# The mineral resource potential of the Nordre Strømfjord – Qasigiannguit region, southern and central West Greenland

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Assessment of the mineral resource potential of the region between Sukkertoppen Iskappe and the southern part of Nuussuaq, West Greenland (66°N to 70°15´N; Fig. 1) is part of a regional resource assessment programme of the Geological Survey of Denmark and Greenland (GEUS) for 2000–2003. The year 2000 was dedicated to the compilation of existing data and the outlining of target areas for the field work in 2001 and 2002. This report gives a review of the work related to the gold and base metal potential in the Nordre Strømfjord – Qasigiannguit region, mainly based on results from the 2001 field work.

Significant geological data have been collected from the region by the Survey, research groups and exploration companies during the past several decades; see Kalsbeek & Nutman (1996), Connelly & Mengel (2000) and van Gool *et al.* (2002, this volume) for geology, Steenfelt (2001) for geochemistry and Rasmussen & van Gool (2000) and Nielsen & Rasmussen (2002, this volume) for geophysics. Most of the region is easy of access, and exposures are excellent along the shores of the numerous fjords. However, inland areas may locally have extensive Quaternary cover.

The target areas (Fig. 2) for the search for mineral occurrences in 2001 were chosen on the basis of compilations of all types of existing data, including the *Ujarassiorit* (‘public mineral hunt’) programme (e.g. Roos 1998).

## Previous exploration

Exploration companies have been active in different parts of the region since 1960. Kryolitselskabet Øresund A/S conducted mineral exploration and prospecting from the early 1960s until the late 1970s, with particular emphasis on investigations of rust zones (Keto 1963; Vaasjoki 1964, 1965; Kurki 1965a, b; Gothenborg 1980; Gothenborg & Keto 1980). During the geological mapping for the Survey’s 1:100 000 Agto (= Attu) map sheet between 1965 and 1978, discontinuous, stratiform massive iron sulphide mineralisations were found in supracrustal rocks around the fjord Ataneq (Fig. 2; Platou 1967). Nunaoil A/S prospecting in the Agto map sheet area during the early 1990s included helicopter-based regional heavy mineral concentrate and stream sediment sampling that was followed up in selected areas by further investigations (Geyti & Pedersen 1991; Gowen 1992; Sieborg 1992; Grahl-Madsen 1993, 1994). The main target of their investigations was location of base and noble metal deposits in exhalative settings. Later in the 1990s, RTZ Mining and Exploration Ltd (Coppard 1995) and Inco Ltd (Car 1997) prospected for Ni-Cu and PGM deposits, inspired by the spectacular discoveries in rocks of comparable age at Voisey’s Bay, Labrador (Li & Naldrett 1999).

## Geological setting

The study region comprises parts of the Palaeoproterozoic Rinkian mobile belt and Nagssugtoqidian orogenic belt (van Gool *et al.* 2002, this volume). The 2001 investigations were concentrated in the northern Nagssugtoqidian orogen (NNO), which consists dominantly of Archaean orthogneisses and paragneisses with several thin belts of supracrustal and intrusive rocks. Granitic rocks and numerous pegmatites intrude the gneisses. Palaeoproterozoic rock units are limited to the Arfersiorfik intrusive suite and minor supracrustal sequences (Connelly & Mengel 2000).

Metamorphic grade is mainly amphibolite facies; the southern part of the NNO south of Ataneq (Fig. 1) is in granulite facies, as is most of the central Nagssugtoqidian orogen (CNO). The gneisses are intensely folded and exhibit general E–W and NE–SW trends. The Palaeoproterozoic reworking of the Archaean gneisses in the NNO decreases gradually northwards,

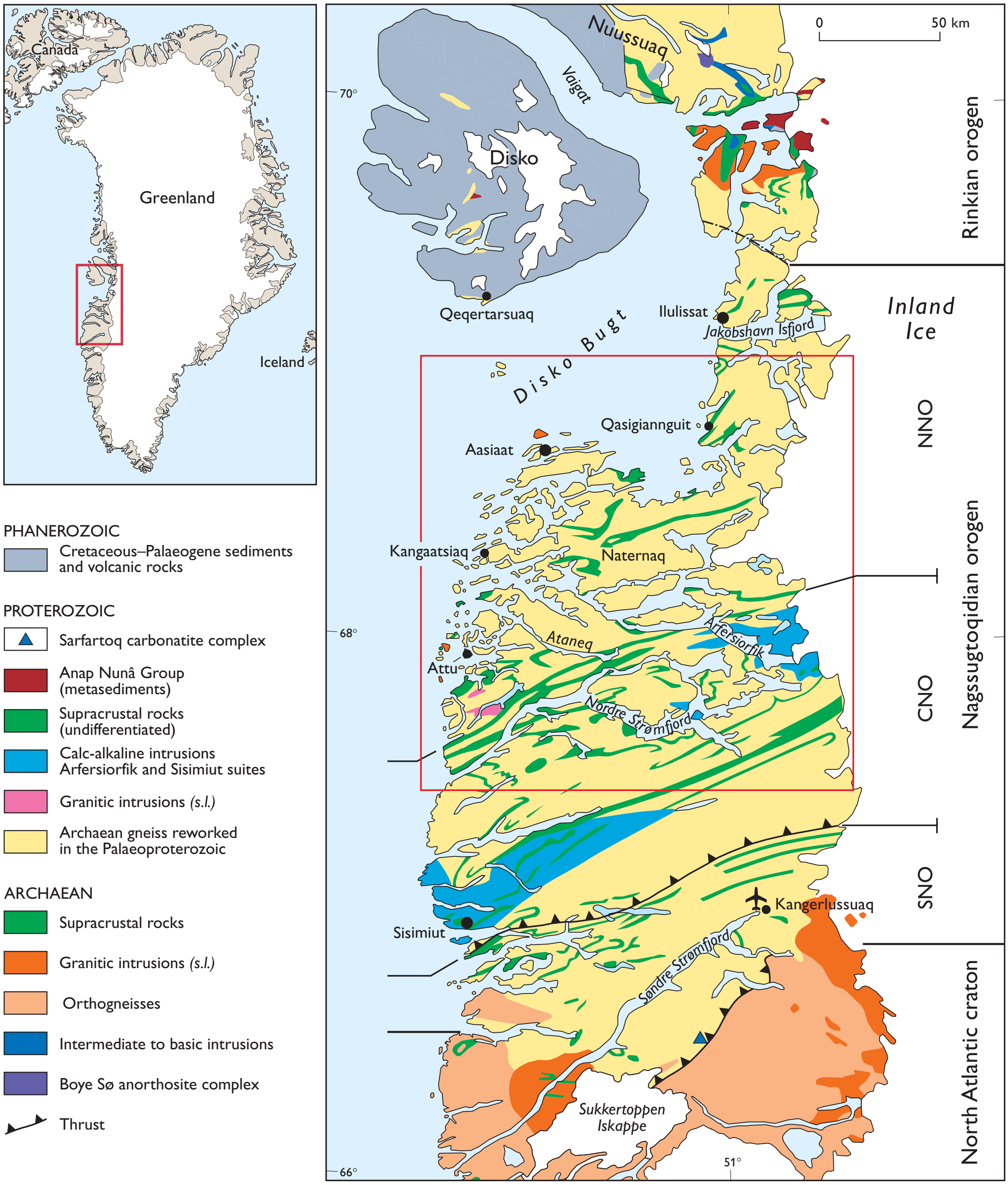


Fig. 1. Geological map of the assessment region in West Greenland. **Red frame** delineates the 2001 field study region. **SNO**, **CNO** and **NNO** are, respectively, the southern, central and northern Nagssugtoqidian orogen. Slightly modified from van Gool *et al.* (2002, this volume).

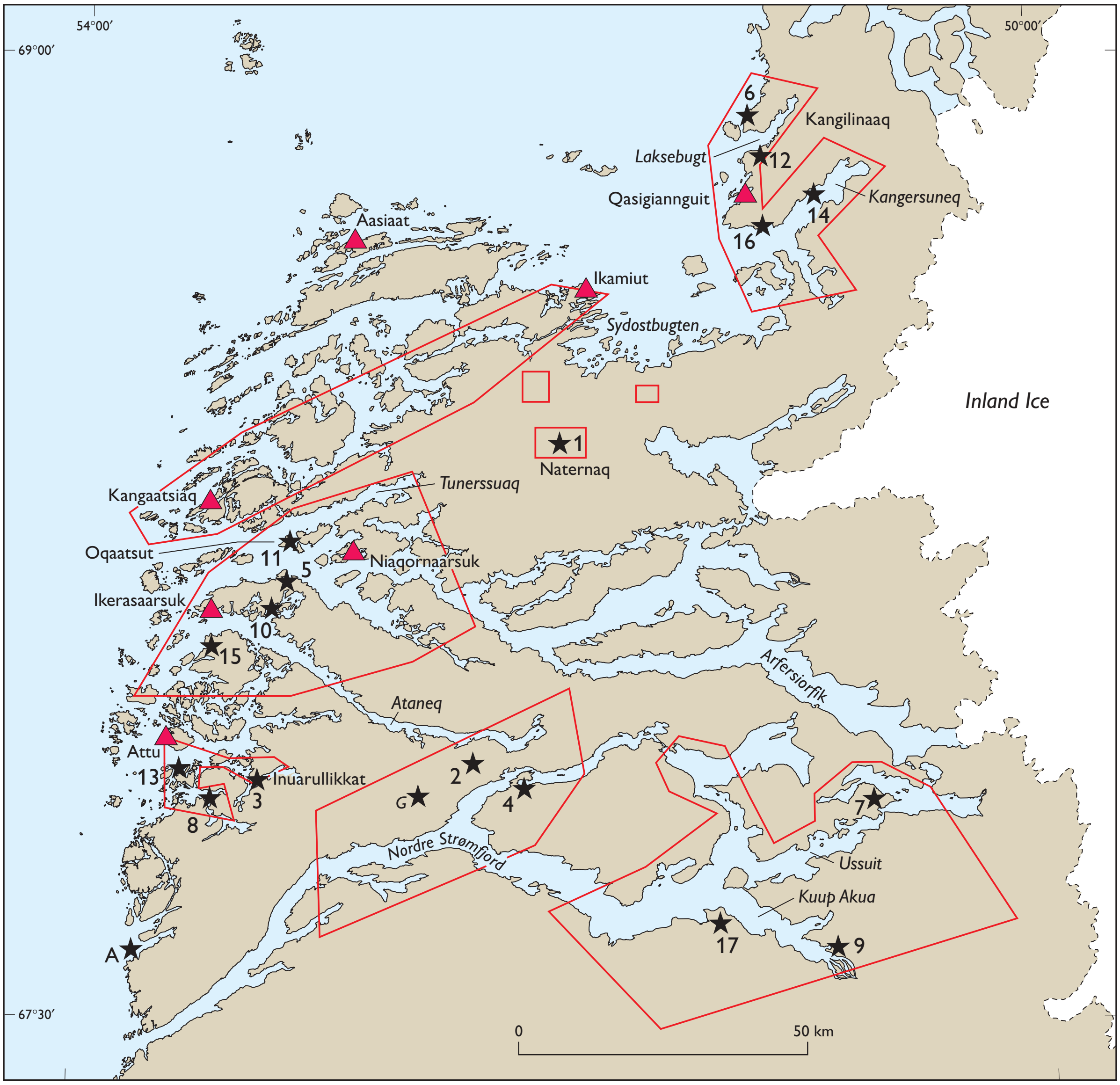


Fig. 2. Index map of the 2001 study region. The **framed areas** are where the main 2001 field work was carried out. **Numbers** refer to the described localities in the text. **A**: Akuliaruseq; **G**: Giesecke Sø.

e.g. from high strain in the south to a more open style of deformation in the north. Steep- and shallow-dipping shear and fault zones are common in contact zones between different types of lithologies. Major fault zones generally trend between NNE–SSW and NE–SW.

The gneisses of the NNO have yielded late Archaean ages between 2870 and 2700 Ma (Kalsbeek & Nutman 1996; Connelly & Mengel 2000), and a discordant Archaean granite occurs in the central part of the NNO (Kalsbeek & Nutman 1996). Only a few younger Palaeoproterozoic ages have been recorded, including an age of about 1790 Ma from an undeformed pegmatite between Attu and Aasiaat (Connelly & Mengel 2000).

## Mineral occurrences

Most of the mineral occurrences in the region are small and their economic potential is limited; at present, the largest known occurrence is the Naternaq pyrrhotite deposit. Descriptions of the different types of mineral occurrences are given below, where the reference numbers refer to localities in Fig. 2.

## Naternaq massive sulphides

The Naternaq supracrustal belt consists of metavolcanic rocks interlayered with pelitic and psammitic metasediments, carbonate/marble units, exhalites and/or chert-rich layers, and minor quartzite and banded iron-formation. In total, these units make up an up to 3 km thick supracrustal sequence which is folded into a major shallow-dipping ENE–WSW-trending antiform; the supracrustal sequence can be traced for approximately 30 km along strike, around the nose of the antiform and into the northern limb. Massive granite sheets and pegmatite veins intrude the supracrustal rocks in the central part of the belt. A detailed description of the stratigraphy of the supracrustal rocks is given by Østergaard *et al.* 2002 (this volume).

Massive to semi-massive sulphide occurrences are found in several distinct rusty beds within the Naternaq supracrustal belt (**1**; Fig. 2), which occur close to the contact of a fine-grained metavolcanic amphibolite with a discontinuous carbonate unit. The mineralised beds consist of banded chert layers, 'black ore' sediments and calcareous schists, and are found both within the amphibolite and the adjacent calc-silicate developments (Fig. 3). Banded iron-formation occurs locally in the amphibolite as exhalite zones composed of cm-banded layers of magnetite, siderite ± quartz and calc-silicates.

Massive sulphide lenses (70–90 vol.%) are usually 2 × 4 m in size, but lenses up to 2 × 10 m across have been observed. Semi-massive sulphides (20–50 vol.%) occur as 0.5–1 m thick parallel zones that can be followed for 50–100 m along strike. The Fe-sulphide content is generally high. The occurrences are characterised by pyrrhotite with minor chalcopyrite and sphalerite, together with subordinate pyrite, arsenopyrite, magnetite and graphite. The sulphide ore may occur within the core of folds, as a result of remobilisation by hydrothermal/metamorphic fluids. Chemical analyses have yielded up to 2.7% Cu and 3.75% Zn, with gold values of 20–80 ppb (Vaasjoki 1965). The sulphide concentrations were estimated by Vaasjoki (1964) to amount to 2.4–4.8 million tonnes of indicated resource and 8.1–16.2 million tonnes of inferred resource.

## Nordre Strømfjord pyrrhotite

Between Giesecke Sø (Fig. 2) and Ataneq, semi-massive pyrrhotite lenses can be traced over a strike length of about 22 km (2; Fig. 2). The lenses occur in two parallel layers up to one metre thick and with varying length (10–100 m) within a supracrustal sequence composed of foliated amphibolite and biotite-garnet (± graphite ± sillimanite) paragneisses. The supracrustal rocks have a general strike of 265° and dip 60°N, parallel to the Nordre Strømfjord shear zone (van Gool *et al.* 2002, this volume). The most common host rocks to the pyrrhotite lenses are skarn, amphibolite, biotite-garnet gneiss and altered silicified lithologies, occasionally with conspicuous amounts of graphite. Chip samples of the mineralised pyrrhotite beds yield up to 0.3% Cu, 4% Mn, 600 ppm Ni and 400 ppm Zn.

Fig. 3. Naternaq massive sulphide deposit ('Rust Hill') with the characteristic yellow-brown weathering colour (locality 1 in Fig. 2). Distance across the hill is *c.* 100 m.

## Iron-formation at Inuarullikkat

At the fjord Inuarullikkat a well-exposed, 10–20 m wide magnetite-bearing amphibolite occurs intercalated with brown coloured gneisses (3; Fig. 2) and can be followed continuously along the coast for several kilometres. The magnetite-bearing layer (Fig. 4) is a 1.5 m thick banded iron-formation with a NE–SW strike and 54° dip to the north-west, and comprises alternating 1–10 mm wide bands of magnetite and quartz. Adjacent to the iron-formation, quartz-bearing rusty horizons contain disseminated pyrite and magnetite.

The occurrences of loose sulphide-bearing blocks in the Inuarullikkat area, thought to be of local origin, suggest the area has a potential for sulphide mineralisation. The main sulphide is pyrite, both disseminated and as veins and veinlets in quartz-rich lithologies; some samples contain graphite. The studied samples have elevated values of Cu (741 ppm), Mn (1170 ppm), Ni (271 ppm), and Zn (272 ppm).

## Graphite-pyrrhotite schist

Graphite-pyrrhotite schists are common in the supracrustal successions of the study area, of which the best known occurrence is the graphite deposit at Akuliaruseq (Fig. 2), which contains 1.6 million tonnes of ore grading 14.8% graphite and 6 million tonnes with 9.5% graphite (Bondam 1992; Grahl-Madsen 1994). The mineralisation is believed to be stratiform. Other graphite-bearing supracrustal rocks occur at Nordre Strømfjord (4; Fig. 2). Graphite layers in the schists range from 1–10 m in width, and are clearly concentrated in fold closures and within shear zones. Iron sulphides range from 1 to 5 vol.% in the most sulphide-rich parts of the schists, and gold is recorded in small amounts (10–100 ppb).

## Mafic to ultramafic rocks

Small gabbroic bodies are found throughout the study region (5, 6, 7; Fig. 2). Locally they preserve well-developed magmatic layering and contain small amounts of magnetite, pyrite, pyrrhotite, and chalcopyrite. One gabbro body north of Ataneq (5), 300 × 400 m in size, is medium-grained, brownish weathering, and preserves magmatic banding as 1–5 cm wide light and dark bands. Some parts of the gabbro contain magnetite-bearing layers and occasional malachite staining is seen. The texture of the gabbro is similar to that of many of the magnetite-bearing amphibolites of the Attu and Ataneq regions.

A hitherto undescribed 10 × 30 m gabbroic body was found on the steep, eastern side of a small island north of Qasigiannguit (6), where it has tectonic contacts against the enveloping banded gneisses. The gabbro is coarse-grained and completely altered; medium- to coarse-grained magnetite occurs throughout the body, with the largest concentration in the centre of the alteration zone. Disseminated pyrite is found throughout the gabbro.

Isolated pods of ultramafic rock up to 30 m thick are common in the supracrustal units of the Ussuit region (7), where they are cut by SSW–NNE-trending joints parallel to the regional faults of the region. They are invariably pervasively altered to light green actinolite, and contain small amounts of interstitial iron sulphides.

Fig. 4. Banded iron-formation with magnetite and rusty pyrite-bearing mica gneiss zone at the fjord Inuarullikkat (locality 3 in Fig. 2).

## Pegmatites

The gneisses throughout the study region are commonly cut by red-coloured pegmatites in which the K-feldspar crystals often reach more than 10 cm in size. These pegmatites occur as concordant and discordant bodies and bands up to 1 m across. Some contain conspicuous aggregates of magnetite, allanite and occasionally pyrite, but they do not seem to have any economic potential.

White-coloured pegmatites are less common than the red K-feldspar pegmatites, and contain minor contents of iron sulphides; up to 400 ppb gold was recorded in a composite chip sample from a sulphide-mineralised pegmatite from the Kangaatsiaq area. This type of pegmatite also carries monazite (Secher 1980).

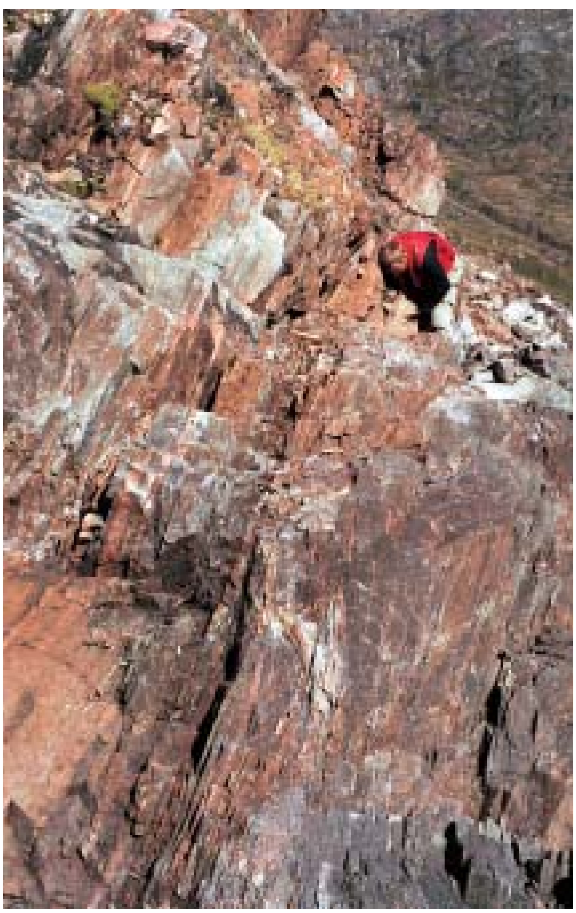

Fig. 5. Shear zone south of Attu (locality 8 in Fig. 2), with mylonite and associated magnetite, pyrite and gold mineralisation.

## Shear zones

In the southern Attu area a 100–330 m wide mylonite zone (8; Fig. 2) cuts through granulite and high amphibolite facies gneisses, and forms part of a complex shear system consisting of three parallel fault systems striking NNE–SSW and dipping 60–70°W.

Gold-bearing *Ujarassiorit* samples originate from a coastal cliff along the mylonite and shear zone, which here consists of 5–20 cm wide bands of mylonite and a rusty band (10–20 cm thick) containing pyrite, magnetite and some chalcopyrite (Fig. 5). The host rock is grey gneiss, which is silicified at its contact with the mineralised zone. New samples collected in 2001 confirm gold contents of up to 4 ppm.

## Fault zones

Mineralised faults occur between the inner parts of Kuup Akua (9; Fig. 2) and Ussuit. Semi-massive 5–10 cm thick lenses of pyrrhotite with pyrite and chalcopyrite occur along both margins of the central part of the fault zone, which is up to 5 m wide, with a high content of graphite. In a zone up to 100 m wide east of the fault zone, intense malachite staining occurs in supracrustal rocks in patches up to 2 m across (Fig. 6).

Prominent SSW–NNE-trending faults cut through all lithologies in the region, and are commonly characterised by red and green colouring due to conspicuous amounts of K-feldspar and epidote, which are related to zones of intense silicification along the fault planes (e.g. 10; Fig. 2).

A crush zone striking 030° occurs on the island Oqaatsut (11; Fig. 2). Along the main crush zone ankerite occurs on joints, and patches of malachite staining occur in the host gneiss. On north-east Oqaatsut the crush zone is locally up to 50 m wide and cuts gneiss, amphibolite and pegmatite. The crush breccia is clast supported (clasts 1–10 cm in size), veined by ankerite and silicified; joints are filled with epidote and chlorite. Several boudins (1 × 4 m) of amphibolite with small amounts of iron sulphides are enclosed in the crush zone.

## Eqaluit 'supracrustals'

A thick NE–SW-trending amphibolite encloses a 5 m thick, rusty weathering garnet-quartz rock (garnetite) which hosts a sulphide mineralisation south of Eqaluit (12; Fig. 2). Pyrrhotite has been identified, and a light brown alteration is caused by haematisation associated with pervasive jointing.

Fig. 6. Fault zone in paragneiss in southern Kuup Akua. Malachite staining occurs in jointed, but unaltered country rock. The pattern of blocky jointing can be recognised in a several hundred metres wide zone along the trace of the fault (locality 9 in Fig. 2).

## Quartz and carbonate veins

Gold-bearing quartz veins were found in an *Ujarassiorit* sample from an island south of Attu (13; Fig. 2), and this site was revisited in 2001. The quartz veins occur as concordant up to 30 cm thick veins and as 5–10 cm thick discordant veins; gold contents of up to 0.5 ppm have been recorded.

At Kangilinaaq on the northern shore of the fjord Kangersuneq (14; Fig. 2) an up to 15 m wide boudinaged metadolerite dyke can be followed along strike for several kilometres. The necks of the boudins are cross-cut by quartz-calcite veins (3–4 cm wide and up to 50 cm long) and pegmatites which contain disseminated sulphides and magnetite (less than 1 vol.%).

## Lithological contacts

Contact zones between different lithologies are often the site of mineralisations, with locally up to one metre wide zones of mineralised host rocks containing disseminated pyrite (max. 5 vol.%) and magnetite (e.g. 15; Fig. 2). These appear to be associated with pegmatitic developments, which has led to enhanced sulphide contents in the host rocks as a consequence of remobilisation along the contacts.

On the Kangilinaaq peninsula a band of semi-massive pyrrhotite occurs in a reaction zone between mafic and supracrustal rocks. Spectacular rust horizons are also associated with an approximately 50 m thick, coarse-grained, hornblende-garnet-rich mafic unit containing disseminated magnetite and hematite (16; Fig. 2). This area has previously been targeted for prospecting by Kryolitselskabet Øresund A/S (Gothenborg 1980) and Nunaoil A/S (Petersen 1997).

## Marble and calc-silicate-rich rocks

Marble and calc-silicate rocks occur in supracrustal sequences over most of the region. At a few localities (e.g. 17; Fig. 2) fluorite occurs in minor amounts in the marble and calc-silicate rocks, especially near the contacts with quartzo-feldspathic country rocks. Graphite is also a common accessory mineral, and is especially common in marbles on the north-west shore of Kuup Akua. In the Naternaq area, carbonate rocks are associated with the sulphide horizons (see Østergaard *et al.* 2002, this volume).

## Summary

Amphibolites south of Ataneq have gabbroic textures and contain magnetite in thin layers of probable magmatic origin. The amphibolites and supracrustal rocks north of Ataneq are reminiscent of supracrustal sequences in the Naternaq area, but lack the carbonate and exhalite components. Carbonates are more common in the southern part of the study area (e.g. Kuup Akua). Exhalite rocks are known from the Naternaq area and from the area between Giesecke Sø and Ataneq in the vicinity of Nordre Strømfjord.

In the study region the only major mineral deposits known are the Naternaq pyrrhotite deposit and the Akuliaruseq graphite deposit. The former is further discussed by Østergaard *et al.* (2002, this volume).

Gold anomalies south of Attu appear to be related to both shear zones and quartz veins. Gold is also found in white pegmatite veins in the Kangaatsiaq area. Gold anomalies in the Attu area are related to shear zones associated with a complex fault system; the gold is associated with pyrite, chalcopyrite and magnetite.

Granite and pegmatite intrusions are often associated with sulphide and magnetite mineralisation in the adjacent host rocks.

Hydrothermal activity along NE–SW-trending lineaments seems to be responsible for sulphide and oxide mineralisation and secondary malachite staining. Crush and mylonite zones with carbonatisation (ankerite) and silicification characterise lineaments and fault zones. Narrow zones of silicification are common throughout the study region.

None of the presently known mineral occurrences seem to have economic potential. The sulphide occurrences are dominated by pyrrhotite with only minor pyrite and chalcopyrite.

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