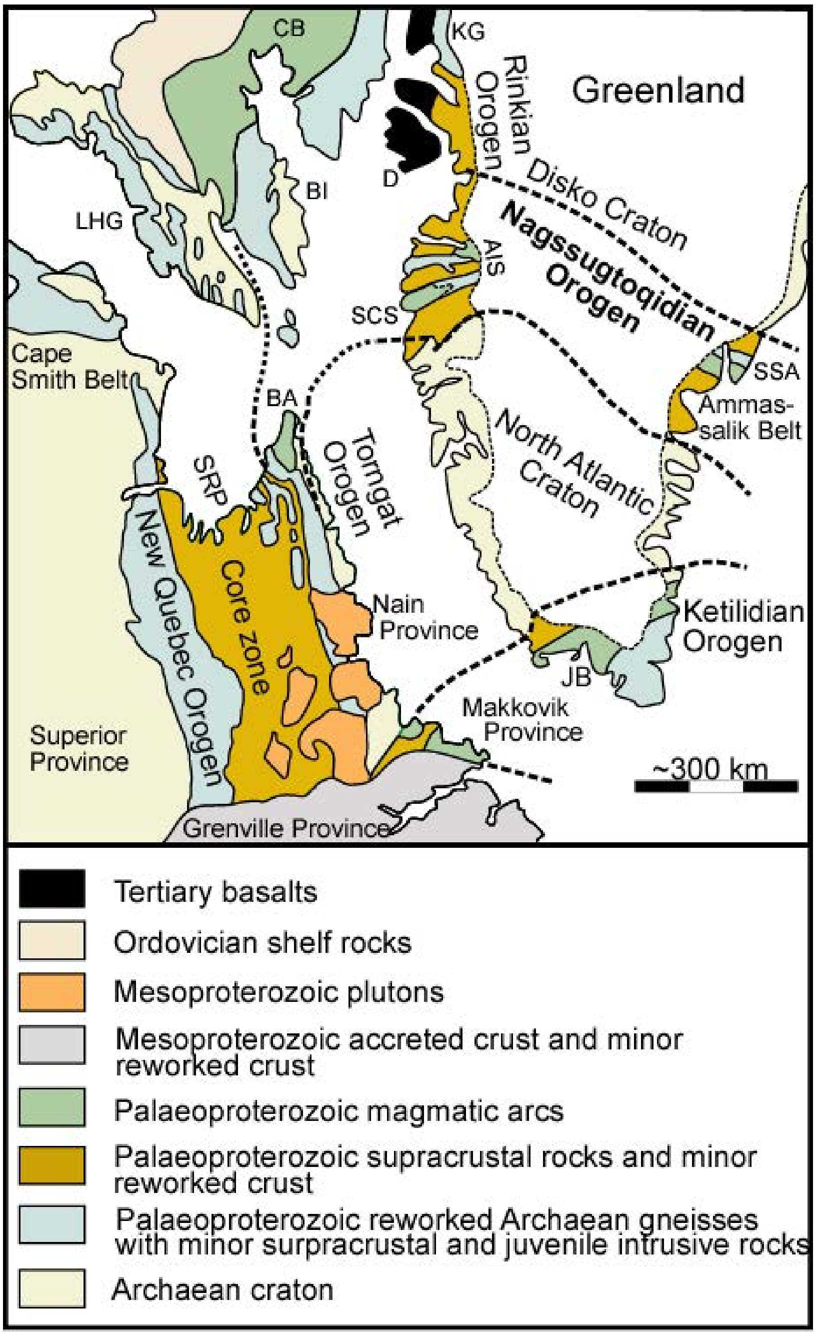

Figure 2. *Reconstruction of eastern Canada and Greenland in Proterozoic time, showing the relation between Palaeoproterozoic orogens and Archaean cratonic blocks - from van Gool et al.(2002). AIC = Ammassalik intrusive complex; AIS = Arfersiorfik intrusive suite; BA = Burwell Arc; BI = Baffin Island; CB = Cumberland batholith; D = Disko Island; ENO = Eastern Nagssugtoqidian Orogen; JB = Julianehåb Batholith; KG = Karrat Group; LHG = Lake Harbour Group; SSA = Síportôq supracrustal association; SCS = Sisimiut charnockite suite; SRP = southern Rae Province; TG = Tasiuyak gneisses.*

Geological setting

The Archaean supracrustal rocks of the Ataa Sund and Torsukattak areas do not form a continuous belt. The belt is scattered into the following areas (Fig. 3): Arveprinsen Ejland, Oqaatsut, Anap Nunaa, Qingaarsuaq and Eqi-Maniitsoq south of Torsukattak, and north of Torsukattak Saqqaq, Naajat Qaqqaat – Itilliarsuk, Itilli and Nunataq (Garde & Steenfelt 1999a). The supposed Archaean supracrustal fragments north of Torsukattak are treated separately, partly because of some differences in lithology compared to those south of Torsukattak. The apparent lack of lithological and structural correlation across Torsukattak, between the Nuussuaq domain and the Ataa domain, suggests that the fjord hides an ENE-WSW-trending structural discontinuity - a shear zone (Garde & Steenfelt 1999b). The following supracrustal units occur along the southern coast of Nuussuaq: Saqqaq, Itilliarsuk, Itilli and Nunataq. Detailed descriptions of the region has changed with time, the first details can be found in (Escher & Burri 1967) but more modern descriptions are found in (Garde & Steenfelt 1999a), (Garde *et al.* 1999), (Rasmussen & Pedersen 1999); and (Higgins & Soper 1999). The Palaeoproterozoic supracrustal rocks are mainly found south of Torssukattak (Fig. 3).

The Precambrian terrain of eastern Nuussuaq and northern Disko Bugt mainly comprises of late Archaean orthogneisses. This orthogneiss terrain is intercalated with units of strongly deformed Archaean supracrustal rocks (Garde & Steenfelt 1999a). Orthogneisses including the essentially undeformed Atâ tonalite (Kalsbeek & Skjernaa 1999) form about 90% of the country rocks. The orthogneisses are all presumed to be of Archaean age and contemporaneous with the Atâ tonalite dated at c. 2800 Ma (Kalsbeek & Taylor 1999; Nutman & Kalsbeek 1999).

The Palaeoproterozoic sedimentary sequence unconformably overlying the Archaean rocks is approximately 3.5 km thick and comprises shallow marine clastic sediments and minor marble (Garde & Steenfelt 1999a). The central part of the area is extensively albitised e.g. and Qeqertakassak (Kalsbeek 1992; Ryan & Escher 1999). Mafic dykes, and dykes and plugs of ultramafic lamprophyre and lamproite with ages of c. 1750 Ma are common (Marker & Knudsen 1989; Skjernaa 1992).

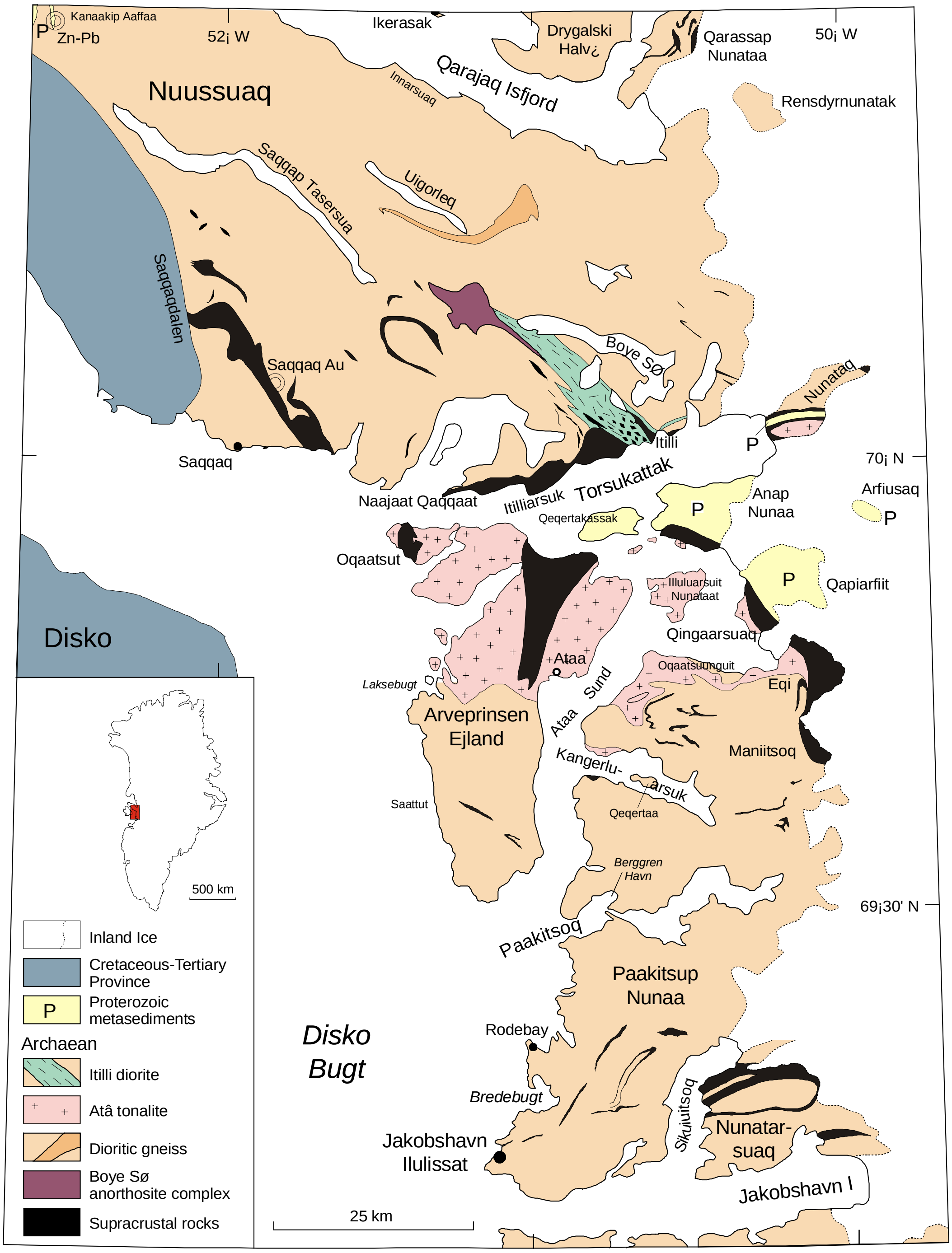

Figure 3. *Geological index map of the Disko Bugt region - from Garde & Steenfelt (1999a).*

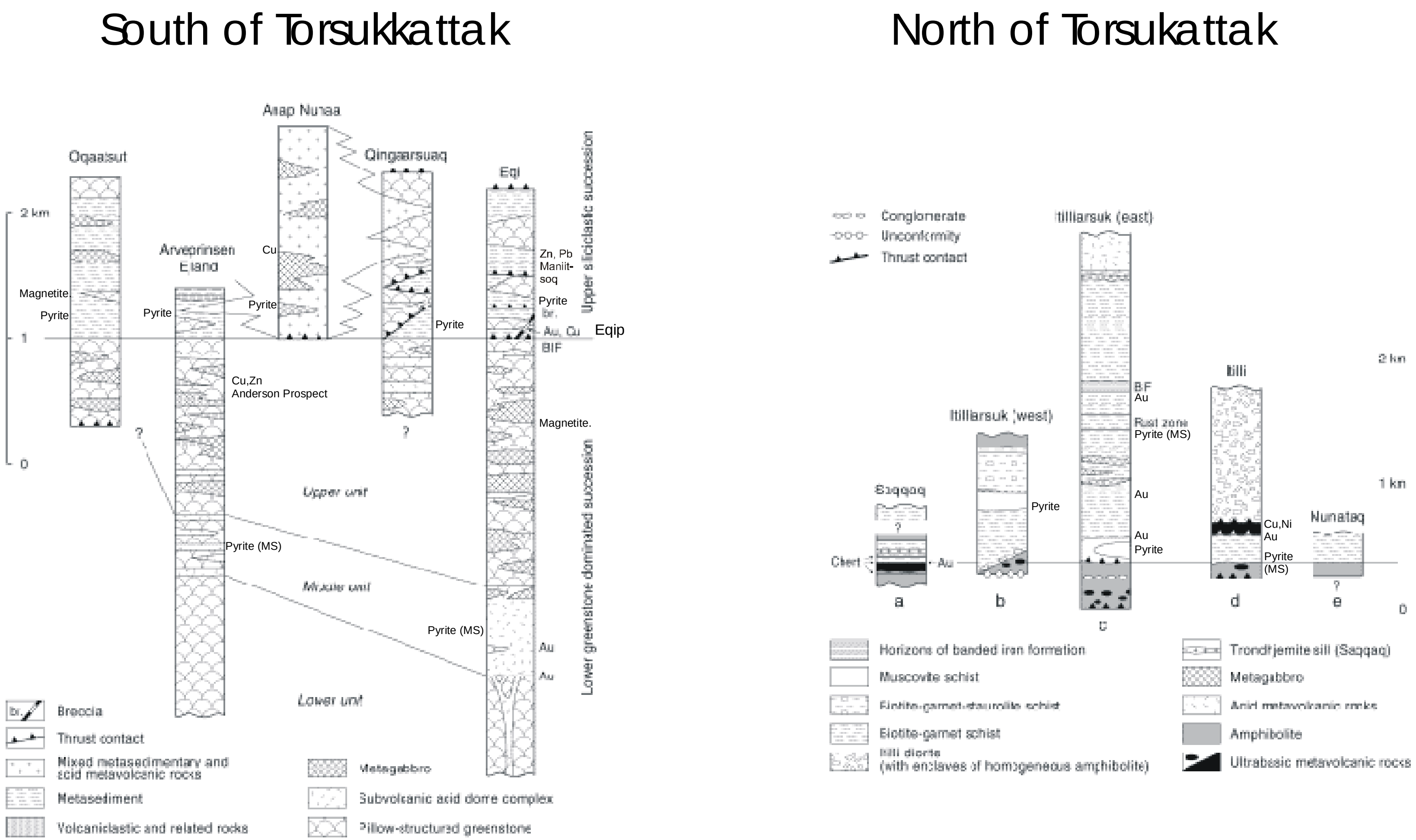

Figure 4. *Simplified stratigraphic colums of the Archaean supracrustal rocks in the Disko Bugt region with indication of the level of mineral occurrences in the region - modified after Garde & Steenfelt (1999a).*

Archaean supracrustal sequences south of Torsukattak

Eqi-Maniitsoq and Arveprinsen Ejland

The two largest Archaean supracrustal sequences south of Torsukattak, Arveprinsen Ejland and Eqi-Maniitsoq, show the same general lithological evolution. In both areas a thick sequence dominated by greenstones is overlain by a thinner sequence characterised by siliciclastic and acid metavolcanic rocks. Based on primary features of pillow lavas the whole greenstone sequence is inverted (Stendal *et al.* 1999). In the northeastern part of Arveprinsen Ejland the Archaean supracrustal rocks are intruded by a voluminous mafic sill complex (Marshall & Schønwandt 1999).

The greenstone sequence

The greenstone sequence in Arveprinsen Ejland and Eqi-Maniitsoq areas can be divided into three units (Fig. 4):

(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 (Garde & Steenfelt 1999a; Stendal *et al.* 1999). The thickness at Eqi-Maniitsoq is a minimum estimate, since the Inland Ice covers the base of the sequence and the primary volcanic structures of the area are distorted by ENE-WSW stretching. The greenstone succession on Arveprinsens Ejland is intruded by the Atâ pluton and its base is therefore unknown.

The lower unit: This unit is very similar in both areas and comprises mainly massive to pillowed greenstones with little evidence of intrusive activity. A few thin felsic layers of crystal tuff and epiclastic sediments are observed on Arveprinsen Ejland. In the Eqi area a network of irregular acid dykes leading up to the middle unit cuts the lower unit (Fig. 5).

Figure 5. *Acid dyke crosscutting the greenstones of the Eqi area.*

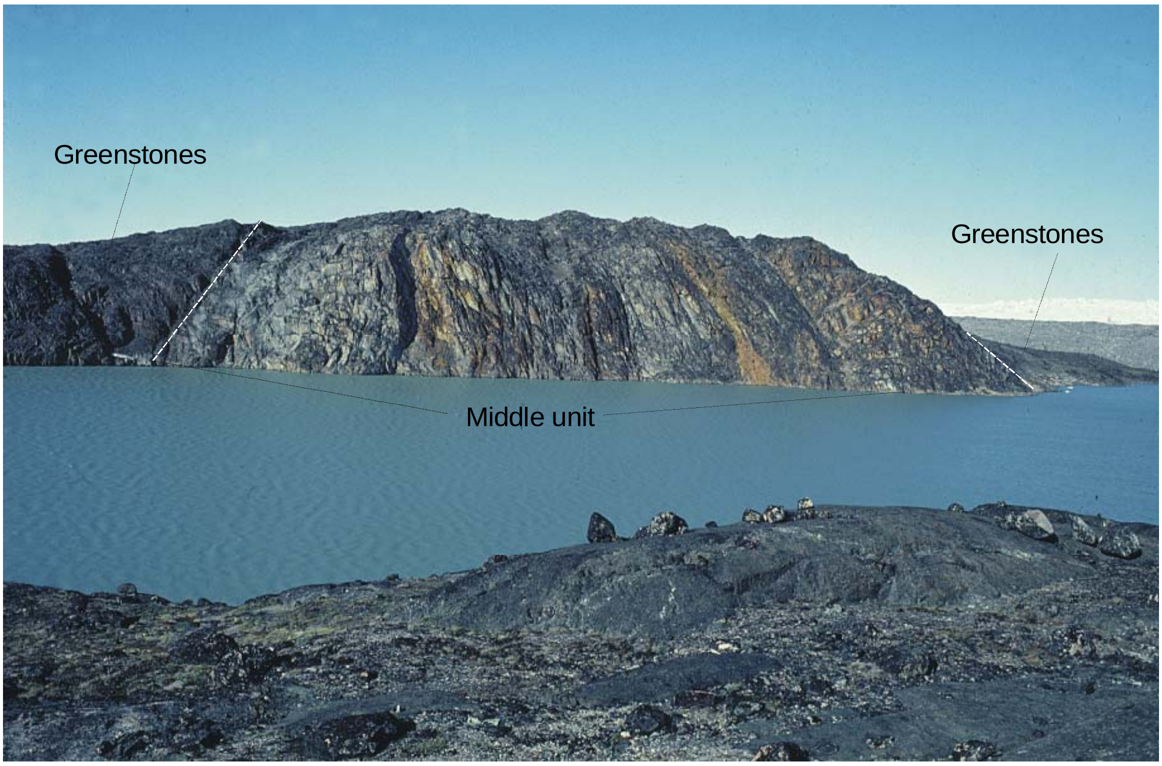

Figure 6. *The middle unit of the Eqi area.*

The middle unit: Widespread acid igneous activity coeval with extrusion of basic lava's dominate the middle unit. At Arveprinsen Ejland the middle unit of predominant greenstones comprises of quartz-feldspar porphyry layers of rhyolitic composition. At Eqi the unit forms an approximately 15 km long and 1 km wide belt (Figs. 6 & 7). Quartz-feldspar porphyries occur within the sequence, but the concentration is highest in the central part where they constitute about 15%. The thickness of the rhyolite layers varies between 1 and 30 m, however, an up to 70 m thick layer occurs in the central part of the sequence (Fig. 6).

A characteristic feature of the middle unit is the presence of carbonate-chert layers showing gradational transition into adjacent greenstones and siliceous or mafic tuffs. The thickness of the carbonate-chert layers is generally about 5 cm but the most conspicuous layer has a thickness of about 10-m and can be followed for several kilometres. This particular layer change in composition from being carbonate dominated in the north to more chert- bearing in the south. The chert-bearing layers represent chemical sediments.

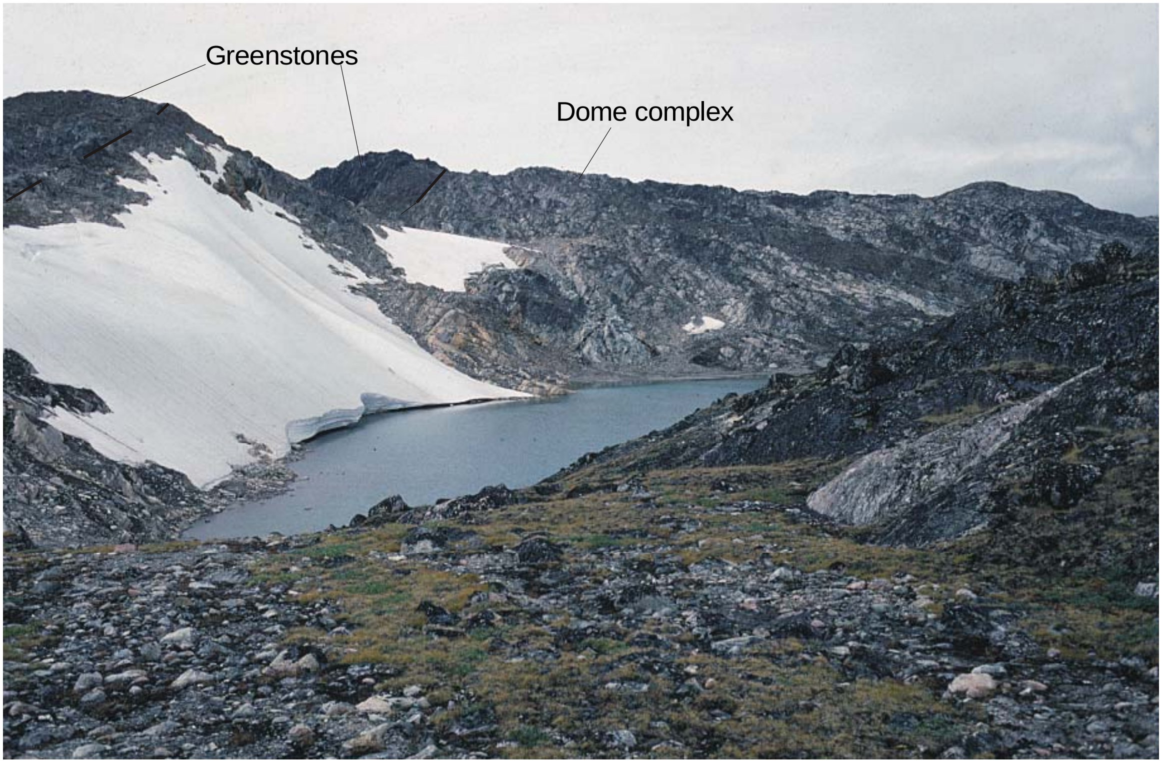

Figure 7. *View of the Middle Unit with the Dome complex in the Eqi area.*

In the eastern part of the Eqi East area a felsic dome complex of quartz and feldspar porphyries (Figs. 6 & 7) dominates the middle unit (Stendal *et al.* 1999). The network of felsic dykes in the lower unit (Fig. 5) obviously represents a feeder dyke system to the complex. The felsic dome complex is at least 2-km long and has a tectonic width of about 1-km. The complex is built up of a massive rhyolitic rock, which rests on pillowed greenstones of the lower unit (a). The massive rhyolitic rock is capped by a sericite schist (Fig. 8) which upwards grades into an agglomerate of closely packed fragments of quartz-feldspar porphyries. The uppermost part of the dome complex is locally overlain by thin layers of graphite phyllite and is intruded by extensive sheets of metagabbro. Extensive hydrothermal activity resulted in intense carbonatisation and quartz veining (Fig. 9) as a late event in the build up of the dome complex (Stendal *et al.* 1999).

Figure 8. *Sericite schist of the Eqi area.*

Figure 9. *Carbonate alteration of the greenstones (basic rocks) at Eqi and quartz veining.*

The upper unit: This unit is similar in the Arveprinsen Ejland and Eqi areas. It is composed of pillow lavas and mafic tuffs with minor felsic layers of mixed tuff and volcaniclastic sediments. The upper unit is further characterised by abundant mafic intrusives which, together with the pillow lavas, make up most of the unit.

The siliciclastic sequence

On Arveprinsen Ejland and in the Eqi-Maniitsoq area consists of fine to medium grained siliciclastic rocks, which laterally interfinger with greenstones. This sedimentary package is locally intercalated with subordinate layers of basaltic hyaloclastic breccia, mafic and felsic tuff, chert and cherty volcaniclastic rocks all of which are best exposed in the less deformed part of the sequence of Arveprinsen Ejland. The siliciclastic rocks are commonly non-graded, but where argillaceous material is present, graded bedding may be observed. On Arveprinsen Ejland cross bedding and scour-and-fill structures occur and, as with graded bedding, usually show eastward younging. In the Eqi area where the siliciclastic sequence is detached from the greenstone sequence by a thrust, the siliciclastic sequence is intensely deformed and primary structures have not been observed. The thickness of the siliciclastic sequence is about 0.4 km on Arveprinsen Ejland and up to 1.2 km in the Eqi area. The greater measured thickness in the eastern area is not necessarily significant, because the siliciclastic sequence here may have undergone tectonic repetition. In the Eqi area, the sediments of the siliciclastic sequence are carbonaceous and argillaceous layers interstratified with several layers of banded iron formations. On Arveprinsen Ejland widespread pyrite-bearing sediments occur in the lower part of the siliciclastic sequence.

Mafic sill complex

A prominent mafic sill complex intrudes the upper part of the stratigraphic sequence in the northeastern part of Arveprinsen Ejland (Marshall & Schønwandt 1999). The mafic sill complex (Fig. 10), 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.

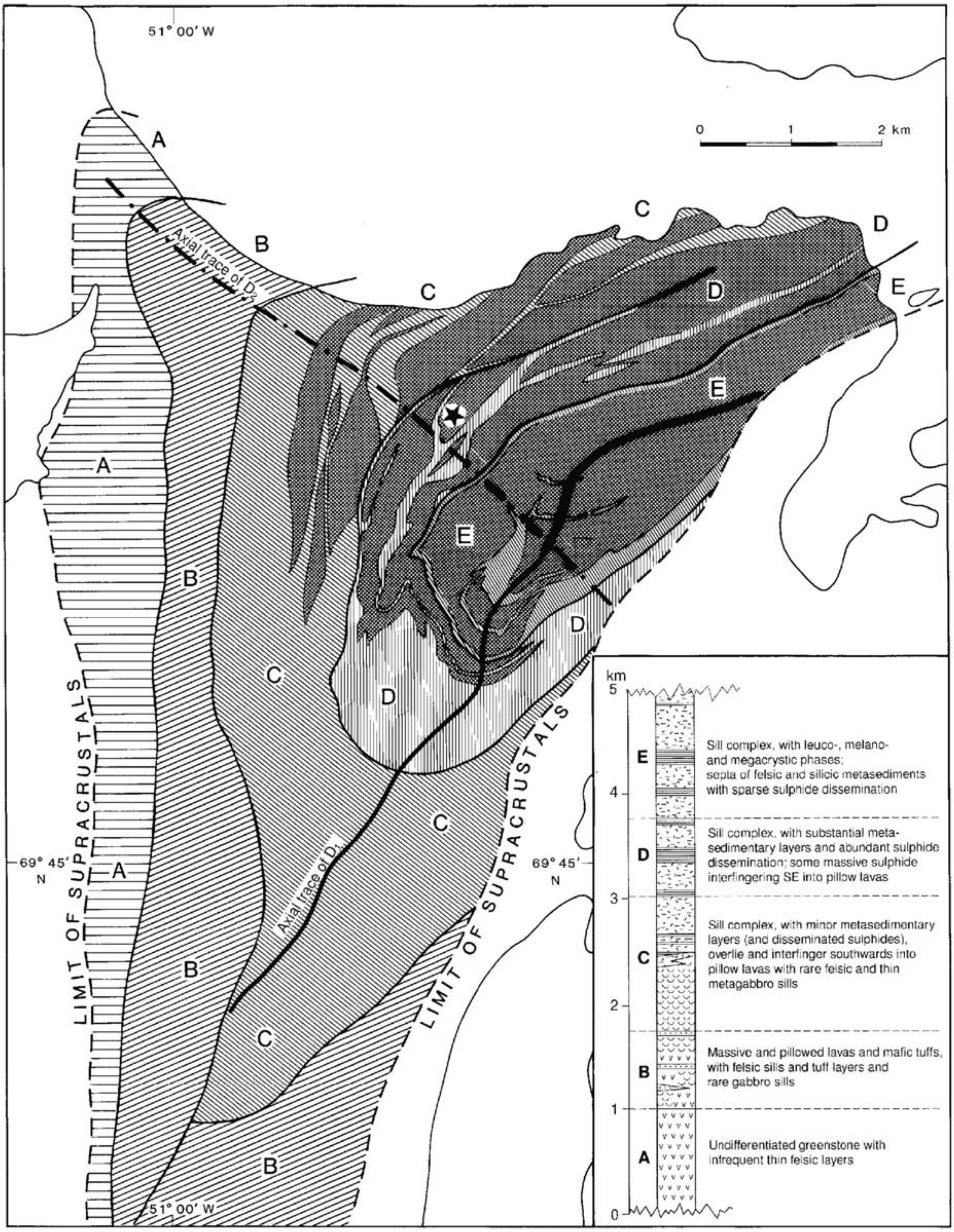

Figure 10. *The sill complex on Arveprinsen Ejland. The star locates Anderson prospect - from Marshall & Schønwandt (1999).*

Anap Nunaa and Qingaarsuaq

In the Anap Nunaa and Qingaarsuaq areas, the Archaean supracrustal rocks mainly consist of low amphibolite facies pillowed greenstones interlayered with felsic volcanics and volcaniclastic to epiclastic sediments. The supracrustal succession contains several thrusts, which presumably have repeated part of the stratigraphy.

In the western part, the sequence contains voluminous gabbroic intrusives. The thickness of the sequence is about 2-kilometres (Garde & Steenfelt 1999a). The package is unconformably overlain by Lower Proterozoic sediments towards northeast bounded towards southwest by a NE-dipping thrust against the Atâ granitoids.

A pronounced gravity high from north-eastern Arveprinsen Ejland to southern Anap Nunaa indicates a submarine connection between the Archaean supracrustal sequences on Arveprinsen Ejland and Anap Nunaa (Thorning 1989). However, the stratigraphic position of Anap Nunaa relative to the sequences in the Arveprinsen Ejland-Eqi-Maniitsoq areas is uncertain. The siliciclastic rocks, which interfinger with greenstones on northern Qingarssuaq, are lithologically very similar to the Anap Nunaa rocks. Thus the Anap Nunaa Archaean supracrustal sequence could possibly correlate with the siliciclastic sequences on Arveprinsen Ejland, Qingarssuaq and Eqi. The suggested correlation is also the most straightforward one from a structural viewpoint since the Archaean sequence is younging westwards in the Eqi area and mainly eastwards on Arveprinsen Ejland.

Oqaatsut

At Oqaatsut, the westernmost occurrence of Archaean supracrustal rocks south of Torsukattak (Fig. 3), the N-S striking and E-dipping supracrustal sequence forms a sandwich between Atâ granitoids (Rasmussen & Pedersen 1999). The upper contact is a thrust whereas the lower contact is intrusive. The succession can be divided into three main units: a lower and an upper amphibolitic greenstone unit, with a metasedimentary unit in between (Fig. 4). The structurally lower (western part) is up to 1.15 km 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 0.9 km 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.

Archaean supracrustal sequences north of Torsukattak

Saqqaq

The Saqqaq supracrustal rocks (Garde 1994) occur as NW-SE striking belt (c. 5 x 29 km), which is enclosed in the Archaean Nuussuaq gneisses (Fig. 1). The exposed thickness of the supracrustal rocks is approximately 0.5 km (Figs. 4, 11 & 18). The boundary relationships to the surrounding orthogneisses are not known nor is the direction of younging (Garde *et al.* 1999).

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 (Figs. 4, 11 & 18). This unit is followed by c. 100 m thick mica-garnet schist, which is overlain by several hundred metres thick succession of interlayered amphibolite and metasediments. A 100 m thick granitoid sill has intruded the upper part of the supracrustal rocks.

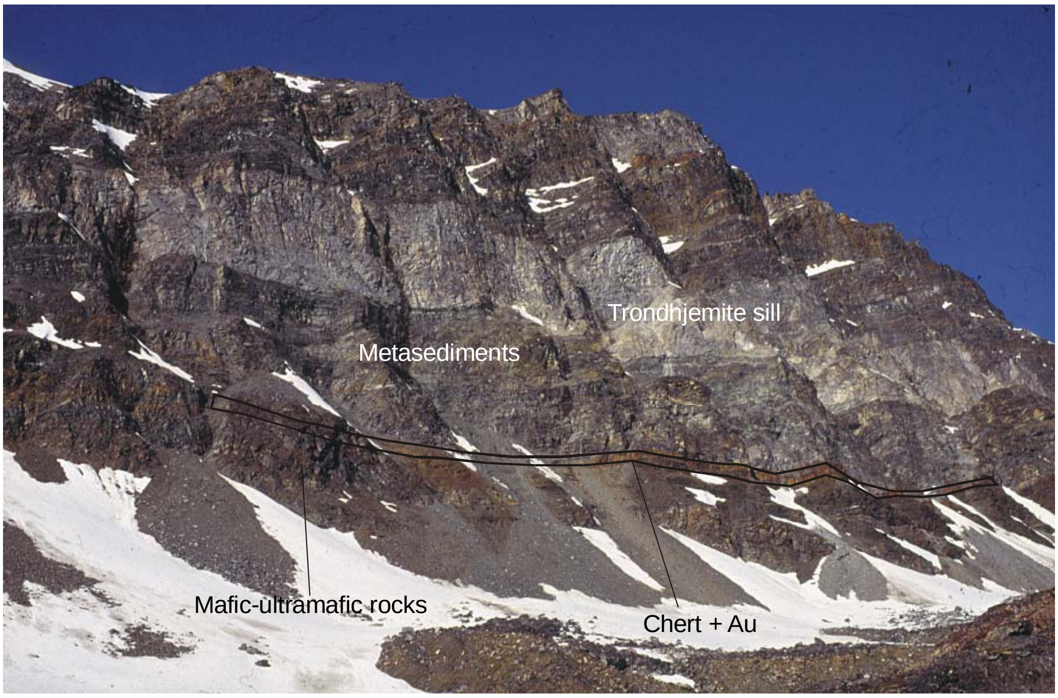

Figure 11. *A section of the Saqqaq supracrustal rocks with rusty metachert.*

Naajaat Qaqqaat

The supracrustal sequence (Figs. 3 & 18) is dominated by staurolite-muscovite- and biotite-rich schists alternating with amphibolitic greenstone units (Rasmussen & Pedersen 1999). Two units of greenstones are present, a lower continuos 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)

Itilliarsuk

The thickest succession of supracrustal rocks north of Torsukattak occurs in the Itilliarsuk area (Figs. 4 & 18). 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 1999a). The sedimentary pile is of presumed Archaean age, and is intruded by gabbroic sills and thin felsic dykes. The lower 0.4 km 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 1999a). 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 1999a).

Itilli

The supracrustal rocks at Itilli comprise three lithological different units: towards SW an amphibolite dominated unit, an ultramafic unit up to 200 m thick and towards NE a unit dominated by biotite-garnet schist with subordinate amphibolite (Figs. 3, 4 & 18). The latter unit is at least 0.35 km 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 (Garde & Steenfelt 1999a). The amphibolite unit consists of massive to fine-grained amphibolites interlayered with biotite-garnet and quartz-mica schists. The 2-5 m thick metasedimentary layers make up for a minor part of the one km thick amphibolite unit. The amphibolite unit is intruded by a quartz-diorite. In the northern part these rocks form an amphibolite-diorite agmatite. Low-grade copper-gold- (cobalt) mineralisation occurs widespread in the southern part of the amphibolite unit.

Nunataq

In the Nunataq area supracrustal rocks preserved in a major syncline in the southern part comprise an Archaean and a Proterozoic sequence (Higgins & Soper 1999). In the Nunataq area the succession of supracrustal rocks occurs and provide indirect evidence that the extensive amphibolite facies metavolcanic and metasedimentary rocks along the south coast of Nuussuaq are Archaean (Garde & Steenfelt 1999a; Higgins & Soper 1999).

The succession has a present thickness of minimum 500 m and comprises a lower amphibolite unit and an upper unit dominated by biotite-garnet schist.

Proterozoic supracrustal sequences

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 (Garde & Steenfelt 1999a) (Fig. 3). This sequence comprises of 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 (Fig. 12;(Andersen 1991). The total thickness of the Palaeoproterozoic sequence (Anap nunâ Group) is at least 3.6 km.

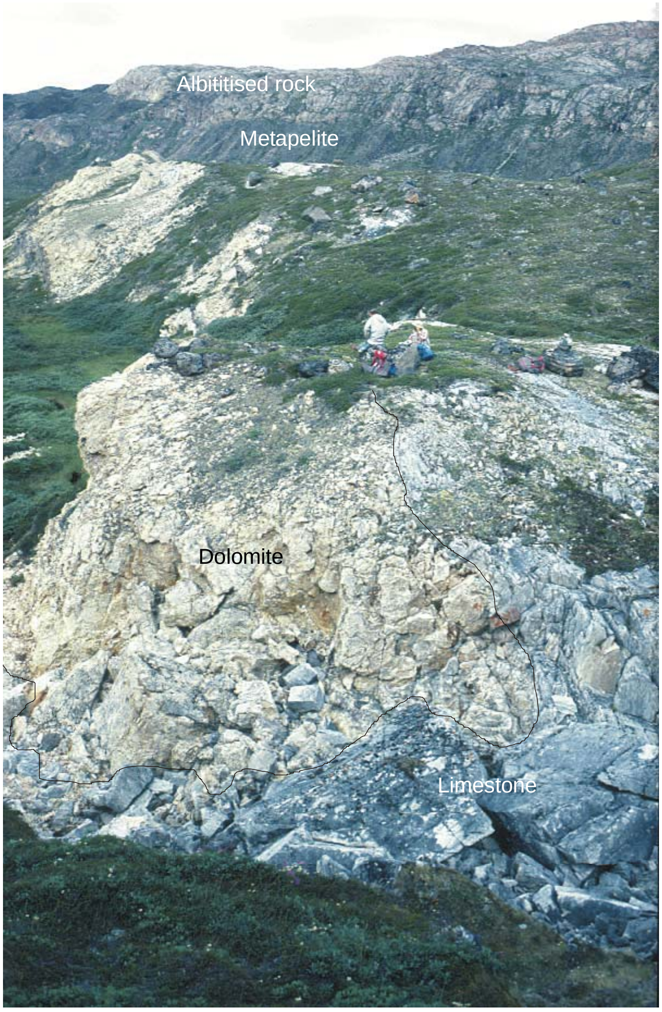

Figure 12. *Carbonates from the Palaeoproterozoic Anap nunâ Group and albitised rock in the background.*

At Nunatak an isoclinal folded greenschist facies sequence of shallow water sediments occur. These rocks have been correlated with the lower part of the Palaeoproterozoic sequence at Anap nunâ Group (Garde & Steenfelt 1999a; Higgins & Soper 1999).

In the northern and central parts of Nuussuaq scattered outcrops of marble and quartzite occurs. The structural setting of isoclinally folded metasediments are tectonically interleaved bodies up to 0.35 km within the Archaean gneisses. The marble shows lithological similarities to the lower Proterozoic Maarmorilik Formation in the Uummannaq district (Garde 1978; Henderson & Pulvertaft 1987; Pulvertaft 1986).

Mafic dykes and sills of Proterozoic age have intruded the region and are particularly common in the Qapiarfit area (Figs. 3 & 18). The Disko Bugt area contains several dykes of Proterozoic lamprophyres and lamproites (Marker & Knudsen 1989; Skjernaa 1992; Thomsen 1991). Age determinations indicate that the dykes are intruded c. 1750 Ma (Larsen & Rex 1992; Rasmussen & Holm 1999). Additionally two minor pipes are known (Skjernaa 1992).

Albitisation is extensively developed on Qeqertakassak, Anap Nunaa (Fig. 12) 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).

Palaeoproterozoic deformation and metamorphism dominate most of the region. Open folds overprint flat-lying ductile shears with north- or northwestward movement of the hanging wall (Escher & Pidgeon 1976; Garde & Steenfelt 1999b; Grocott & Davies 1999).

Geochemistry

The geochemical data used below are all analysed by XRF at GEUS (Tables 1 & 2). Different collectors have sampled the rocks. From the Eqi area the sampling is done by the first Author (#350XXX) and by Christian Knudsen (GEUS; # 341XXX), from Arveprinsen Ejland by Marshall & Schønwandt (1999; #362XXX) and Nielsen (1992; #311XXX); from Oqaatsut and Naajaat Qaqqaat by Rasmussen and Pedersen (1999; #349XXX and #354XXX), and samples from Itilli are collected by Agnete Steenfelt (GEUS; # 2726XX).

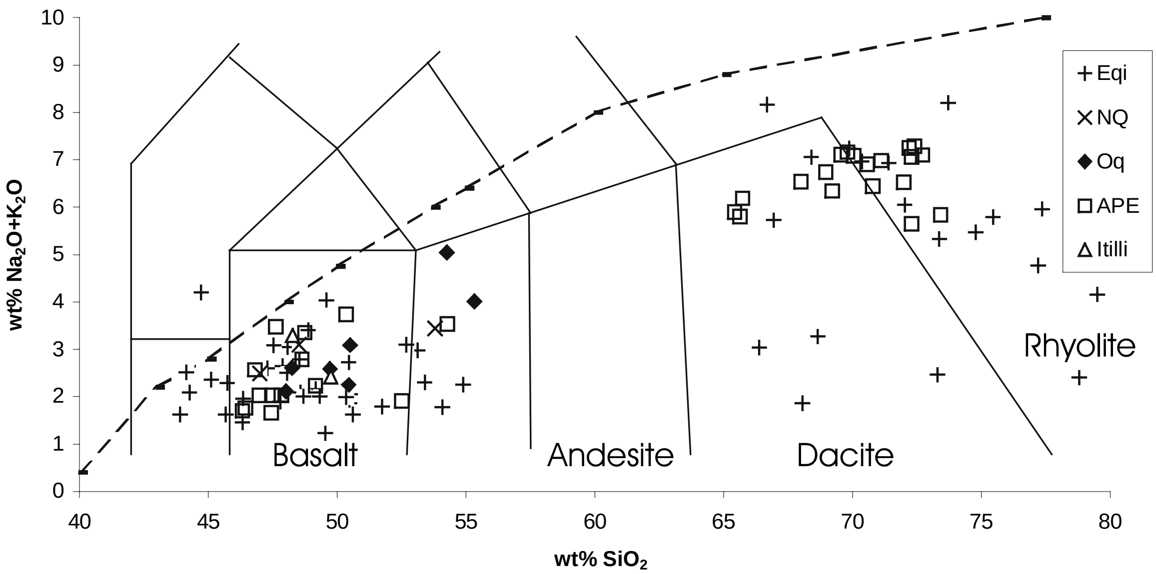

Figure 13. *Rock classification TAS diagram(Le Maitre et al. 1989) defines the field borders and the stipled line is after (Irvine & Baragar 1971). NQ = Naajaat Qaqqaat; Oq = Oqaatsut; APE = Arveprinsen Ejland.*

The volcanic activity in the Eqi and Arveprinsen Ejland areas of the middle volcanic unit has a bimodal chemical signature with both basic and acid volcanic rocks (Tables 1 & 2). The classification of the rocks in the total alkalis-silica diagram (TAS) yields a rhyolitic to dacitic composition of the acid rocks and basalt to basaltic andesite composition of the basic rocks (Fig. 13). From the same diagram it is obvious that the rocks has a subalkaline (tholeiitic) affinity with almost all samples plotting below the shown trendline. The subdivision of subalkalic rocks (Fig. 14) show that the basaltic samples for the Arveprinsen Ejland population belong to the low-K series and the Eqi samples both to the low-K series and calc-alkaline series for. The dacitic to rhyolitic rocks of both the Arveprinsen Ejland and Eqi areas are even divided into the low-K series and calc-alkaline series. The basic samples from Oqaatsut have a composition that resembles the chemistry from the Eqi and Arveprinsen Ejland areas (Figs. 13 & 14). The few samples north of Torsukattak (Itilli and Naajaat Qaqqaat) plot in the basalt field of the TAS diagram (Fig. 13) and close to the trend line between low-K series and calc-alkaline series (Fig. 14).

Sample #	Area	SiO2	TiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	Volatiles	Sum
		%	%	%	%	%	%	%	%	%	%	%	%	%
341410	Eqi	66.95	0.59	17.63		1.49	0.04	2.71	1.15	2.8	2.93	0.09	2.49	98.87
341418	Eqi	73.38	0.52	12.85	0.26	2.49	0.1	0.86	2.2	2.8	2.52	0.15	1.41	99.55
341419	Eqi	77.21	0.26	11.2	0.19	2.65	0.06	0.42	1.73	3.39	1.38	0.07	0.8	99.36
341430	Eqi	79.51	0.11	11.22	0.35	1.16	0.04	0.53	0.69	2.84	1.32	0.07	1.34	99.18
341450	Eqi	74.79	0.4	12.86	0.15	2.35	0.04	0.64	0.59	4.13	1.35	0.1	1.49	98.89
341461	Eqi	72.02	0.31	14.69	0.81	0.32	0.06	0.25	1.99	4.45	1.6	0.11	2.07	98.68
341463	Eqi	77.37	0.11	12.92	0.37	0.09	0.03	0.18	0.69	4.01	1.95	0.06	1.32	99.1
341506	Eqi	73.72	0.22	15.28		0.23	0.01	0.33	0.39	7.14	1.06	0.12	0.63	99.13
341514	Eqi	71.41	0.34	15.5		0.49	0.02	0.41	0.85	6.29	0.65	0.13	1.15	97.24
341515	Eqi	66.69	0.61	14.5		5.04	0.01	0.15	0.2	7.69	0.47	0.09	3.62	99.07
341517	Eqi	69.86	0.3	14.19	0.17	2.11	0.05	1.16	2.1	6.64	0.6	0.13	1.44	98.75
341523	Eqi	75.45	0.22	12.79	0.02	1.41	0.02	0.86	0.96	4.6	1.19	0.11	1.13	98.76
341532	Eqi	68.4	0.59	15.34	0.1	2.81	0.04	1.8	1.22	6.88	0.18	0.09	1.46	98.91
341537	Eqi	70.37	0.29	14.1	0.45	1.8	0.05	0.94	2.35	6.42	0.55	0.12	1.47	98.91
350373	Eqi	73.3	0.15	13.23	2.89		0.09	1.25	3.23	1.44	1.02	0.06	2.8	99.46
350374	Eqi	68.66	0.27	15.55	3.65		0.08	1.25	2.8	1.61	1.66	0.08	2.52	98.13
350383	Eqi	68.06	0.46	14.1	9.74		0.11	1.02	1.8	1.02	0.84	0.06	3.39	100.6
350386	Eqi	78.81	0.1	11.94	2.13		0.04	0.54	1.39	1.2	1.2	0.06	1.77	99.18
350387	Eqi	66.39	0.43	14.4	4.05		0.13	1.87	4.84	1.58	1.46	0.06	5.04	100.25
362601	APE	68	0.3	15.17		2.09	0.04	1.16	3.3	5.04	1.5	0.09	0.5	97.19
362602	APE	69.8	0.26	14.76	0.37	1.48	0.02	0.93	2.09	6.18	0.98	0.08	0.48	97.43
362657	APE	65.63	0.41	15.04	2.1	3.67	0.03	2.3	1.92	5.21	0.59	0.15	0.42	97.47
362656	APE	73.42	0.28	13.75	0.52	1.7	0.01	1.35	1.32	4.58	1.26	0.14	0.53	98.86
362664	APE	68.97	0.27	15.3	0.32	1.26	0.03	0.87	2.4	4.59	2.15	0.07	0.5	96.73
362709	APE	70.8	0.27	14.2	0.28	1.59	0.04	1.29	2.08	4.73	1.71	0.09	0.56	97.64
362732	APE	71.11	0.24	15.35	0.14	1.56	0.03	0.79	2.09	5.77	1.21	0.06	0.46	98.81

Sample #	Area	SiO2	TiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	Volatiles	Sum
		%	%	%	%	%	%	%	%	%	%	%	%	%
362743	APE	70.04	0.24	15.01	0.08	1.39	0.03	0.9	2.29	5.22	1.86	0.06	0.52	97.64
362745	APE	65.73	0.45	16.57	0.37	2.93	0.04	1.55	4.09	5.05	1.14	0.08	0.46	98.46
311701	APE	72.41	0.3	14.52	0.89	1.81	0.04	1.35	1.23	5.31	1.97	0.1	1.49	101.42
311704	APE	72.72	0.29	14.24	0.8	1.63	0.04	1.16	1.82	5.36	1.74	0.09	1.83	101.72
311720	APE	71.99	0.27	15.72	0.23	1.58	0.02	0.8	2.09	6.46	0.07	0.06	0.72	100.01
311726	APE	70.58	0.29	15.62	0.78	1.8	0.04	1.1	2.68	5.04	1.87	0.09	2.25	102.14
311739	APE	72.3	0.25	15.4	0.37	1.48	0.02	0.76	2.24	5.92	1.14	0.06	1.23	101.17
311754	APE	69.22	0.41	15.53	0.42	0.31	0.04	2.69	2.13	5.29	1.05	0.09	1.51	98.69
311761	APE	72.2	0.22	15.69	0.89	0.63	0.03	0.55	2.37	5.42	1.83	0.06	0.84	100.73
311762	APE	69.56	0.32	15.72	0.42	2.13	0.05	1.3	3.15	5.35	1.76	0.12	0.8	100.68
311763	APE	65.42	0.5	17.38	1.17	3.28	0.06	2.19	3.92	4.11	1.79	0.08	1.46	101.36
311776	APE	65.39	0.51	19.74	0.22	1.2	0.01	1.35	0.81	10.26	0.38	0.02	1.27	101.15
311784	APE	72.3	0.3	15.45		2	0.02	0.93	3.22	4.79	0.86	0.07	0.35	100.29

Table 1. *XRF analyses of acid rocks. APE = Arveprinsen Ejland.*

Sample #	Area	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Volatiles	Sum	Y	Zr
		%	%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm
350371	Eqi	50.47	0.82	13.07	9.21		0.28	2.56	9.67	1.26	0.6	0.1	9.6	97.64	16	48
350376	Eqi	47.29	1.02	16.71	11.26		0.31	3.31	8.48	1.54	1.06	0.08	6.98	98.04	10	53
350377	Eqi	45.73	0.71	15.32	9.43		0.25	4.05	9.27	1.47	0.82	0.08	11.42	98.55	12	41
350379	Eqi	54.08	0.71	13.27	8.1		0.22	3.55	8.8	1.28	0.5	0.06	10.16	100.73	12	36
350380	Eqi	50.6	0.76	14.52	10.13		0.25	3.7	8.11	1.22	0.4	0.08	9.94	99.71	14	42
350389	Eqi	45.11	0.74	16.15	9.55		0.27	4.08	9.78	1.44	0.92	0.08	11.96	100.08	12	37
350390	Eqi	44.26	0.76	16.74	10.79		0.25	3.81	8.91	1.15	0.94	0.06	10.79	98.46	12	39
350393	Eqi	49.15	1.08	18.29	11.64		0.27	2.69	6.01	1.22	0.94	0.08	6.68	98.05	12	68
350394	Eqi	50.51	1.12	18.21	11.93		0.27	2.61	6.16	1.25	0.8	0.1	6.33	99.29	16	56
350395	Eqi	48.57	1.04	16.39	10.93		0.29	3.37	7.83	1.45	0.64	0.08	7.44	98.03	10	54
350397	Eqi	43.89	0.96	15.83	12.08		0.36	3.93	8.69	1.02	0.6	0.08	10.63	98.07	18	56
341411	Eqi	54.89	0.45	12	2.79	6.17	0.16	5.68	8.3	1.93	0.33	0.06	5.67	98.43		
341423	Eqi	44.72	1.34	14.29	0.49	9.86	0.18	5.29	8.43	3.31	0.89	0.22	10.62	99.64		
341424	Eqi	50.35	0.9	14	2.04	10.23	0.24	6.72	10.9	1.86	0.13	0.1	2.99	100.45		
341426	Eqi	48.07	1.28	13.17	0.81	9.79	0.2	6.28	6.27	3.04	0.01	0.15	10.45	99.52		
341428	Eqi	50.45	0.73	16.03	1.27	8.11	0.18	8.14	10.89	2.17	0.55	0.11	1.44	100.08		
341431	Eqi	48.54	0.97	16.27	1.34	8.19	0.25	3.46	8.7	2.58	0.2	0.09	8.23	98.82		
341432	Eqi	47.87	0.89	14.77	1.07	6.96	0.27	2.85	11.02	2.16	0.49	0.09	10.09	98.53		
341454	Eqi	48.69	0.79	15.6	0.74	10.58	0.15	8.27	4.27	1.68	0.33	0.09	7.61	98.79		
341455	Eqi	46.35	0.94	13.6	0.49	9.08	0.25	5.19	10	1.13	0.83	0.1	11.75	99.71		
341456	Eqi	49.32	0.95	12.68	0.76	8.75	0.18	3.98	9.92	1.94	0.07	0.11	9.58	98.24		
341457	Eqi	49.57	1.51	15.8	0.92	5.98	0.14	5	7.59	4	0.04	0.19	7.36	98.1		
341458	Eqi	46.32	1.06	14.25	1.62	7.22	0.33	5.97	13.22	1.38	0.08	0.12	7.61	99.18		
341459	Eqi	44.14	0.73	13.8	0.88	10.1	0.19	7.43	8.15	2.02	0.5	0.09	10.67	98.7		
341465	Eqi	53.12	1.33	17.75	0.57	7.19	0.17	6.25	5.25	2.91	0.07	0.13	4.78	99.52		

Sample #	Area	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Volatiles	Sum	Y	Zr
		%	%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm
341467	Eqi	51.74	1.07	15.44	2.97	8.44	0.22	4.46	9.95	1.63	0.16	0.11	3.45	99.65		
341468	Eqi	47.53	1.07	13.75	0.41	10.22	0.16	6.4	7.18	2.46	0.62	0.19	9.47	99.47		
341478	Eqi	45.67	0.9	15.08	0.69	11.07	0.16	7.73	6.97	1.59	0.04	0.09	9.48	99.47		
341482	Eqi	53.4	1.13	16.02	0.93	4.77	0.13	2.84	10.78	2.19	0.11	0.11	6.93	99.35		
341484	Eqi	48.87	1.09	15.09	0.84	5.92	0.17	3.9	10.38	3.37	0.04	0.12	9.34	99.13		
341493	Eqi	47.79	0.98	14.24	2.76	10.88	0.19	7.31	9.73	1.71	0.19	0.1	3.28	99.15		
341499	Eqi	48.05	1.07	14.08	1.65	10.78	0.36	5.43	11.37	2.3	0.21	0.11	4.44	99.85		
341503	Eqi	49.54	0.92	14.37	3.11	9.76	0.22	6	12.67	0.99	0.24	0.1	2	99.91		
341504	Eqi	52.68	0.92	14.32	2.33	9.22	0.19	5.7	9.21	2.09	1.01	0.15	1.83	99.64		
349006	NQ	48.51	0.78	14.95	1.37	10.15	0.22	8.61	10.61	3.01	0.09	0.05	1.64	99.99	18	46
349007	NQ	53.8	0.78	14.6	3.01	5.75	0.15	6.25	9.84	2.86	0.58	0.42	1.66	99.7	19	158
354493	NQ	46.99	0.86	15.19	1.76	10.75	0.22	8.11	10.95	2.36	0.13	0.04	1.87	99.23	17	84
348914	Oq	55.33	0.74	15.03	1.39	7.58	0.13	5.38	8.26	3.07	0.94	0.11	1.2	99.16	21	124
349023	Oq	48.24	1.04	15.48	1.76	10.34	0.2	8.18	10.43	2.33	0.28	0.06	1.61	99.95	22	63
349029	Oq	50.45	1.76	13.49	2.91	12.23	0.22	5.84	9.24	2.15	0.1	0.13	1.67	100.19	38	110
349030	Oq	49.72	1.4	15.73	2.24	10.21	0.19	6.17	9.74	2.44	0.15	0.11	1.8	99.9	32	95
349033	Oq	48	1.01	14.43	1.61	10.7	0.17	7.66	8.94	2.03	0.08	0.06	4.61	99.3	25	64
354355	Oq	54.26	0.96	17.57	2.13	5.5	0.13	4.55	7.84	4.28	0.76	0.34	1.24	99.56	20	108
354366	Oq	50.49	0.98	14.47	1.69	9.69	0.19	7.17	10.6	2.86	0.23	0.06	1.47	99.9	24	63
362694	APE	49.15	1.43	14.62	2.06	10.12	0.2	7.3	8.94	2.14	0.09	0.14	3.79	99.98	32	100
362695	APE	47.46	1.46	14.84	2.34	10.18	0.25	6.41	10.35	1.88	0.15	0.14	3.59	99.05	33	100
362663	APE	46.32	1.03	12.18	0.73	10.84	0.21	5.97	8.96	1.66	0.04	0.07	11.14	99.15	24	59
362652	APE	48.74	0.68	17.1	1.36	8.69	0.16	9.12	5.1	2.08	1.27	0.03	5.55	99.88	18	49
362684	APE	47.83	0.59	14.88	0.97	9.23	0.17	11.55	6.54	1.97	0.06	0.03	5.99	99.81	13	45
362685	APE	52.51	0.55	14.29	0.98	8.12	0.16	10.16	6.22	1.87	0.04	0.03	4.72	99.65	12	50
362686	APE	50.35	0.6	14.96	0.39	8.25	0.17	7.67	6.41	3.66	0.08	0.04	6.71	99.29	11	39

Sample #	Area	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Volatiles	Sum	Y	Zr
		%	%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm
311707	APE	47.61	0.96	16.28	2.03	10.06	0.17	8.3	6.91	3.41	0.07	0.07	5.06	100.93	22	55
311708	APE	46.81	1.62	13.5	3.79	11.47	0.2	6.88	9.71	2.35	0.22	0.18	2.93	99.65	43	155
311728	APE	46.43	0.31	20.2	1.75	3.8	0.11	6.34	14.03	1.58	0.18	0.02	1.89	96.65	7	16
311736	APE	46.98	0.62	18.77	1.62	6.2	0.1	9.06	11.74	1.9	0.13	0.03	3.49	100.64	15	38
311741	APE	48.62	0.8	15.73	1.82	7.72	0.18	7.45	11.8	2.65	0.14	0.04	3.2	100.16	22	50
311749	APE	47.43	0.64	17.36	2.53	7.34	0.16	8.74	11.31	1.6	0.06	0.04	3.56	100.77	14	36
311759	APE	54.28	2.11	11.25	7.08	9.38	0.21	2.04	7.98	3	0.54	0.37	2.4	100.65	80	304
272617	Itilli	48.26	0.78	14.93	2.43	11.22	0.22	6.74	9.71	2.91	0.38	0.06	2.03	99.67		
272623	Itilli	49.74	1.23	13.8	1.66	11.82	0.22	6.64	9.7	1.9	0.52	0.07	2.4	99.7		

Table 2. *XRF analyses of mafic rocks. APE = Arveprinsen Ejland; NQ = Naajaat Qaqqaat; Oq = Oqaatsut.*

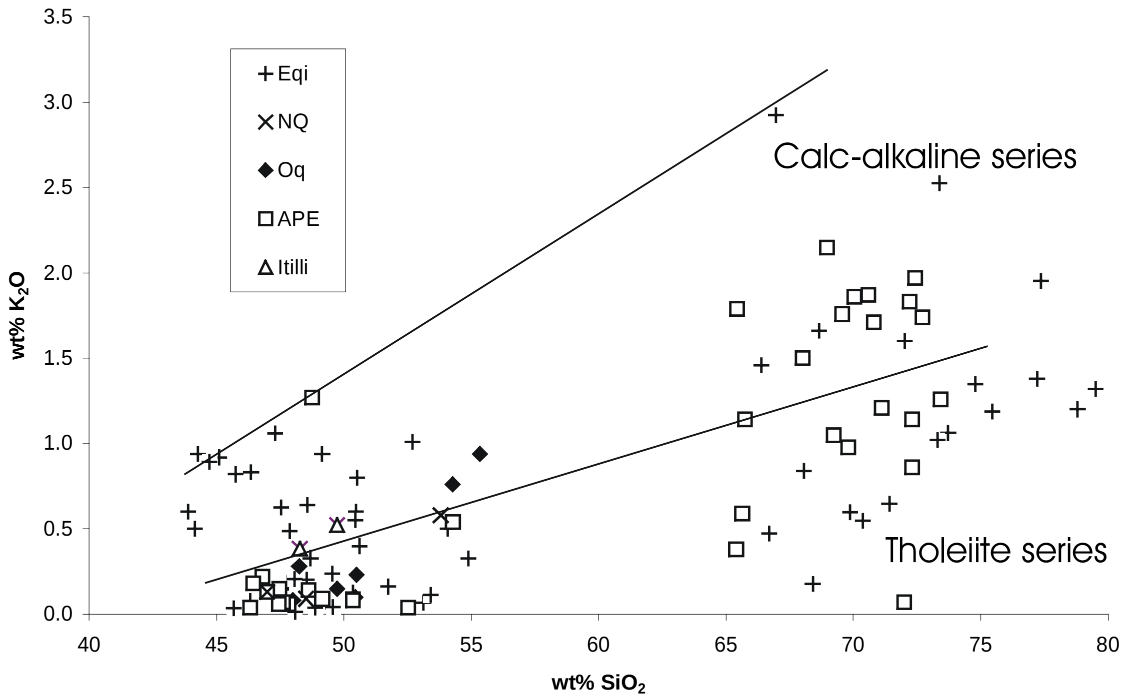

Figure 14. *SiO_2 - K_2O diagram. Trend lines after (Le Maitre et al. 1989). NQ = Naajaat Qaqqaat; Oq = Oqaatsut; APE = Arveprinsen Ejland.*

The K_2O – TiO_2 – P_2O_5 discrimination diagram shows affinity to oceanic basalts for the Arveprinsen Ejland area. The Eqi region has two populations of basalts with one population in each of the fields of oceanic and non-oceanic basalt (Fig. 15) equivalent to the samples with the calc-alkaline trend in the SiO_2 – K_2O diagram (Fig. 14). The few basalt samples north of Torsukattak (Itilli and Naajaat Qaqqaat) plot in the oceanic field of the K_2O – TiO_2 – P_2O_5 discrimination diagram except for one outlier from Naajaat Qaqqaat.

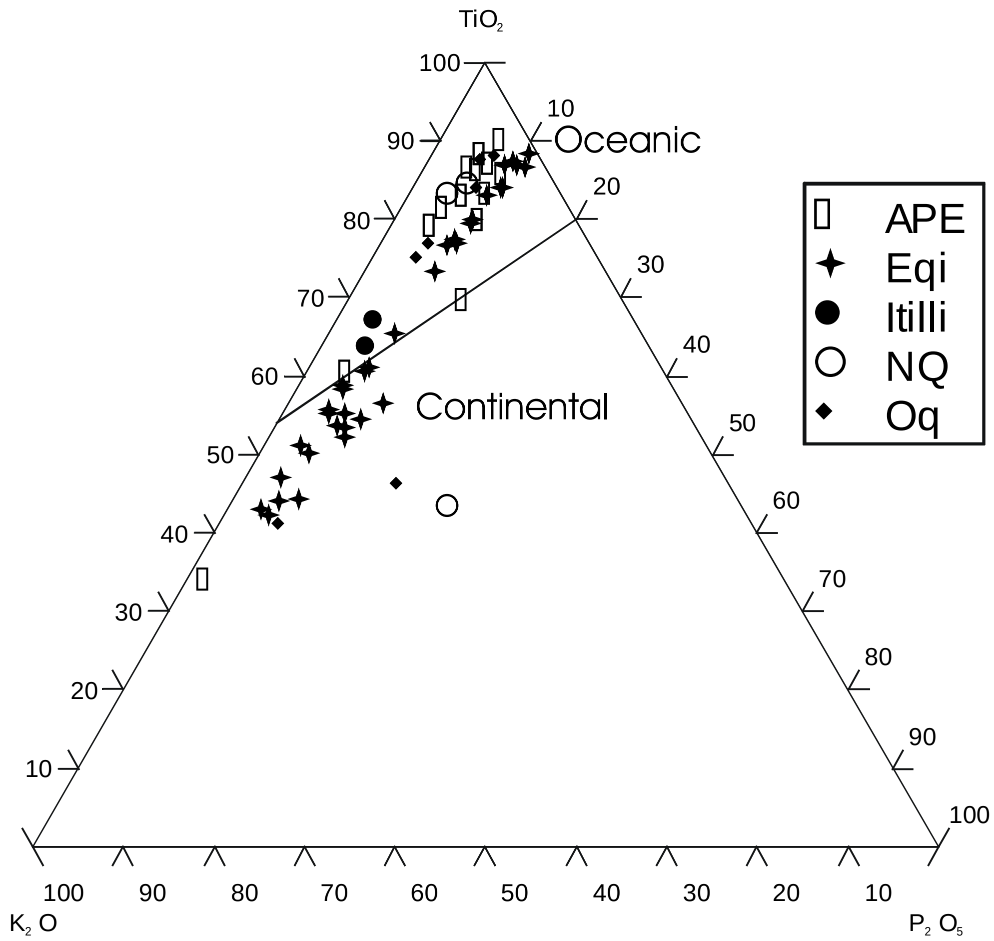

Figure 15. *The K_2O – TiO_2 – P_2O_5 discrimination diagram - after (Pearce et al. 1975). Oceanic basalts (MORB and ocean-island basalts) plots near the TiO_2 apex; non-oceanic basalts plot below the boundary line. NQ = Naajaat Qaqqaat; Oq = Oqaatsut; APE = Arveprinsen Ejland.*

In the Ti-Zr-Y discrimination diagram (Fig. 16) most of the basalt samples plot in the field of MORB, island-arc tholeiites and calc-alkali basalts. In the Ti-Zr diagram (Fig. 17) samples from Arveprinsen Ejland and Oqaatsut are not so uniform as the samples from Eqi.

The mafic sill complex and petrogenetically related mafic volcanic rocks are high-magnesium tholeiites and basaltic komatiites with a continental crust influence (Marshall & Schønwandt 1999).

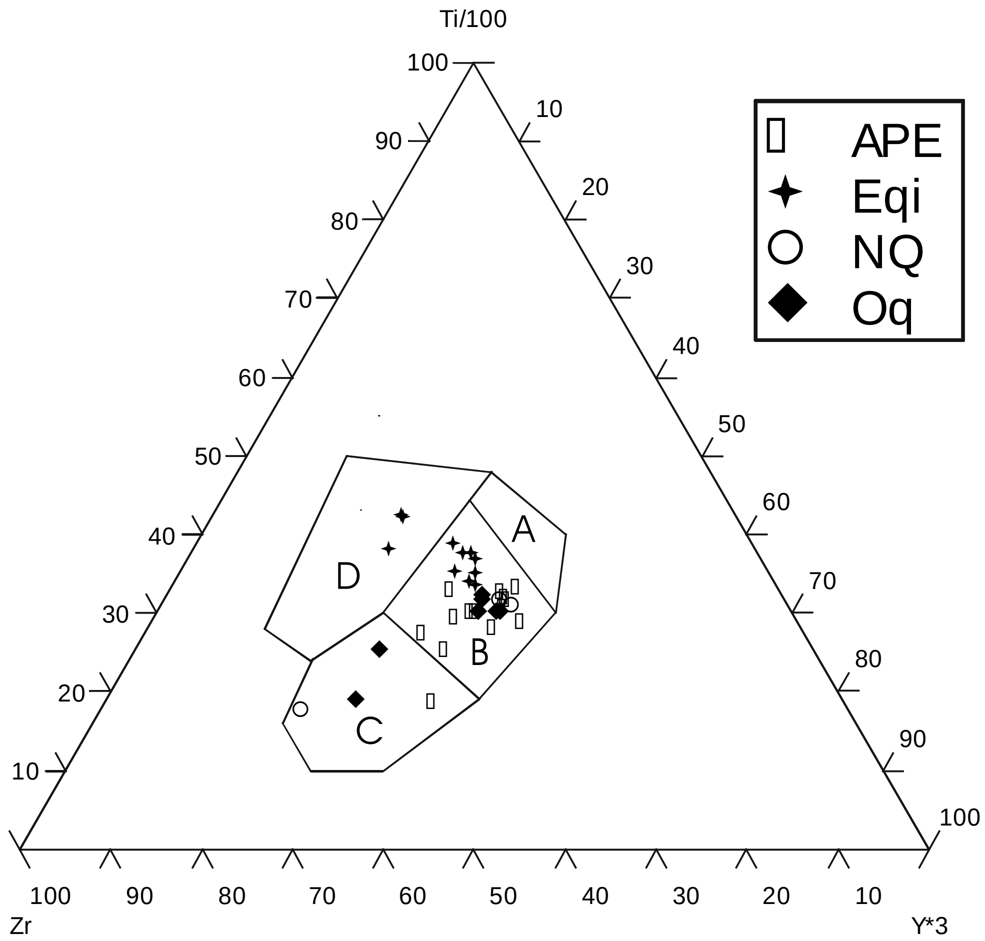

Figure 16. *Zr-Ti-Y discrimination diagram - after (Pearce & Cann 1973). A = Island-arc tholeiites; B = MORB, island-arc tholeiites and calc-alkali basalts; C = calc-alkali basalts; D = within-plate basalts. NQ = Naajaat Qaqqaat; Oq = Oqaatsut; APE = Arveprinsen Ejland.*

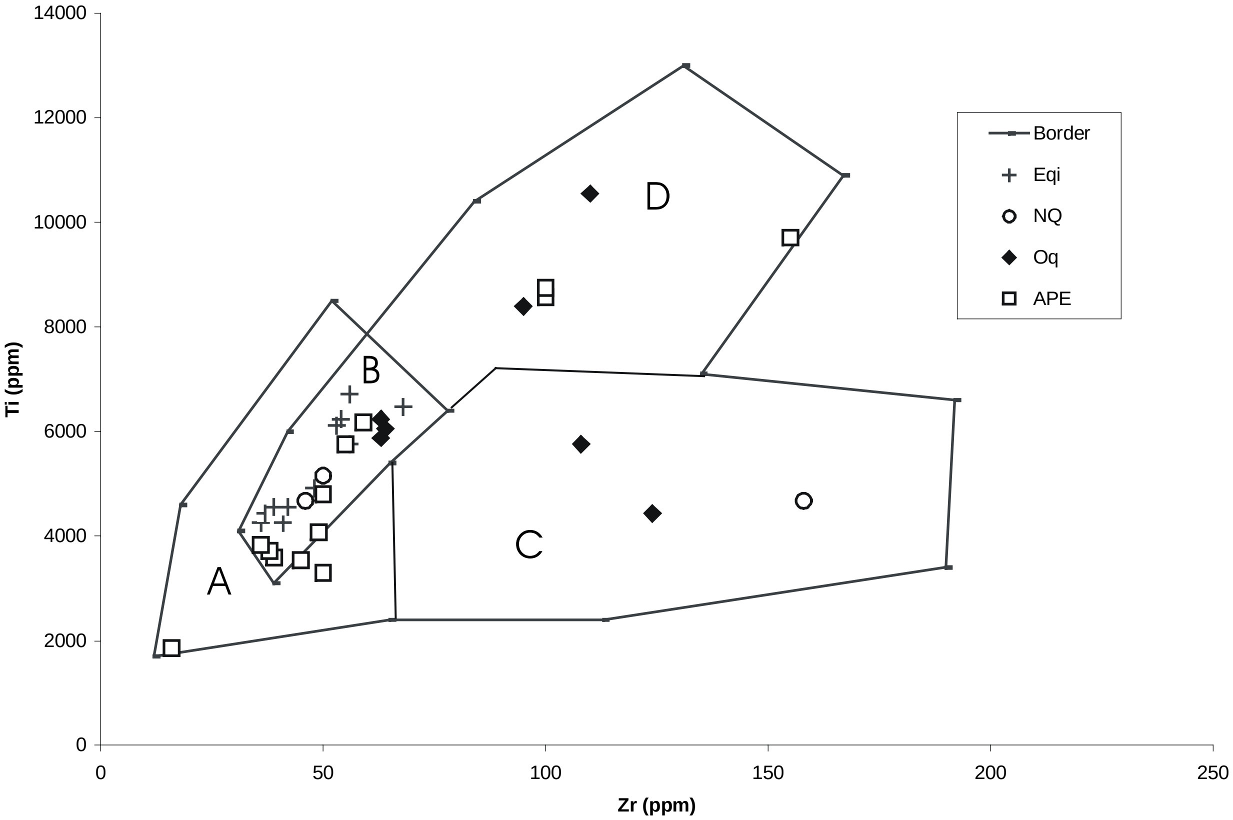

Figure 17. *Discrimination diagram for basalts based upon Ti-Zr variations - field boundaries after (Pearce & Cann 1973). A = Island-arc tholeiites; B = MORB, island-arc tholeiites and calc-alkali basalts; C = calc-alkali basalts; D = within-plate basalts. NQ = Naajaat Qaqqaat; Oq = Oqaatsut; APE = Arveprinsen Ejland.*

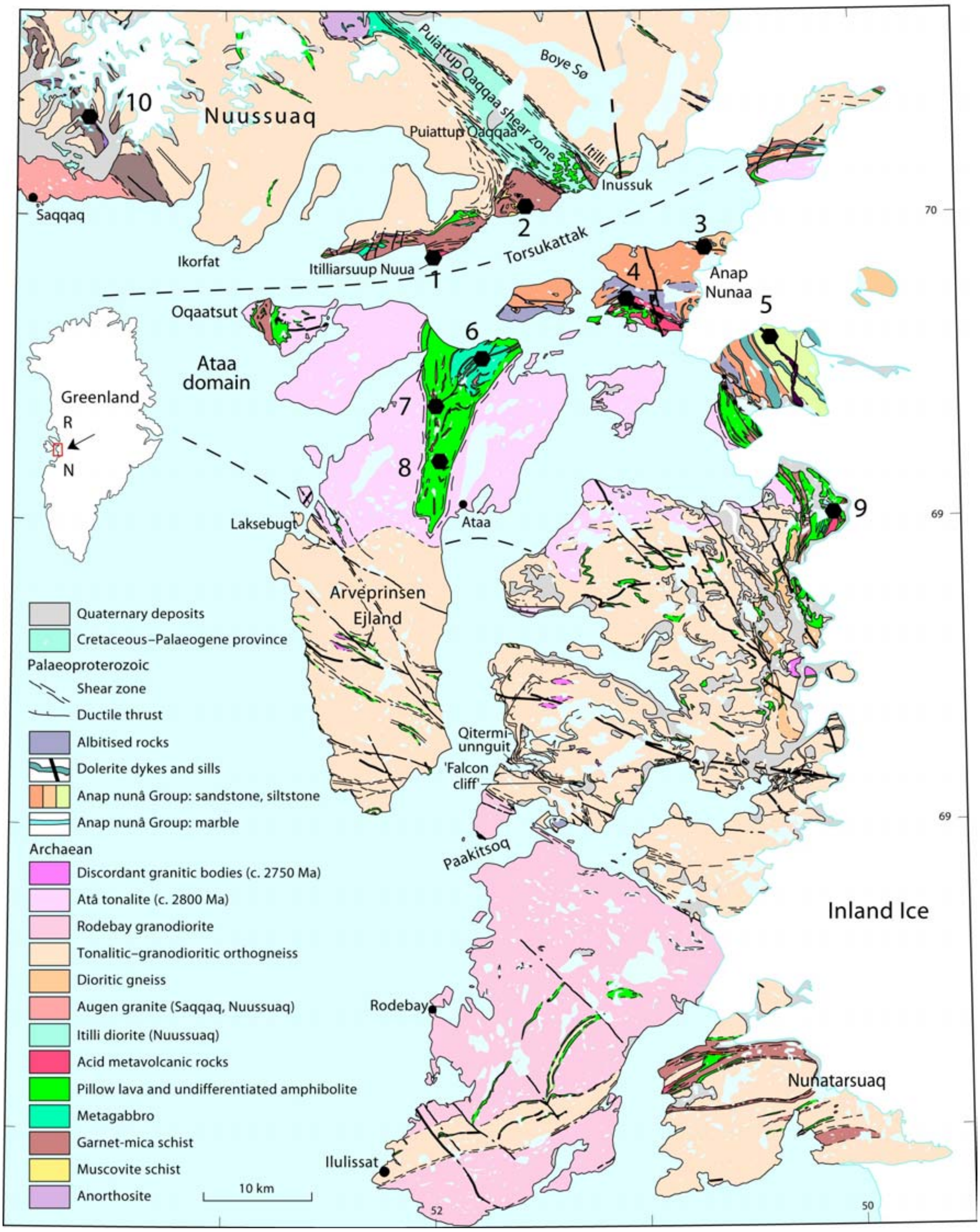

Figure 18. *Mineral occurrence map (black dot) of the northeast Disko Bugt region. 1 = Itilliarsuk; 2 = Itilli; 3 = Anap Nunaa - silicified fracture zone, see Fig. 26; 4 = Anap Nunaa - carbonate zone, see Fig. 12; 5 = Qapiarfiit; 6 = Anderson prospect; 7 & 8 = Iron sulphides at Arveprinsen Ejland; 9 = Eqi; 10 = Saqqaq. The map is modified after (Garde et al. 2002).*

Mineral occurrences

Archaean hosted mineral occurrences

The distribution of the mineral occurrences in the northern Disko Bugt region is shown on Fig. 18 and stratigraphic locations are given in Fig. 4.

Eqi and Arveprinsens Ejland

The majority of mineral occurrences are found in:

- the middle unit of the greenstone succession closely associated with acid volcanic rocks and
- at the boundary between the upper siliciclastic sequence and the greenstone succession.

In the eastern Eqi area (Eqi East) the mineral occurrences are closely related to the rhyolite dome complex (Figs. 6, 7 & 19), at Arveprinsen Ejland the mineral occurrences are bounded to the greenstones. Two types of mineralisation are associated with the complex:

a) Pyrite dominated type, which occurs in a 50-200 m thick transition zone between the massive rhyolitic rocks and the sericite schist (Fig. 20). This mineralisation appears as rusty zones due to disseminated pyrite and locally small lenses of massive to semimassive pyrite, in up to 20 cm thick lenses are often sheared. Composite grab samples of the mineralisation has yielded up to 0.2% Cu and 1 ppm Au.

b) Gold-bearing type, which is associated with a pervasive carbonate alteration, which 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. The carbonatized rocks consist of ankerite, chlorite, green fuchsitic mica and disseminated pyrite (Fig. 21). Locally centimetre-wide quartz veins occur within the carbonate alteration. 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 (Fig. 22) vary between 5 ppb and 60 ppm gold (Stendal *et al.* 1999).

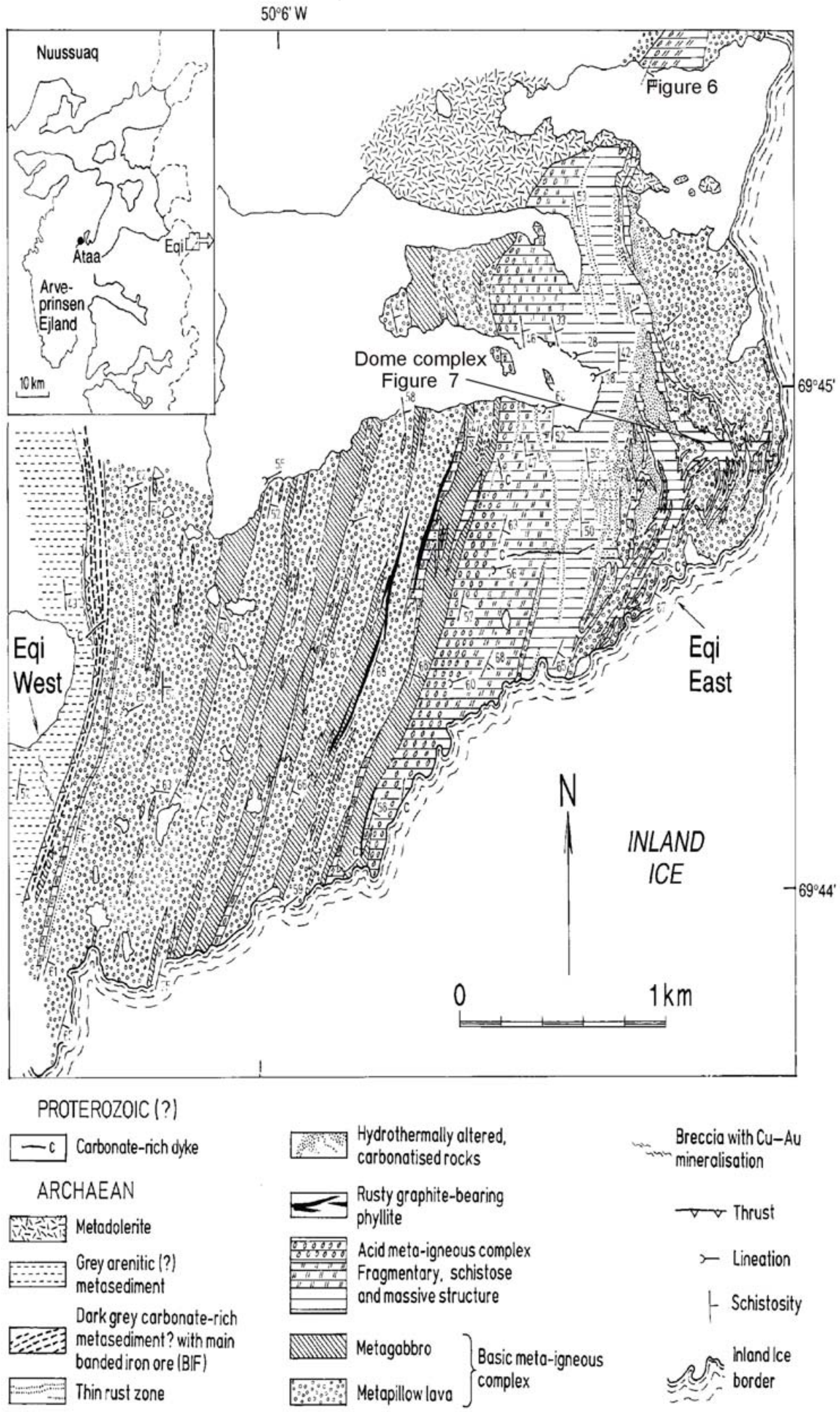

Figure 19. *Geological map of part of the Eqi area - from Stendal et al. (1999).*

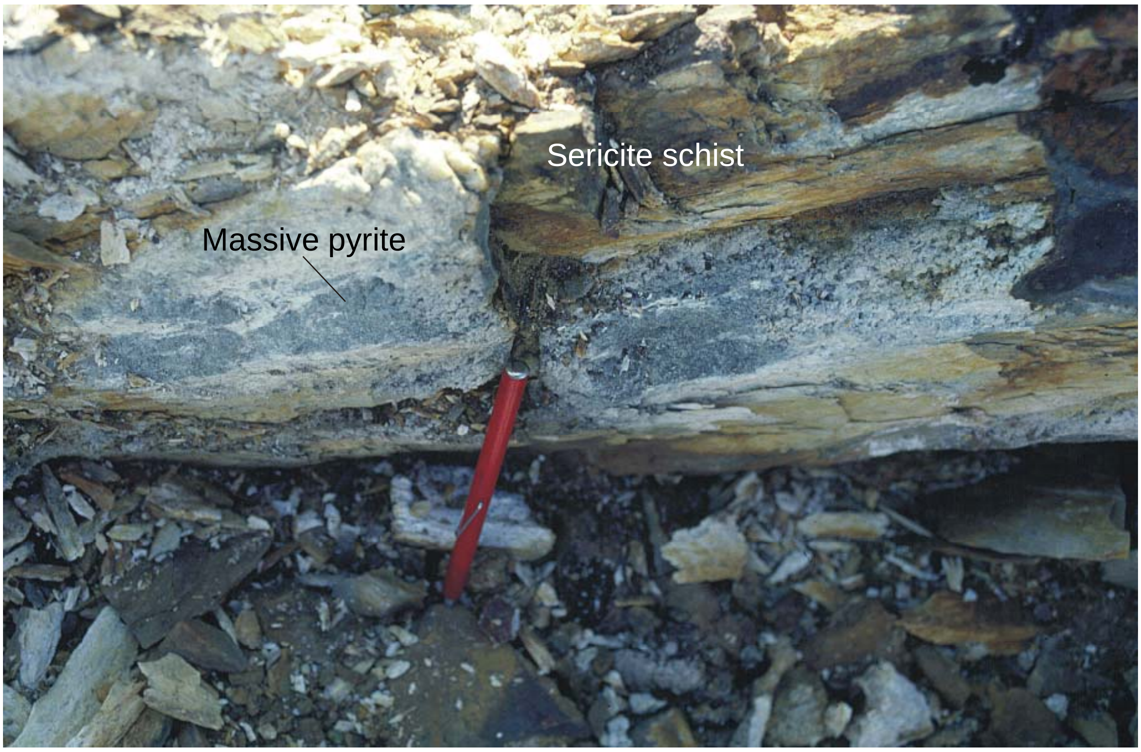

Figure 20. *Semimassive pyrite in sericite schist, Eqi.*

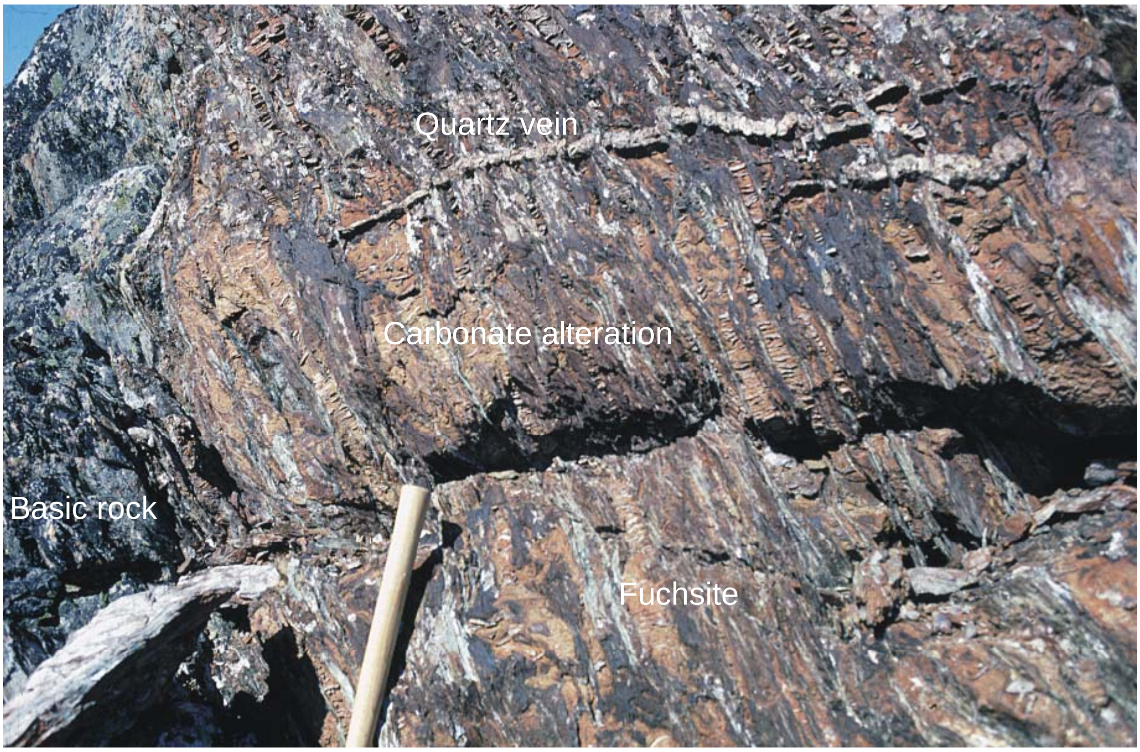

Figure 21. *Hydrothermal carbonate alteration and formation of fuchsite and quartz veins, Eqi.*

On Arveprinsen Ejland mineral occurrences in the middle greenstone succession are associated with interflow sediments and minor ductile shears in greenstones. Sulphide mineralisation associated with the interflow sediments is minor but widespread. The dominant sulphide is pyrite but locally minor chalcopyrite and occasionally sphalerite occur. 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.

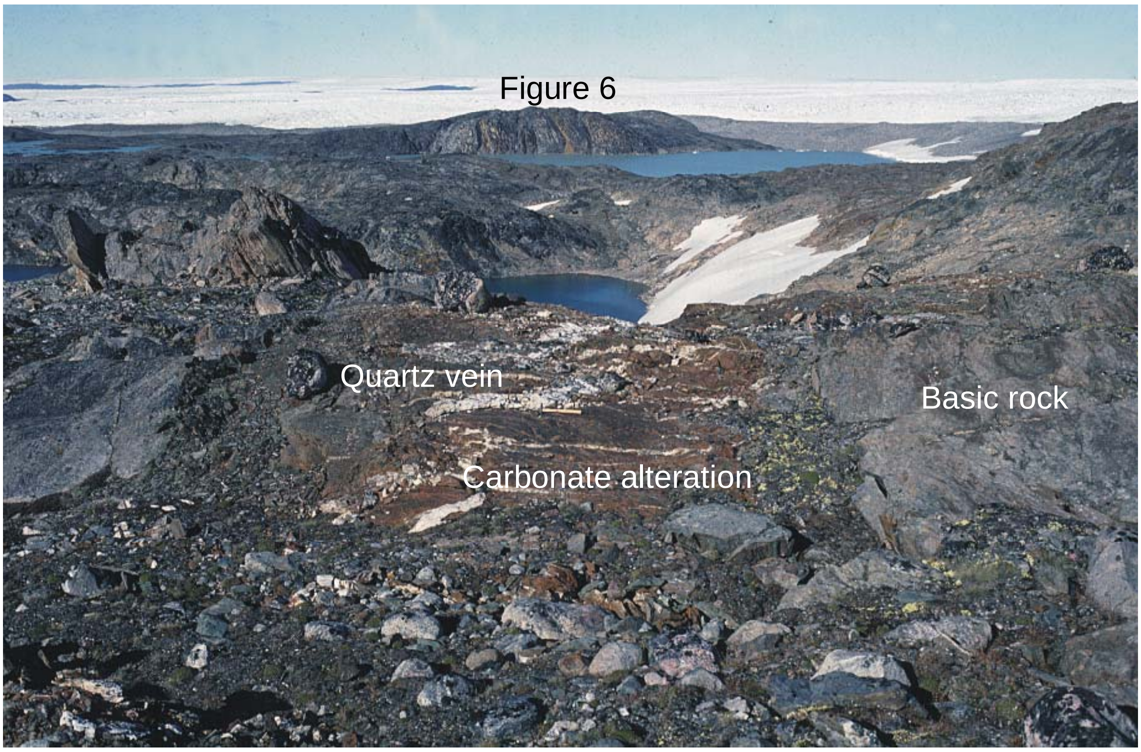

Figure 22. *Quartz veins and carbonate alteration, Eqi.*

Additionally a few mineral occurrences related to shear movements have been found:

a) quartz veins occurring en echelon of which one yielded up to 2.6 ppm Au over 2 m and
b) veinlets of chalcopyrite occurring in a metre wide sheared greenstone returned 2% Cu and 230 ppb Au from a composite grab sample.

The epigenetic mineralisation is not associated with any significant alteration.

In the transition zone between the siliciclastic sequence and the greenstones banded iron formations occur interstratified with both chlorite and quartz-mica schist (e.g. Eqi West, Fig. 19). These stratiform layers are up to one metre thick and traceable for at least 6 km in the Eqi sector. The banded iron formation comprises mm-cm-scale-laminated magnetite and quartz-rich layers. Chlorite forms a significant part of the quartz-rich laminae (up to 40%). Carbonate is a minor component in both the magnetite- and quartz-rich layers. The metal-liferous sediment sequence grades into a succession of carbonate rocks in the northern part of the Eqi area. The sulphide mineralisation is generally hosted in quartz-mica schists but occurs close to the contact between felsic and mafic schists.

In all sectors (Maniitsoq, Eqi, Qingarssuaq, Anap Nunaa, Arveprinsens Ejland and Oqaatsut) the sulphide mineralisation is underlain by the supracrustal sequence as disseminated iron sulphides into massive to semi-massive lenses of pyrite and/or pyrrhotite. Generally these lenses are c. 0.5 m wide and a few metres long, locally they form 'a row of pearls' due to strong deformation e.g. Oqaatsut. Chalcopyrite is sporadic distributed within the sulphide mineralisation, but copper grades are low, however, occasionally composite grab samples yield up to 0.5% Cu. 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 1982).
Other mineral occurrences on Arveprinsens Ejland are widespread pyrite-bearing mainly argillaceous sediments form part of the lower part of the siliciclastic sequence.

Anderson prospect, Arveprinsen Ejland

The Anderson prospect (Figs. 10, 18, 23) 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 sequence comprises of a unit of mafic and felsic tuffs and hyaloclastite which interlayers between 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 (Fig. 23). 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 characterized by veinlets and disseminated specks of sulphides. Pyrrhotite and pyrite dominate the sulphide mineralisation, chalcopyrite and sphalerite and accessory minerals are galena and native bismuth. Chip samples along strike yielded 3.7% Cu, 0.6% Pb, 1% Zn and 0.6 ppm Au over 1.5 m and 0.7% Cu, 0.2% Pb, 3.1% Zn and 85 ppb Au over 1 m from the sulphide lenses on the upper and the lower limbs respectively (Blackwell 1989). Chip sampling of the sulphide halo around the lenses yielded 0.2% Cu, 0.08% Pb, 0.09% Zn and 11 ppb Au over 1.5 m.

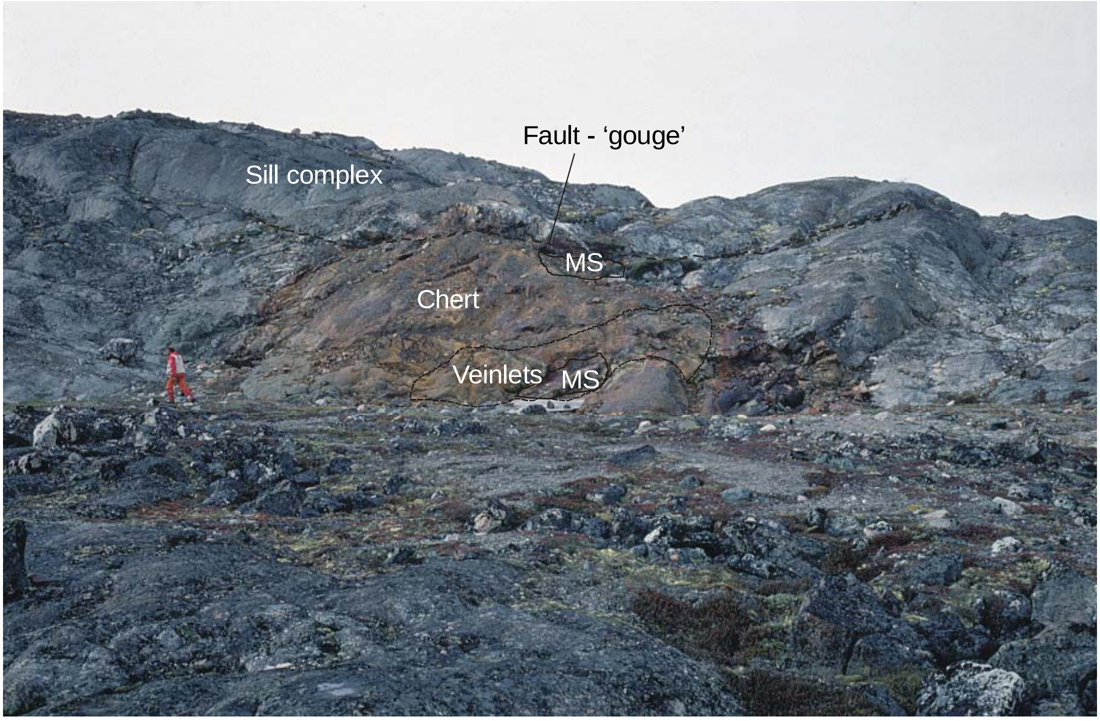

Figure 23. *Anderson prospect, Arveprinsen Ejland with the sulphide occurrence. MS = Massive sulphides.*

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. Locally along the fault zone, minor carbonate quartz veins with pyrite and chalcopyrite occurs. The sulphide lense cut by the fault has been strongly hydrothermally altered to a "sulphide-bearing clay" (gouge up to 1 m thick). Gold content of the gouge varies between 8 - 25 ppm.

Qingarssuaq

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.). Although these strata-bound mineralised sediments in Qingarssuaq and on Arveprinsens Ejland occur in the same general stratigraphic position as the banded iron formations at Eqi, it is difficult to prove if they are a sulphide facies equivalent to the oxide occurrences.

Eqi West prospect

Epigenetic mineralisation in the siliciclastic sequence is related to shear movements at the Eqi West prospect (Figs. 18 & 19; in some literature called Eqip). This epigenetic gold occurrence in this sedimentary sequence has been located by Kryolitselskaber Øresund A/S (Gothenborg & Morthorst 1982; Sotka 1984). The main breccia zone is approximately 100 m long and up to 10 m wide. The zone comprises mica schist and phyllite fragments cemented by calcite, quartz and sulphides. Locally, the sulphides form up to 10% of the breccia. The sulphides occur as veinlets and specks dominated by pyrrhotite, pyrite and chalcopyrite and minor amounts of sphalerite and arsenopyrite. In 1982 the Kryolitselskabet Øresund A/S drilled 12 short holes totalling 487 m. The best 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.

Oqaatsut

In the quartz-biotite schist quartz-magnetite rich rocks were found at two localities as 1-2 m thick layers. They consist of alternating quartz and magnetite laminae a few millimetres to about 1-2 cm wide (Rasmussen & Pedersen 1999). 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).

Saqqaq

An auriferous metachert horizon occurs between a mafic/ultramafic metavolcanic sequence and the overlaying metasedimentary rocks (Garde *et al.* 1999; Thomassen & Tukiainen 1992). The auriferous metachert layer contains a few percent of disseminated iron sulphides with accessory amounts of arsenopyrite and chalcopyrite.

Nunaminerals (2000) described the auriferous metachert horizon as the low angle ‘Saqqaq Shear Zone’. According to this company the ore zone is silicified and chloritized ductile shear zone. Gold values in the range of one ppm over two metres 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).

Naajaat Qaqqaat

Three layers of banded iron formation, each less than one metre thick are located in the lower amphibolitic greenstone unit. They are laminated at 1-5 cm scale, with irregular alternating layers of quartz and magnetite. Quartz bands comprise about 50% of the banded iron formation (Rasmussen & Pedersen 1999).

Itilliarsuk

The sulphide mineralisation at Itilliarsuk has a thickness of about 150-m of mica schist with disseminated pyrrhotite and pyrite (Figs. 4 & 24). In the middle part of the metalliferous sediments several minor lenses of massive to semi-massive pyrrhotite occur spatially related to thin amphibolite layers. 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 gossanous material. This ‘Rust zone’ has until now shown itself 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. Drill-core samples show that the sulphides are pyrrhotite and minor pyrite. One part of the sulphide-rich schist is associated with gold bearing quartz veins with As-Sb sulphosalts. New investigations by Nunaminerals (2000) have revealed gold targets in sulphide-rich schists, quartz veins, and shear zones. The best target is a shear zone that hosts quartz-sericite rock. This rock yields a gold value of 9 ppm over 1,7 m and a strike length of 125 m. The mineralised structure can be traced 500 m along strike. Drill-core samples hit the mineralisation 80 m down dip and returned 0.82 ppm gold over 3.1 m.

Sulphide-bearing metasediments spatially related to outcrops of metagabbro sills. Late faults and second order shears also host gold mineralisation throughout the Itilliarsuk region.

Banded iron formation (Fig. 25) occurs 200 m above the ‘Rust zone'. It is an approximately 200 m thick sequence of centimetre thick magnetite-rich cherty bands alternating with quartz-mica schists. The gradual transition zone between the iron formation and the other 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. The Kryolitselskabet Øresund A/S has estimated that the best mineralised part covering an area of 130x1000 m contains a resource of 150-200 million t of ore grading 20% Fe (Gothenborg & Morthorst 1981).

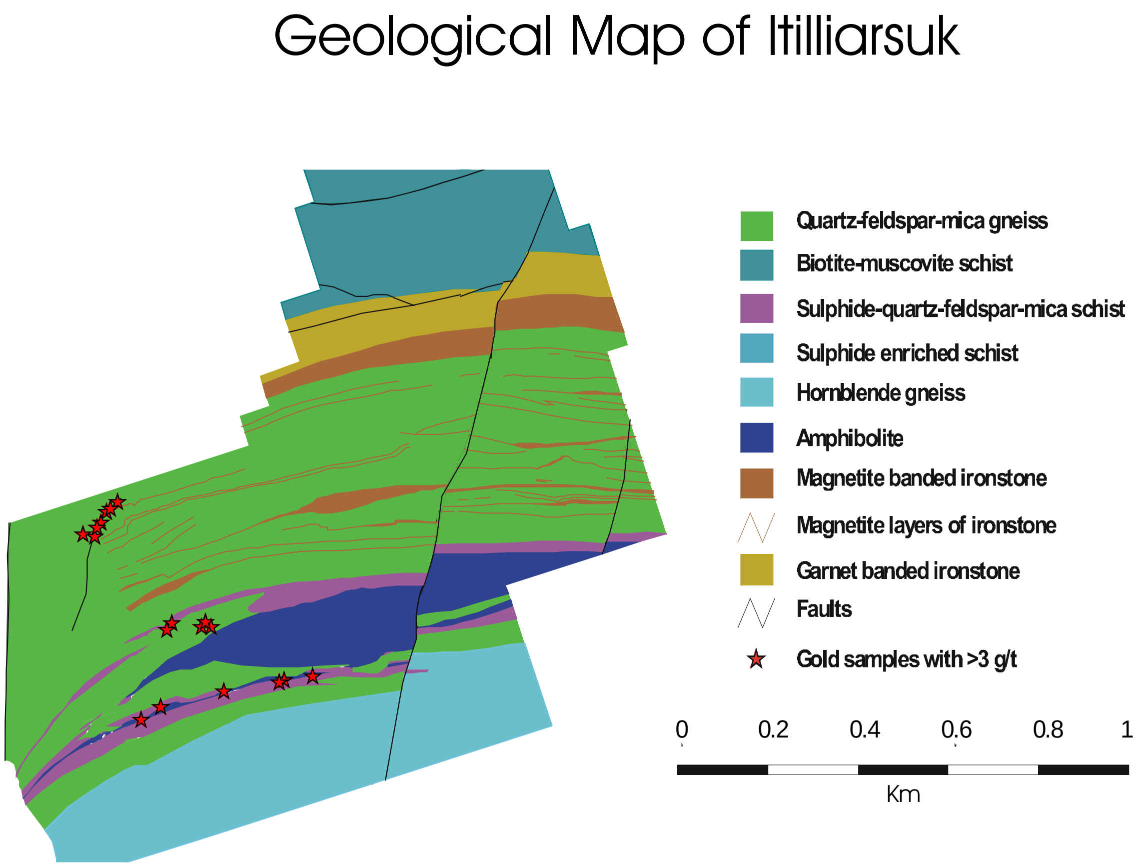

Figure 24. *Geological map of Itilliarsuk - modified from Nunaminerals (2000).*

Figure 25. *Banded iron formation from Itilliarsuk. Photo Nunaminerals A/S.*

Itilli

Syn- and epigenetic sulphide mineralisation is hosted in the 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 from schists to paragneisses. Some of the massive sulphide lenses have a texture indicating that they have been subjected to recrystallization. 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).

Disseminated sulphides hosted in amphibolites occur in close relation to minor shear zones about one metre. The orientation of the shear zones varies. 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.
Veinlets and disseminated sulphides including chalcopyrite occur both in the quartz lenses and the sheared amphibolite. This type of widespread epigenetic copper mineralisation occurs in the southern part of Itilli in an amphibolite unit mainly associated with shear-zones. The best-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).

Shear-zones (up to 25 cm) with a mineral assemblage dominated by nickel-arsenides (e.g. gersdorffite) occur along the boundary between amphibolites and metasediments. The general impression is that the nickel-arsenide-bearing shear-zones are more extensively altered than the chalcopyrite-bearing ones. Quartz lenses in the nickel-arsenide-bearing shear-zones occur as sheared lenses parallel to the fabric, shear-folded lenses and as cross cutting tension gashes indicating both syn- and post-kinematic hydrothermal activity. Analyses of chip samples from this type of shear zones yield values up to 0.3% Cu, 1.3 ppm Au and 1.5% Ni for nickel-arsenide-bearing shear-zones and 0.7 ppm Au for chalcopyrite bearing veins. The rusty metasediments only yielded moderate copper values (up to 560 ppm) and gold below detection limit (<0.2 ppm).

Palaeoproterozoic hosted mineral occurrences

Among mineral occurrences hosted in Palaeoproterozoic rocks of the Disko Bugt area the most interesting occurrence is the sphalerite-galena-pyrite mineralisation (Fig. 3). The occurrence has been found by Greenex A/S in the marbles presumed to belong to the Maarmorilik Formation interleaved in the orthogneisses of central and northern Nuussuaq (Garde & Thomassen 1990; King 1983). The general width of the mineralisation is 20-100 cm yielding between 35-46% Zn and approximately 1% Pb. The sphalerite-galena-pyrite mineralisation is comparable to the ore types of the Black Angel deposit 80-km NE of the Nuussauq occurrences (Garde & Thomassen 1990).

A few up to 10 m wide silicified fracture zones cut across the Palaeoproterozoic sediments e.g. Anap Nunaa. The fault-zones host quartz-carbonate veins with minor pyrite dissemination yielding up to 510 ppm Cu (Thomsen 1991). Higher copper grades occur where the silicified and bleached fractures cut through mafic intrusions (Fig. 26). The same vein type is found on Qapiarfiit as quartz-carbonate veins up to 0.5 m wide and 30 m long. The amount of veins is variable but generally they constitute about a half per cent of the intrusive body. 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. Chip samples over 1 m yielded up to 90 ppb Au. Sulphide-bearing grab samples gave up to 1.8% Cu (Gothenborg & Morthorst 1982).

Figure 26. *Quartz carbonate veins in metagabbro, Anap Nunaa. The same type can be found at Qapiarfiit.*

A minor copper mineralisation on Anap Nunaa is hosted in the carbonate unit above the basal quartzite. The bedded carbonate is cut by an approximately 15 m wide breccia zone, which presumably is related to minor tectonic movements (Fig. 12). The breccia zone contains of up to ten metres thick limestone, which partly is dolomitised and brecciated. Disseminated chalcopyrite and pyrite occur together with quartz and secondary sparry calcite in the matrix. The sulphides constitute less than 1% of the breccia-zone and botroyidal textures occur locally as up to few centimetres across. Sulphide-bearing grab samples yielded up to 0.56 %Cu (Gothenborg & Morthorst 1981) and 600 ppb gold (Blackwell 1989).

The most pronounced hydrothermal alteration found in is at a regional pervasive albitisation (Fig. 10), which has mainly affected the lower part of the siliciclastic sequence (Kalsbeek 1992). The albitisation post-dates the regional Proterozoic deformation. Locally the albitisation seems to have penetrated laterally from fractures hosting carbonate veins. Albitisation is elsewhere known to be related to ore deposits e.g. (Ettner *et al.* 1993). However, the only sulphide mineral related to the albitisation here seems to be accessory disseminated pyrite. Chip sampling of pyrite-bearing rocks yielded up 220 ppm Co and 18 ppb Au (Thomsen 1991).

Radiogenic isotopic signatures

A review of radiogenic isotope data (Pb-Pb, Rb-Sr, Sm-Nd) of whole-rock samples is given by Kalsbeek and Taylor (1999). Some Pb-Pb work has been carried out on sulphide separates (mainly pyrite) from mineralisation in the Disko Bugt region (Stendal 1998). The felsic volcanic rocks at Eqi have a Pb-Pb isotopic composition with a low μ_1 value of 7.26 and a model age of 2821 +77/-82 Ma (Stendal 1998). Sm-Nd whole-rock data for the acid metavolcanics within the Archaean supracrustal sequences yield ages of c. 2800 Ma (Kalsbeek & Taylor 1999). This is within error similar in age as the Atâ tonalite and the emplacement of a younger granite yielding 2758$\pm$2 Ma (Nutman & Kalsbeek 1999). The Pb-Pb isotopic study of Stendal (1998) confirmed two mineralisation stages in the Archaean, a syngenetic and at least one epigenetic ore. Furthermore, Stendal (1998) concluded that the individual gold mineralisation has its own Pb isotope signature.

The Pb-Pb isotopic composition of the sulphides of the Palaeoproterozoic rocks form a well-defined linear trend with a primitive composition (low μ_1 value = 8.05) and a model age of 1903 +84/-89 Ma. There is a distinct difference within the region concerning sulphides from quartzites and marbles. This difference is in $^{208}Pb/^{204}Pb$ - $^{206}Pb/^{204}Pb$ arrays where a non-radiogenic signature is dominating for the samples from Nuussuaq compared to the rest of the Disko Bugt area (Stendal 1998). Sulphides from the albitised rocks from Anap Nunaa have Pb signatures, which coincide with the general metamorphic peak of the region. However, the albitisation took place hundreds of millions of years after the peak of Palaeoproterozoic orogenic activity (Kalsbeek and Taylor 1999), which was c. 1850 Ma (Kalsbeek *et al.* 1984; Taylor & Kalsbeek 1990).

Discussion

Geology

Primary setting

The supracrustal rocks in the areas south of Torsukattak are inferred to be intruded by the 2800 Ma old Atâ granitoids (Kalsbeek & Taylor 1999; Kalsbeek & Skjernaa 1999; Kalsbeek *et al.* 1988). The supracrustal rocks north of Torsukattak are presumably intruded by precursors to orthogneisses of supposed Archaean age.

The five areas of Archaean supracrustal rocks south of Torsukattak seem to have common lithological features, which allow a provisional lithostratigraphic correlation between the areas to be established. Each group of supracrustal rocks consists of a mixed igneous and sedimentary sequence, which was deformed and metamorphosed under greenschist to amphibolite facies conditions. The supracrustal rocks north and south of Torsukattak have certain similarities but differ from each other in especially two points. These points are (1) the much more common presence of ultrabasic, probably mainly metavolcanic rocks in the lower part of the sequence north of Torsuttak. (2) The much thicker units of clastic metasediments in the upper part of the northern sequence compared to the region south of the fjord (Garde & Steenfelt 1999a). The structural development includes early tight to isoclinal folding and thrusting of which at least part of the thrusting that post dates the Atâ granitoids. Later part of the supracrustal rocks was refolded into open folds or warped (Garde & Steenfelt 1999a).

The siliciclastic sequence represents a major change in the evolution of the geological environment from dominating deposition of basaltic material to an environment dominated by felsic volcano-clastic sedimentation (e.g. Eqi West, Figs. 18 & 19). There is a gradational transition from the greenstone succession into the siliciclastic sequence over a section of a few hundred metres. The transition zone is characterised by interbedded quartz-mica schist, chlorite schist, phyllites and arenitic sediments locally with chert and carbonates. The felsic and mafic schists probably represent rhyolitic and basaltic tuffs respectively.

Generally the metamorphism has reached the amphibolite facies (staurolite zone) with kyanite, staurolite and garnet developed in metapelites. The grade of metamorphism is therefore generally higher than is the case for the area south of Torsukattak.

The non- to low metamorphic Palaeoproterozoic Anap nunâ Group is unconformably deposited on the Archaean supracrustal rocks both north and south of Torssukattak. These rocks comprise shallow water sediments in the lower part of the sequence and an upper part dominated by a turbidite succession.

Geochemical signatures

The lithogeochemistry also gives some indications of the geological setting. The reason for the variation in the chemistry of the rocks from the Eqi area should be found in the extensive hydrothermal alteration of this area compared to e.g. Arveprinsen Ejland but the samples are still within the geochemical constraints to be used in the diagrams. K_2O might have been mobile during this hydrothermal activity as well as during metamorphism (Figs. 13 & 14). The volcanic sequence (Eqi, Arveprinsen Ejland and Oqaatsut) 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. On Arveprinsen Ejland the sub-alkalic sill complex and the petrogenetically related mafic lavas and tuffs are high-magnesium tholeiites and basaltic komatiites whereas the felsic rocks are calc-alkaline rhyolites and dacites (Marshall & Schønwandt 1999). The tectonomagmatic environment suggests an ensialic arc-related setting for the sill complex and the mafic and felsic volcanic rocks (Marshall & Schønwandt 1999).

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.* 1999). The intercalation of siliciclastic sediments in the upper parts of the sequence represents a basin with infill of epiclastic sediments. The dominantly tholeiitic nature of the mafic volcanic rocks and the sill complex in the Eqi – Arveprinsen Ejland belt is typical of most Archaean greenstone belts (e.g. (Condie 1990).

The geotectonic setting of the Archaean supracrustal rocks of the area north of Torskattak represent an environment with more metasediments intercalated in the volcanic sequences than in the island arc setting towards south (Garde & Steenfelt 1999a). The basic volcanics (mainly basalts) from Naajaat Qaqqaat (Rasmussen & Pedersen 1999) and Itilli have a Mg- and Fe-rich tholeiitic and komatiitic composition, together with minor intercalations of banded iron formations and rocks of detrital sedimentary origin. Geochemical data from Naajaat Qaqqaat suggest that parts of the succession were deposited in an ocean floor environment. The presence of a polymict conglomerate at base of the Naajaat Qaqqaat sequence suggests that at least in the initial rifting of an older Craton and the creation of a continental margin basin (Rasmussen & Pedersen 1999). The similarities in geochemistry, stratigraphy and structural style suggests that the supracrustal sequences at Oqaatsut and Naajaat are very closely correlated (Rasmussen & Pedersen 1999).

Mineralisation

Archaean

Different types of mineral occurrences are distinguished in the Archaean supracrustal rocks of the Disko Bugt area such as – (a) massive sulphides, (b) iron formation, and (c) epigenetic gold.

(a) Massive sulphide occurrences are scattered throughout the supracrustal sequence at two main levels south of Torsukakttak:. Firstly, in the middle unit of the greenstone succession closely associated with acid volcanics (e.g. Eqi East). Secondly, in the lower part of the siliciclastic sequence close to the boundary to the greenstone succession (e.g. Anderson prospect and Eqi West). The base metal mineralisation comprises semi- to massive sulphides with copper associated with small amounts of Zn, and at a few sites Pb is present as well. The rhyolitic to dacitic volcanic rocks associated with tholeiitic suites of basalts is a favourable environment for massive sulphide (Cu-Zn) ore. The stratiform pyrite and pyrrhotite sulphide horizons show no alteration halos and metal zonation is absent. This may be due to 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.

North of Torsukattak the sulphidic schist at Itilliarsuk (the 'Rust zone') contains layers and lenses of deeply weathered gossanous material. Drill-cores show fresh parts with up to 30 % combined pyrrhotite and pyrite.

(b) Iron formation is located at different levels in the volcanic sequence. In the central and southern part of the Eqi area siliceous iron formation is located in three horizons at the lowermost part of the metasedimentary sequence. Such thin horizons of siliceous iron formation normally found in greenstone belts are overlying the massive sulphide deposits (Franklin 1993). The banded iron formation at Itilliarsuk is by far the largest magnetite deposit in the Disko Bugt area. This is a banded iron formation sensu stricto and might be comparable to Algoma type BIF (Gross 1995).

(d) *Epigenetic gold* is found in different geological settings. Mesothermal gold at Eqi East is discussed by Stendal et al. (1999) who concluded that the gold mineralisation is formed in an island arc environment in four steps:

(1) syngenetic gold in the massive sulphides,
(2) pervasive mineralisation during carbonate alteration,
(3) remobilisation of gold into quartz veins, and
(4) metamorphic remobilisation during the Palaeoproterozoic.

The pervasive gold mineralisation was caused by hydrothermal leaching and carbonate alteration of the rock pile related to acid igneous activity. During the formation of late quartz veins gold was remobilised and deposited with these together with iron sulphides. This gold occurrence at Eqi is similar to gold mines in the Abitibi greenstone belt, especially in the Timmins area e.g. the 'Dome-type' deposit (Hodgson 1986; Hodgson *et al.* 1982).

A second gold mineralisation at Eqi West is located 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. At Itilliarsuk the sulphide-rich zone is associated with amphibolite and gold bearing quartz veins with As-Sb sulphosalts, which are formed in shear zones. Other epigenetic mineralisation is widespread in the area in shear- and breccia-zones. The occurrences are all very small with pyrite and copper as the main constituents, but locally also As, Ni, Co and Au are found. It is not possible to see whether these shear- and breccia-zones are of Archaean or Palaeoproterozoic age.

A third type of gold mineralisation is the stratiform type of exhalative origin (e.g. Saqqaq) as interpreted by Thomassen and Tukianinen (1992) and Garde *et al.* (1999). However, the mining company Nunaminerals A/S is of the opinion that the gold is related to shear zones (Nunaminerals 2000).

Palaeoproterozoic

The most pronounced hydrothermal alteration is a regional pervasive albitisation which has mainly affected the lower part of the Archaean siliciclastic sequence (Kalsbeek 1992; Ryan & Escher 1999). The albitisation post-dates the regional Palaeoproterozoic deformation. Mineralisation in the Palaeoproterozoic supracrustal rocks is scarce and no occurrences of economic interest have been located. However, quartz-carbonate veins are common in shear – and fault zones through Palaeoproterozoic basic dikes.

Mineralising events

The preliminary conclusions of the Pb-Pb isotope investigation of pyrite described in a previous section confirmed two stages of mineralising events forming mineral occurrences in the Archaean and Palaeoproterozoic respectively (Stendal 1998). The semi-massive sulphides represent a syngenetic stage yielding c. 2.8 Ga in age. Epigenetic mineral fluids form the gold-bearing sulphide in the Eqi area. These mineral separates have the same Pb isotopic signature as the local host rocks, but no common event for the gold mineralisation of the region can be outlined. The Anderson and Eqi West prospects, have their own unique Pb-Pb isotope patterns. The Anderson prospect has an overprinted signature of Palaeoproterozoic age. The Eqi West prospect has its own Pb-isotopic signature with no defined isochron, thus an age is not possible to establish. Stendal (1998) concluded that the paragenetic evolution in the Eqi West prospect deduced from Pb-Pb ratios of two samples indicate at least two mineralising events with mixed fluids from different lead reservoirs.

The epigenetic fault zones and shear zones with sulphides hosted in the Palaeoproterozoic supracrustal rocks have model ages of c. 1900 Ma. This is an important mineralising event for small occurrences of base metals, nickel and gold. The age is comparable within errors with Pb-Pb isotope ratios obtained by Taylor and Kalsbeek (1990), which yield whole-rock isochrons of 1881±20 Ma thought to represent the age of metamorphic recrystallisation of the marbles north of the Disko Bugt region. These events is comparable with the peak of orogenic activity in the Nagssugtoqidian and Rinkian mobile belst c. 1850 Ma (Kalsbeek *et al.* 1984; Taylor & Kalsbeek 1990). Locally albitisation seems to have penetrated laterally from fractures hosting carbonate veins. Albitisation is known to be a good indication for mineral deposits such as Cu-Au mineralisation (e.g. (Ettner *et al.* 1993). Unfortunately, no major mineral occurrences in the Disk Bugt area are related to this extensive hydrothermal activity. The only exception is some accessory disseminated pyrite.

Stendal (1998) argued that the albitisation took place at the same time as the peak metamorphism due to the Pb-Pb signature of sulphide separates from the albitised rocks. According to Kalsbeek and Taylor (1999) this is not correct. Rb-Sr data for albitised siltstones indicating that albitisation took place hundreds of millions after the peak of the Palaeoproterozoic orogenic activity. It is not known if the hydrothermal alteration process is younger or older than the intrusion of the lamprophyres and lamproites at c. 1750 Ma. However, Kalsbeek and Taylor (1999) propose that the igneous event registered by the 1645 Ma basic dykes in the eastern part of the region might have triggered the hydrothermal activity that gave rise to a late phase of albitisation. The dykes themselves, however, appear to be totally unaffected (Kalsbeek & Taylor 1999).

K-Ar and ^{40}Ar-^{39}Ar mineral age investigations suggest that the Palaeoproterozoic tectono-thermal activity in the Archaean basement took place in two steps. The first step took place at 1950-1925 Ma and the second around 1750 Ma (Rasmussen & Holm 1999). The second step might coincide with the intrusion of lamprophyres and lamproites. This latter tectono-thermal event has not led to any recognisable mineral formation. The mineralising event comprising the epigenetic occurrences related to fault and shear zones in the Palaeoproterozoic is either related to the tectono-thermal event at 1950-1925 Ma or to the orogenic activity c. 1850 Ma.

Mineral potential and similarities with the Abitibi greenstone belt

The 2800 Ma Disko Bugt greenstone belt and the 2700 Ma Abitibi greenstone belt have many similarities concerning their mineral occurrences. The Abitibi belt has produced more gold than any other Archaean greenstone belt (Cameron 1993) and in addition major massive sulphide deposits are common. Stendal et al. (1999) describe the Eqi East gold prospect as similar in many respects to gold occurrences in the Abitibi greenstone belt, especially the Dome Mine (‘Dome-type’) in the Timmins area (Hodgson 1986; Moritz & Crocket 1991). However, there are major differences between the mineral potentials of the two areas. First of all, the Abitibi greenstone belt comprises about 65.000 km^2 of Archaean supracrustal rocks – mainly volcanics – and syn- to post tectonic granitoids, and the estimated aggregate thickness is 40 km (Hodgson 1993). This is at least ten times thicker than the greenstone belt in the Disko Bugt area. The size of the greenstone exposures is several hundred times lesser in Greenland. The age of the Disko Bugt greenstones south of Torsukattak is approximately 100 Ma older than the Abitibi belt. No data of the age of the supracrustal rocks north of Torsukattak are available. This latter fact might be significant in older greenstone sequences the chance for massive sulphide deposits are lesser and the deposits smaller. The most prolific period of VMS mineralisation in terms of number of deposits are Late Archaean (2750-2700 Ma) and the Palaeoproterozoic (1900-1800 Ma) as the so-called bimodal-mafic type (Barrie & Hannington 1999). The bimodal-mafic type is defined as having >50% mafic rocks and >3% felsic rocks in the host stratigraphic succession, with subordinate siliciclastic rocks. According to (Sawkins 1990) old greenstone successions (more than 3 Ga) do not carry huge massive sulphide deposits. However, gold will be present in all greenstone belts independent of the age.

Volcanogenic massive sulphide deposits in the Abitibi belt are preferentially associated with volcanic successions containing >150 m thickness of felsic volcanic rocks in volcanic terrains with bimodal, tholeiitic basalts and high-silica rhyolites or with bimodal, transitional tholeiitic to calc-alkalic andesite and rhyolite (Barrie *et al.* 1993). Similar settings but with much smaller dimensions occur both on Arveprinsen Ejland and at Eqi-Maniitsoq, where small occurrences of massive sulphides are known. The potential to find an economic massive sulphide deposit in the Disko Bugt region is present, but the size might be small due to the relative small volume of volcanic rocks.

The geological setting of the mesothermal gold occurrence at the Eqi East with major ankerite alteration, fuchsite and quartz veining is similar to several deposits in the Abitibi greenstone belt. This indicates that the Disko Bugt region has the right environment for formation of mesothermal gold occurrences. The small volume of the greenstone succession might again be a disadvantage.

The stratiform metachert horizon at Saqqaq hosts a good candidate for a potential gold deposit– and massive sulphide mineralisation. Gold-bearing massive sulphide deposits associated with rhyolitic breccias as found at Eqi West are also well known from the Abitibi greenstone belt e.g. Noranda area (Kerr & Gibson 1993; Larocque *et al.* 1993).

Conclusions

- Archaean supracrustal rocks and c. 2800 Ma granitoid plutons are part of the Disko Craton in the northeastern part of Disko Bugt region. The Disko Craton is influenced by Palaeoproterozoic orogenic activity with peak metamorphism around 1900 Ma. Palaeoproterozoic sediments unconformably overlie the Archaean rocks.
- The Archaean supracrustal rocks south of Torsukattak are formed in an island-arc environment and north of Torsukattak the environment belongs to back-arc setting with an the initial rifting of an older Craton and the creation of a continental margin basin. One major difference between the two areas is that the supracrustal rocks of the northern part have ultrabasic rocks and more clastic sediments compared to the southern part.
- The main mineral occurrence types are:

(a) Archaean iron formation forms layers of both banded iron formations (BIF) s. and mixed oxide and sulphide horizons within the greenstone-dominated successions.

(b) Semi-massive pyrite occurs as fine-grained pyrite in centimetre to decimetre-thick massive layers with quartz (e.g. Eqi East and Arveprinsen Ejland).

(c) Massive pyrrhotite (e.g. Saqqaq) occurs within chemical sediments in several beds as stratiform quartz/chert and massive-sulphide layers. These pyrrhotite-mineralised horizons are associated with chalcopyrite and gold. The beds can be followed over 15-20 km continuos strike lengths.

(d) Gold mineralisation is hosted in the c. 2800 Ma old basic-acid succession at Eqi. The deposition of gold took place in several steps: (1) syngenetic gold in the massive sulphides, (2) pervasive mineralisation during carbonate alteration, (3) remobilisation of gold into quartz veins, and (4) metamorphic remobilisation during the Palaeoproterozoic.

(e) A pronounced regional albitization post-dates the regional Palaeoproterozoic deformation but has no related mineral occurrences.

- The Archaean rhyolitic to dacitic volcanics associated with tholeiitic suites of basalts is a favourable environment for massive sulphide (Cu-Zn) ores especially in the Eqi-Maniitsoq area. The potential to find an economic massive sulphide deposit in the Disko Bugt region is present, but the size might be small due to the relative small volume of volcanic rocks.
- The best potential for gold occurrences occurs in the Eqi area, Itilliarsuk, and Saqqaq. The Disko Bugt region has the right environment for formation of mesothermal gold occurrences but the small volume of the greenstone succession might again be a disadvantage. The stratiform metachert horizon at Saqqaq hosts a good candidate for a potential gold deposit– and possibly massive sulphide mineralisation.
- Pb-Pb isotopic compositions confirm two major episodes of mineralising events. The first one is syngenetic massive sulphides in the greenstone succession (~2800 Ma); the second episode is contemporaneous with the regional peak metamorphism in the region (1900-1850 Ma).
- The geological setting, geochemistry and formation of mineral occurrences in the Disko Bugt region have many similarities with the Abitibi greenstone belt in Canada.

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