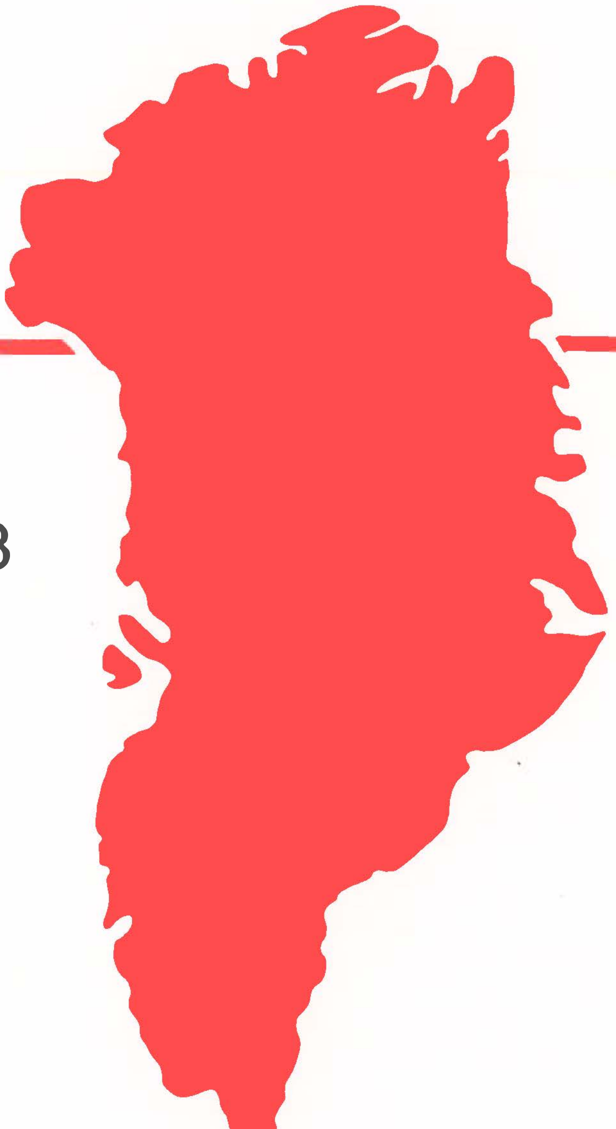
Economic geology and exploration potential of the Frederikshåb Isblink – Søndre Strømfjord area (Sheet 2 Geological map of Greenland)



William J. Anderson

Open File Series 94/18

February 1995

GGU

GRØNLANDS GEOLOGISKE UNDERSØGELSE
Ujarassiortut Kalaallit Nunaanni Misissuisoqarfiat
GEOLOGICAL SURVEY OF GREENLAND

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ABSTRACT

The region of Frederikshåb Isblink - Søndre Strømfjord is centred roughly over the town of Nuuk on the southwest coast of Greenland. Nuuk, with a population of about 12 000 boasts excellent air and other support services and along with most of the coast in this area is ice-free throughout most of the year.

The area is entirely underlain by Archaean basement, including some of the oldest dated successions known. Quartzo-feldspathic gneisses of several ages predominate, but within them there are extensive screens and enclaves of metamorphosed supracrustal rocks, and intrusive bodies of anorthosite and leucogabbro. Swarms of early Proterozoic mafic dykes are common, a few carbonatites and many kimberlitic bodies have been mapped.

Mineral occurrences discovered through routine geological mapping and by reconnaissance prospecting by a few companies are typical of those found in other shield areas of the world. Showings include copper-zinc occurrences of possible volcanogenic massive sulphide affinity, gold mineralisation, copper-nickel sulphides associated with norite bodies, and PGE and chromite occurrences within a deformed anorthosite complex. In addition there are niobium and phosphate deposits associated with carbonatites. In a stream draining a multitude of kimberlite dykes a few microdiamonds have been found.

Despite all the indications that the region has at least some of the classic geology of some productive shield areas in the world, the area is very lightly explored, and indeed can be said to have never been systematically examined for gold and base metals. The belts of supracrustal rocks are similar in size and extent to those in other areas in the world such as the western Superior and southwestern Grenville Provinces in Canada, where economic discoveries of both gold and base metals have been made and developed.

A strong case can be made that the exploration potential of this area has been undervalued by industry in the past, and that given the number of promising geological indicators and low level of competitive activity, the area merits a fresh look for groups seeking excellent grassroots opportunities.

CONTENTS

INTRODUCTION

This report presents a review of the geology and history of exploration in the Frederikshåb Isblink - Søndre Strømfjord area (1:500 000), Sheet 2 of the Geological Map of Greenland, and concludes with an evaluation of the region's exploration potential. The work is based upon an examination of reports and publications on the area and of all the company files listed in the GREENMIN database at the GGU offices in Copenhagen.

The work was initiated and funded by the Minerals Office of the Greenland Home Rule Government.

LOCATION AND ACCESS

Map sheet 2 is located on the southwest coast of Greenland (Fig. 1), almost centred over the town of Nuuk, the administrative capital of the island. Nuuk provides all the services and amenities to be expected of a community with a population greater than 12 000, and which is also the main seat of government. There is a local airport from which scheduled service is available to Iqaluit in Canada, and Rekjavik in Iceland, and charter helicopter companies also operate from there. To the immediate north of the map area there is a major airfield at Søndre Strømfjord from which SAS operates flights to and from Copenhagen. There are also marine shipping services available in Nuuk.

A number of small communities dot the coast of which the only one with regular air service (by helicopter) is Maniitsoq.

TOPOGRAPHY AND CLIMATE

As over the rest of the island the ice cap dominates the physiography of the region, and in this area it ranges from as little as 20 km inland around Maniitsoq to as much as 120 km in the centre of the sheet. Arctic conditions prevail on and very near the ice, and the ice cap also has a strong influence on local weather conditions, but the overall climate near the coast is moderated by the West Greenland Current, to the extent that the shore is usually ice-free beyond the interior of the fjords.

Relief across the region is generally high with numerous deeply-incised fjords, of which the most extensive is the complex of channels comprising the Godthåbsfjord system east of Nuuk. Maximum elevations of more than 2000 m are common around the Sukkertoppen ice sheet, and across the remainder of the sheet relief across fjords and local highs is frequently 1000 m or more.

REGIONAL GEOLOGY

Previous investigations

The regional geology has been summarized in the text which accompanies the 1:500 000 map sheet (Kalsbeek & Garde, 1989). Mapping of the area is detailed for the southern half of the sheet where a series of 1:100 000 geological maps have been published. This detailed mapping, at field scales of 1:20 000, was carried out over the 1960s and 1970s by GGU. In the north half of the region the 1:500 000 scale sheet is the main published document. The map in this area is a product of recconnaissance efforts at 1:50 000 and 1:250 000 by the GGU, and 1:10 000 across parts of the area by Kryolitselskabet Øresund A/S.

Regional geochemical surveys at reconnaissance scales have been conducted across much of the area by GGU staff (Appel, 1989, Erfurt *et al.*, 1991, Steenfelt *et al.*, 1994). In addition there is airborne magnetic survey coverage at relatively wide line-spacing from programmes by the GGU (Thorning, 1984) and also from a very large effort by Kryolitselskabet Øresund A/S in the late sixties (Peltonen, 1968). The survey results from the latter are lodged in the GGU offices and have been compiled in digital form from the original contour plans (Thorning, 1994, pers. comm.). Data within the area from 64°N to 66°N have been compiled by GGU into thematic maps at scale 1:1 000 000 for comparing geology, geochemistry, aeromagnetic surveys, airborne radiometric surveys, mineral occurrences, and some gravity measurements (Steenfelt *et al.*, 1990). A similar compilation of data exists from South Greenland (Thorning *et al.*, 1994) and in the near future (early 1995) the area in between will also be covered (Ady & Tukiainen, pers. comm. 1994).

General

Essentially all of the bedrock geology is of early to late Archaean age with the exception of some minor younger intrusions noted below. The vast majority of the area consists of quartzo-feldspathic gneisses which surround and enclose remnants and screens of supracrustal rocks and lesser amounts of mafic and ultramafic intrusive bodies. Within the quartzo-felspathic suites several large granite complexes have been recognised. Two main periods of plutonic and metamorphic activity have been discerned, at 3800-3400 Ma, and 3100-2600 Ma (Kalsbeek & Garde, 1989).

The northern 5% of the sheet, beginning more or less at Søndre Strømfjord, consists of Archaean gneisses re-worked and deformed as part of the Nagssugtoqidian mobile belt (~1850 Ma). Extensive swarms of pre-Nagssugtoqidian dolerite dykes have also been mapped in this area. Younger intrusive bodies within Sheet 2 include several Palaeozoic carbonatite complexes, kimberlite dyke swarms, and a few scattered Mesozoic and Tertiary alkali dykes noted in the southern limits of the area (Kalsbeek & Garde, 1989).

Since the publication of the 1:500 000 map, further investigations in the area have resulted in the proposal (McGregor, 1993) that the central portion of the map can be subdivided into three terranes which were emplaced in their present positions in late Archaean along two major structures (Fig. 2). Each of these terranes displays different lithological and tectonic histories.

Supracrustal rocks

Screens and enclaves of metamorphosed supracrustal rocks appear throughout the region, but are most common and best described in the central portion of the area around Gothåbsfjord. The oldest units have been identified in what is now known as the Akulleq terrane (Fig. 2) (McGregor, 1993).

The best known group of these rocks is the Isua sequence, an arcuate belt up to 4 km wide which outcrops in the Isukasia area at the margin of the Inland Ice. The rocks have been dated at 3800 Ma and have been the subject of numerous studies (Nutman, 1986).

The Isua succession consists of pillow lavas, layered amphibolites, metacherts, felsic rocks, banded iron formation, ultramafic units and calc-silicates rocks. At least some of the felsic rocks are interpreted as being derived from acid volcanics, whereas staurolite schists presumably are of clastic origin (Nutman, 1986).

Throughout the Akulleq area a number of small slivers of mainly amphibolite with lesser amounts of ultramafics, cherts, iron formation, and calc-silicate rocks have been mapped and interpreted to be older supracrustals similar to the Isua rocks. They have been given the name Akilia association (McGregor, 1969).

Elsewhere in the region extensive exposures of mid- to late-Archaean supracrustals occur. These have previously been called Malene supracrustal rocks. However, McGregor (1993), has proposed abandoning this name as field relationships indicate that these sequences are probably of several ages.

These middle to late Archaean supracrustals include some interesting lithologies, particularly in the Godthåbsfjord area. The amphibolite units often contain well-preserved pillow structures, and along with the associated ultramafic suites have been described as ranging in composition from low-K tholeiitic to komatiitic (Chadwick, 1986, 1990). In addition the metasediments frequently include biotite and garnet-rich quartz-plagioclase gneisses along with quartz-cordierite-anthophyllite gneisses (Fig. 3). Some authors, such as Smith *et al.* (1992) have interpreted the geochemical data on the latter rocks to indicate their protoliths may have been altered felsic volcanoclastic sediments.

Anorthosite, leucogabbro and associated rocks

Metamorphosed anorthosites and related gabbroic rocks are exposed in several areas across the map sheet, but are particularly common in the Fiskenæsset region where they underlie up to 5% of the surface and were apparently once part of a single stratiform complex. The main lithologies in the Fiskenæsset complex are anorthosite, leucogabbro, and gabbro, along with lesser amounts of ultramafic rocks and chromitite (Ghisler, 1976).

Metanorite

A group of norite bodies is exposed between Fiskefjord and Søndre Isortoq (Fig. 4). They are not well-studied, but were first mapped and explored by Kryolitselskabet Øresund A/S and later described by Secher (1983). The rocks form an arcuate belt about

15 × 75 km around the margin of the Finnefjeld gneiss complex (Fig. 4), and are described as being mainly of norite composition, more or less undeformed, and conformable with the surrounding gneisses, leading to the conclusion that they were emplaced syn- or late tectonically.

Carbonatite complexes

Three carbonatites have been identified in the area: the Mesozoic (173 Ma) Qaqarssuk complex east of Maniitsoq; the Cambrian (~600 Ma) Sarfartoq complex near Søndre Strømfjord; and a small Archaean (~2650 Ma) sheet-like body at Tupertalik, about 11 km northwest of Qaqarssuk (Kalsbeek & Garde, 1989).

Kimberlite dykes

Two kimberlite dyke swarms (Fig. 5) have been mapped. In the Sarfartoq area a large number of dykes have been observed as cone sheets centred about the coeval carbonatite complex. Their full extent is not known, but in all instances the thicknesses of the dykes are 2 m or less.

Farther south at Maniitsoq another swarm of similar age (586-613 Ma) was discovered by Kryolitselskabet Øresund A/S. As in the previous instance the thicknesses were all less than 2 m (Larsen, 1991).

ECONOMIC GEOLOGY

The region has a variety of showings and occurrences that are typical of older shield terranes. With the notable exception of the iron deposits found at Isukasia and the extensive chromite layers in the Fiskenæsset anorthosite complex, no economic mineral deposits of any significance have been found, but in general this reflects the lack of any intense systematic exploration. In the sections that follow the headings used are, for convenience, common metal groupings.

Iron formation

The banded iron formation located in Isua supracrustal rocks at Isukasia is the most documented and best known of any economic mineral in the region. The deposit hosting about 2000 million tonnes quartz-magnetite banded iron formation grading on average 32% Fe was found in the sixties by Kryolitselskabet Øresund A/S and was investigated with drilling and economic studies during the seventies before it was concluded that it was uneconomic (Appel, 1991).

Copper-zinc

Most of the known occurrences of copper-zinc mineralisation associated with supracrustals have been well-documented in Appel (1990b) and also on the thematic maps (Steenfelt *et al.*, 1990).

In the early Archaean supracrustals at the Isukasia area, a handful of minor copper occurrences have been noted as veinlets and as disseminated grains in amphibolite (Appel, 1990b).

In the younger supracrustals quite a few indications of mineralisation have been located in outcrop. Although by themselves none of the occurrences is noteworthy, as Appel (1990b) has pointed out, the lithological associations accompanying many of the sulphides are potentially very significant.

The volcanic component of the younger supracrustals includes intercalated units of quartz-biotite schist which is frequently pyritiferous, and also layers of cordierite-sillimanite schist. The latter often contain variable amounts of anthophyllite-gedrite as bands or layers up to a few metres wide, and traceable for hundreds of metres (Fig. 3). Appel (1990b) recognized that these anthophyllite-rich zones are reminiscent of similar lithologies which are viewed as alteration assemblages around some Canadian base metals deposits. For example at Manitouwadge laterally persistent cordierite-anthophyllite-garnet gneisses stratigraphically underlie the Geco orebodies (Zaleski & Peterson, 1993). Similar alteration suites are known at Winston Lake, Ontario, and at Montauban and Calumet in Québec (Stamatelopoulou-Seymour & MacLean, 1984, Bishop & Jordain, 1987).

The sulphides found with the anthophyllite-gedrite lithologies include pyrite, pyrrhotite, chalcopyrite, sphalerite, and ocasionally molybdenite. Gahnite, the zinc spinel, has been observed, and in some areas there are also magnetite-rich units associated with these rocks. In addition, another unique lithology appearing amongst these suites is thin stratiform bands of tourmalinite up to one metre thick. Appel also recognized the potential metallogenic significance of tourmaline in discussing these rocks and stratiform scheelite occurrences (Appel & Garde, 1987). Tourmaline-rich suites have been suggested as arising from the same systems which generated massive sulphide deposits at Broken Hill, Australia (Slack *et al.*, 1993). On a smaller scale, narrow short stratiform quartz-tourmaline rocks appear as part of the package including cordierite-anthophyllite assemblages at the afore-mentioned Montauban mine in Québec (Bernier *et al.*, 1987).

Virtually all of the copper-zinc occurrences described by Appel (1990b) and also in the GREENMIN Databank at the GGU office represent sulphides recorded from routine mapping investigations. The analyses reported in these files tend to be based upon grab samples of sulphides but there do not appear to be any systematic sampling investigations of either base metal and other metal distributions, or whole rock analyses and alkali element distribution in the anthophyllite rocks. Some areas, notably the islands south of Nuuk off Godthåbsfjord, seem to have widespread indications of anthophyllite-rich rocks and base metals, and would be worthy of examination.

Copper, nickel, ± platinum-group elements

In the Maniitsoq district the series of norite intrusions which flanks the Finnefjeld gneiss complex on its east side has sometimes been referred to as the "Norite Belt" (Secher, 1983) (Fig. 4). The belt is arcuate in form and is roughly 15 km wide by 75 km long. The area was investigated and reported upon by Kryolitselskabet Øresund A/S (Nielsen, 1976).

Mineralization consists of disseminated sulphides, and local networks of sulphide veinlets in the norite bodies. No significant massive mineralisation was found, although sulphide content could reach a maximum level of 25 per cent by volume locally, nor were any substantial zones of lower grade material outlined (Secher, 1983).

Chromite ± platinum group elements

The Fiskenæsset layered complex is exposed over an extensive area, and the chromite mineralisation and platinum potential have been reported upon by Ghisler (1976) and Appel (1993), and Appel (1991) respectively. During the 1970s Platinomino A/S actively explored the complex. The latter was searching mainly for platinum, with the work consisting of grab samples of sulphide zones, and the only analyses based on modern geochemical techniques are those of Appel (1993).

Chromite layers up to tens of metres wide are found in the anorthosite. Mostly, however, they are less than a metre wide. They can be traced continously for many hundred of metres throughout the entire Fiskenæssset anorthosite complex. The average chromite content is 37% by weight. Beneficiation tests have yielded concentrates with the following average composition: Cr_2O_3 35.1%, Al_2O_3 41.5% and FeO 41.5% with Cr/Fe ratio of 0.75. Rutile amounts to as much as 0.35 weight per cent. Systematic studies of the PGE potential have never been carried out, but analyses by Appel (1993) revealed concentrations up to several hundred ppb. These were generally much lower than assays reported twenty years earlier by Platinomino, which probably reflects better precision in modern analysis.

P_2O_5, Nb_2O_5 & REE mineralisation

The two main carbonatite complexes (Fig. 1) have been investigated for various minerals (Knudsen, 1986, Druecker, 1990, Kalvig & Appel, 1994).

At Qaqarssuk exploration has revealed concentrations of all of the above elements, but attention has focussed on the phosphate potential where a reserve of roughly 4 million tons averaging 4.4% P_2O_5 has been suggested.

The Sarfartoq complex was discovered in 1975 and has been studied by the GGU and examined most recently by Hecla Mining (Druecker, 1990). It has the usual suite of carbonatite-associated minerals, but it has been explored primarily as a high grade Nb_2O_5 prospect, where a narrow (~5 m) zone some hundreds of metres in length contains lenses grading up to 10% Nb_2O_5.

Diamonds

Two kimberlite dyke fields have been identified in the area (Fig. 5) (Larsen, 1991), and diamonds have been recovered from stream sediments.

Brunet (1974, 1976) reported the recovery by Charter Consolidated of two microdiamonds from stream sediment samples in the Sarfartoq region. There was also a report (Geisler, 1973) of 1 and 9 microdiamonds recovered respectively from two stream sediment samples near Qeqertarssuatsiaq in Fiskenæsfjorden, but this account may be apocryphal as subsequent resampling (Geisler, 1974) did not find any more diamonds.

In the Sarfartoq area a swarm of dykes coeval with the nearby carbonatite complex has been identified (Larsen, 1991). The kimberlites are aligned as a system of cone sheets centred about the carbonatite and dip 20-60° towards it. Elements of the swarm have been observed up to 25 km from the carbonatite, beyond which the attitudes become more variable and less obviously related to the complex. The dykes are narrow, with observed thicknesses ranging from a few centimetres to 2 m.

Farther south, in the Maniitsoq region, another swarm of dykes was found in the course of exploration by Kryolitselskabet Øresund A/S. Seventeen occurrences have been located, and they are all of the same age as the Sarfartoq field, and therefore not linked to the nearby Qaqarssuk carbonatite, which is Mesozoic in age. As in the other area, the dykes are all very narrow, and can only be traced over short distances.

Larsen & Rønsbo (1993) conducted considerable whole rock geochemical work on Greenland kimberlites, and concluded from electron probe studies on garnets in inclusions from nodules in dykes from Maniitsoq that the latter dykes likely originated at depths within the diamond stability field.

In 1993 GGU carried out a pilot study of indicator minerals in stream sediments draining known kimberlite dykes. The study showed that in spite of very low concentrations of indicator minerals in the kimberlites and in spite of a high degree of dilution by glacial material, it was possible to detect indicator minerals such as pyrope garnets, picroilmenite, chromediopside and chromite in the stream sediments (Appel, 1994).

The 1993 GGU study also showed that kimberlite features such as intensive fracture patterns on either side of kimberlite dykes are quite widespread.

Tungsten, molybdenum

The mid- to late Archaean supracrustals in the area have been shown to contain widespread tungsten mineralisation. Appel (1990a) and Appel & Garde (1987) describe tungsten mineralisation, essentially as scheelite occurring in stratabound form in amphibolites, calc-silicate rocks, and tourmalinites. These zones can often be traced for kilometres along strike. Limited sampling has been undertaken on these occurrences, but in one instance at Ivisârtoq, channel sampling revealed values up to 0.44% W_2O_3 across 2.5 m (Appel, 1990a).

Molybdenite is frequently reported as an accessory mineral in many different rock types of the region. It has been found in supracrustal rocks in gneisses and even in anorthosites. At Lille Narssaq (Fig. 1) GEMCO explored patchy MoS_2 mineralisation in a calc-silicate rock (Greenland Exploration Management Company Inc, 1972, Gustavson & Karup-Møller, 1974).

Olivine

At Tasiussarssuaq in the Fiskefjord area a dunite body referred to as the Itipilua massif was explored by Kryolitselskabet Øresund A/S. Reserves of dunite at this site have been estimated at from 45 to 100 million tonnes (Kalvig, 1994).

Gold

Until very recently gold occurrences were unknown in the region, reflecting the lack of any serious previous prospecting and the few geochemical studies undertaken. Investigations and compilations by Appel (1990c) and the Thematic Map Series (Steenfelt *et al.*, 1990) reveal several significant bedrock anomalies scattered across the area in supracrustal rocks (Fig. 6).

Most importantly the announcement in 1993 by Nunaoil A/S of values of up to 5-12 ppm Au in boulders on Aappalaartoq Mountain on Storø Island (Fig. 6), and an isolated value of 12.6 ppm Au from sulphide-bearing amphibolite in the Isua area, indicates that the gold potential of the region has been underrated in the past. The Aappalaartoq

Mountain area was investigated further in 1994, resulting in the finding of native gold in sheeted quartz veins in a pillowed amphibolite by the GGU (loc. 144/9 on Fig. 6), and another discovery by Nunaoil A/S several kilometres away on Quingat Ridge. In a press release late in 1994 Nunaoil reported the best results were 91 ppm across 4.0 m, 42 ppm over 2.5 m and 24 ppm over 2.0 m. This new zone has been sampled up a steep slope along a length of about 200 m, and the associated structure appears from aerial reconnaissance to extend for some 700 m before disappearing unders scree cover to the the northeast and under a glacier to the southwest.

The locations depicted on Fig. 6 and the values listed in Table 1 represent all of the known gold occurrences from the public records. Most of the analyses are the result of the initiative taken by Appel (1990c, 1992a, b) to investigate the gold potential of some of the sulphide occurrences in supracrustals, and a handful are from sampling carried out by Kidd Creek Mines Ltd. (Downes & Gardiner, 1986) as part of a tungsten programme. Bearing in mind that none of the occurrences has ever been systematically sampled and evaluated along the lines of a typical gold anomaly in Canada, some of the descriptions in Appel and elsewhere are intriguing.

As noted previously the few gold analyses available represent scattered samples often originally selected for another purpose, and usually there is no accompanying investigation of the geological setting. One exception is the Ivisârtoq peninsula, where there are both interesting gold values and a geological setting that invites further study.

In the Ivisârtoq area Kryolitselskabet Øresund A/S discovered massive to semimassive pyrite mineralisation over thirty years ago. The showing was investigated by mapping, sampling, and limited diamond drilling. The showing was described by Keto (1961) as being a sulphide-bearing rusty horizon adjacent to a quartz-feldspar schist and amphibolite. Pyrite is the dominant sulphide and is accompanied by minor molybdenite, rutile, ilmenite, and titanite. Keto also noted substantial microcline, suggesting potassic alteration. Enclosing rocks, which were mapped by Chadwick (1986) include mafic and ultramafic pillow lavas, intrusive mafic and ultramafic rocks, tourmalinites, calc-silicates and quartz-rich schists. Overall the picture is one of a package of layered chemically diverse rocks bearing unusual sulphide mineralisation and sitting within or adjacent to a high strain zone.

In 1985 Downes & Gardiner (1986) while investigating the same general area for tungsten recognised the gold potential of the setting and grabbed about 25 rock samples for gold geochemistry. From 12 taken from the quartz-muscovite schist with pyrite, the highest ran 225 ppb Au, but one sample of a calc-silicate in the same package of rocks analysed 1420 ppb Au. Appel (1990c) in his review of gold in the region reported the results of further geochemical sampling of these rocks, including core samples from the original drilling and other grab samples taken by Kryolitselskabet Øresund A/S. The best results were 2520 ppb and 1760 ppb Au from amphibolites containing disseminated pyrite. His study also indicated that the mineralised zones were anomalous in Ba as well as Au and Mo.

Most of the other gold values catalogued in Table 1 do not have the benefit of additional sampling and mapping as described above, as they often represent selections taken originally for other studies, and subsequently analysed for gold. The values reported by Downes & Gardiner (1986) were grab samples selected for gold analysis but they were picked during the course of a programme for tungsten, and were not followed up or studied in detail.

In the southern part of the area around Bjørnesund Appel (1992a, b) reported a value of 5.2 ppm Au from a group of grab samples taken from carbonate-altered amphibolite near a shear zone. Another sample of similar material bearing a rusty malachite stain and adjacent to a contact with an ultramafic returned 1.37 ppm Au, 4.6 ppm Ag and 0.27% Cu across 2 metres. These samples were taken as part of a programme in that area to investigate gold-platinum mineralisation, and not for the purpose of looking for gold alone.

Table 1. Selected gold analyses from publications and released company reports

Loc. No.	Source	Sample Description	Au Analysis	
13/1	Appel (1990)	Grunerite iron formation	1.03	ppm
12/4	Appel (1990)	Siderite iron formation with magnetite	0.2	ppm
12/7	Appel (1990)	Shaly iron formation	0.107	ppm
14/7	Appel (1990)	Amphibolite with iron sulphides	0.25	ppm
141/1	Appel (1990)	Amphibolite with 10% pyrite	2520	ppb
		" " " "	1760	ppb
144/1	Downes & Gardiner (1986)	Pyrite zone, Ivisârtoq	225	ppb
144/2	Downes & Gardiner (1986)	Calc-silicate rock	1420	ppb
144/3	Downes & Gardiner (1986)	Biotite amphibole schist	110	ppb
144/4	Appel (1990)	Tourmalinite	210	ppb
144/5	Appel (1990)	Pyroxene-bearing amphibolite	180	ppb
21/3	Christensen (1985)	Amphibolite	56	ppb

EXPLORATION HISTORY

The files of the GGU indicate that very little modern systematic exploration has been undertaken in the region. There is no indication of any modern airborne EM surveys, nor any signs that there have ever been programmes launched for gold or base metals, other than the recent announcement by Nunaoil of its findings from gold exploration (Robyn, 1993).

The most extensive work was performed by Kryolitselskabet Øresund A/S during the sixties and into the seventies. Their efforts resulted in the discovery of the Isua iron deposits, the carbonatite deposits in the north, and the copper-nickel showings of the Norite Belt east of Maniitsoq. This work was wide-ranging and extensive, including airborne magnetic surveys totalling about 60 748 line-kilometres (including areas beyond this sheet) (Peltonen, 1968). They also examined some of the kimberlite dykes east of Maniitsoq (Kurki *et al.*, 1973). They did not however explore directly for gold, and in fact did not include gold among the elements routinely analysed for. Their reports also do not indicate any serious evaluation of any of the supracrustal rocks for volcanogenic massive sulphide deposits.

In the southern portion of the region Platinomino A/S carried out programmes for chromite, platinum, and rubies around the Fiskenæsset igneous complex (Geisler, 1981). Platinomino's work was primarily centred on the anorthosite complex and the chromite horizons. Furthermore a chromite layered bronzitite with minor sulphides was sampled and attempts were made to trace it along strike. Extensive metallurgical tests were carried out on the chromite.

Charter Consolidated conducted regional stream sediment sampling campaigns over several seasons along the west coast in a search for diamonds (Brunet, 1974, 1978). These programmes included examinations of many of the kimberlites identified previously by Kryolitselskabet Øresund A/S as well as those found by themselves. Microdiamonds were found in the Sarfartoq valley in stream sediment samples, but no stones were ever recovered from any of the kimberlites studied and sampled. They concluded that as all of the observed kimberlites and lamprophyres in the area were narrow dykes, the diamonds located in streams were probably derived from one of these sources, and the potential for a large body was poor.

The Greenland Exploration Management Company examined and sampled the molybdenite showings at Lille Narssaq in 1972-1973 before concluding that they were too small.

Cominco (Gill, 1975) performed some limited reconnaissance during 1974 in the region without seeing anything warranting further work, while in 1975 Union Carbide (Liverton, 1975) passed through the Godthåbsfjord area in the course of a brief recconnaissance for quartz for silica feedstock.

Greenex A/S carried out some limited prospecting on Ravns Storø and Bjørnesund in 1985 (Christensen, 1985) and reported a geochemical value of 56 ppb Au from an amphibolite on the south side of Bjørnesund (Fig. 1).

Also in 1985 Kidd Creek Mines Ltd. (Downes & Gardiner, 1986) mounted a field programme of scheelite prospecting based upon Appel's (1983) report. In the course of his work Downes sampled the Ivisârtoq pyrite zone and several other areas for gold, and recommended follow-up, but none was undertaken.

Hecla Mining (Druecker, 1990) organised a small drilling programme in 1989 to investigate the potential for higher grade zones of pyrochlore mineralisation at Sarfartoq. Thirteen holes were put down for a total of 567.51 metres, and their conclusion was that the zones investigated were too small.

DISCUSSION OF EXPLORATION POTENTIAL

The most striking exploration targets are gold and volcanogenic massive sulphide deposits, both of which are untested and virtually never been searched for, in spite of the recognition by Appel (1990b & c) of these settings in the region.

Gold in particular warrants exploration and prospecting especially considering the recently discovered visible gold found by GGU and Nunaoil. The known occurrences have undergone only cursory sampling, and none has been subjected to the systematic sampling and assaying that would have been carried out in say, Canada, or Australia.

The supracrustal belts in the central part of the area where they are most extensive deserve programmes of prospecting and sampling.

Base metals also are worthy of more attention. The supracrustals in the Akulleq terrane and to the south are the thickest and most extensive, and in these the relatively widespread occurrences of cordierite-anthophyllite have been noted and compiled by Appel (1990b). Mineral assemblages of this type have been observed in close association with massive sulphide deposits in Canada at Montauban, Geco, Winston Lake and elsewhere. The rocks are usually interpreted to represent alteration products. In this area the genesis of this distinctive suite has been variously interpreted as felsic volcanoclastic sediments altered by seawater prior to metamorphism (Smith *et al.*, 1992), and as analogues to the alteration products at northwestern Ontario deposits such as Geco by Appel (1990b).

From an exploration point of view the observation that base metal sulphide mineralisation, gahnite, and large amounts of pryite and pyrrhotite are associated with the quartz-cordierite-anthophyllite rocks, should be enough incentive to investigate these suites further, particularly with a view to carrying out whole rock geochemistry to delineate alteration focal centres.

Diamondiferous kimberlites may still be found in the area. Obviously the fact that Charter Consolidated found diamonds in stream sediments at Sarfartoq is noteworthy, and they also found numerous indicator minerals. Moreover the mineralogical investigations by Larsen & Rønsbo (1993) suggest that some of the kimberlites were derived from mantle depths appropriate for diamond generation. All of the kimberlites found to date are in the form of dykes. It is, however, not uncommon to have an abundance of kimberlite dykes occurring together with kimberlite pipes as seen in South Africa.

Other established targets in the region such as the Cu-Ni (PGE) mineralisation in the Norite Belt, the chromite and PGE mineralisation in the Fiskenæsset complex, and the carbonatite complexes at Sarfartoq and Qaqarssuk, are all available immediately to explore, but activity in these areas is a function of commodity prices and demand, and the competition from other regions in the world.

Finally there is still a vast area across the northern third of the sheet, roughly above Maniitsoq, where the geology is very imperfectly known, and reconnaissance at a wide scale by Kryolitselskabet Øresund A/S and Charter Consolidated is really the only work done to date. On the basis of present knowledge the only exploration potential identified is for diamonds as noted above.

CONCLUSIONS

The Frederikshåb Isblink - Søndre Strømfjord sheet has excellent potential for gold, base metal massive sulphide, and perhaps to a lesser extent diamond deposits. The region is virtually unexplored for the first two targets, and given the fact that the existing mineral occurrences and other indications to support this contention have all been located basically through conventional mapping or limited direct field work, the potential to generate targets and prospects by simple prospecting must be rated high.

The attractiveness of the region is further enhanced both for exploration and development by the fact that the town of Nuuk with its good port facilities, air access, and air charter and other services is located in the heart of the most favourable geology.

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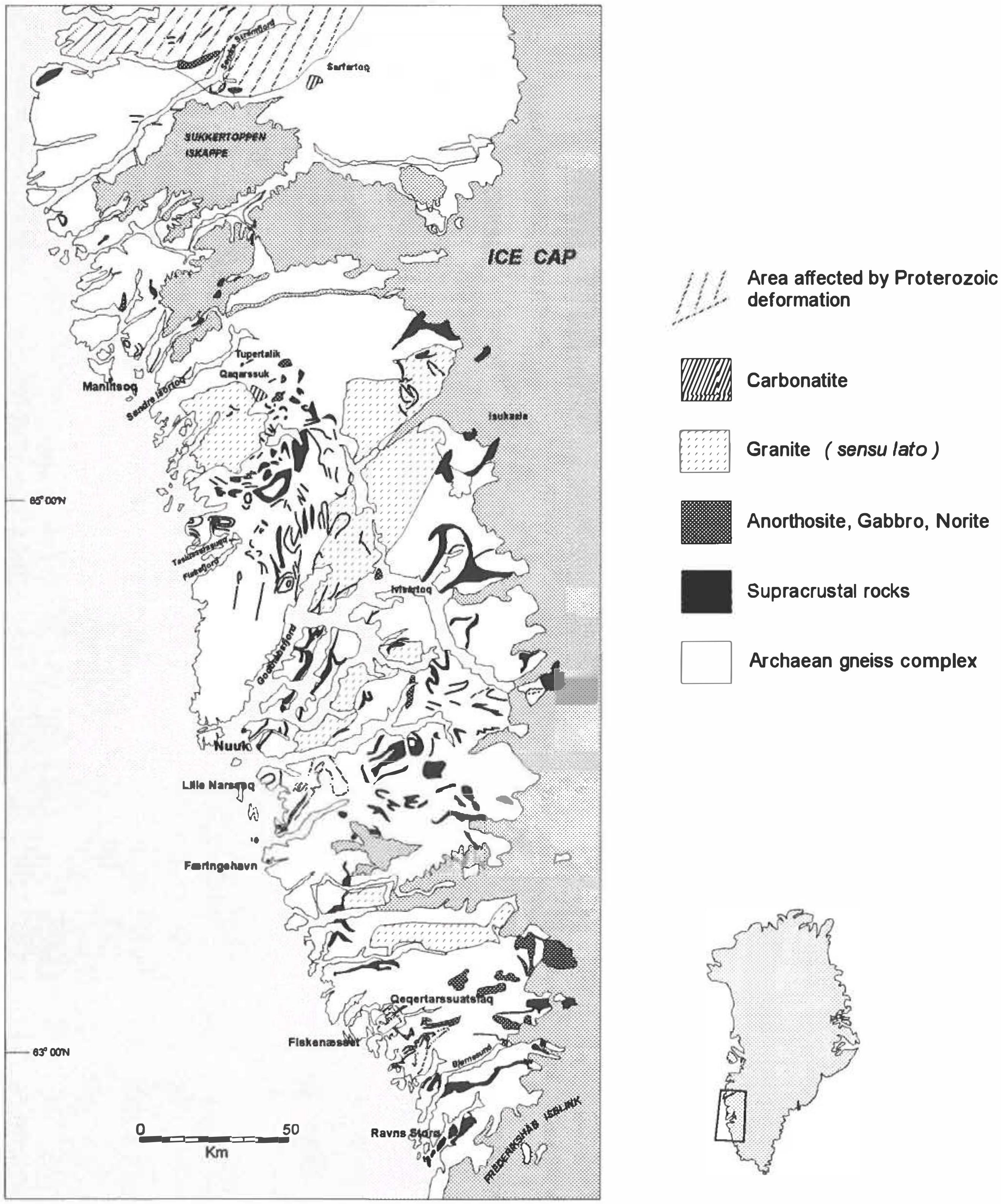

Fig. 1. Geological summary map Frederikshåb Isblink - Søndre Strømfjord
(After Kalsbeek & Garde, 1989)

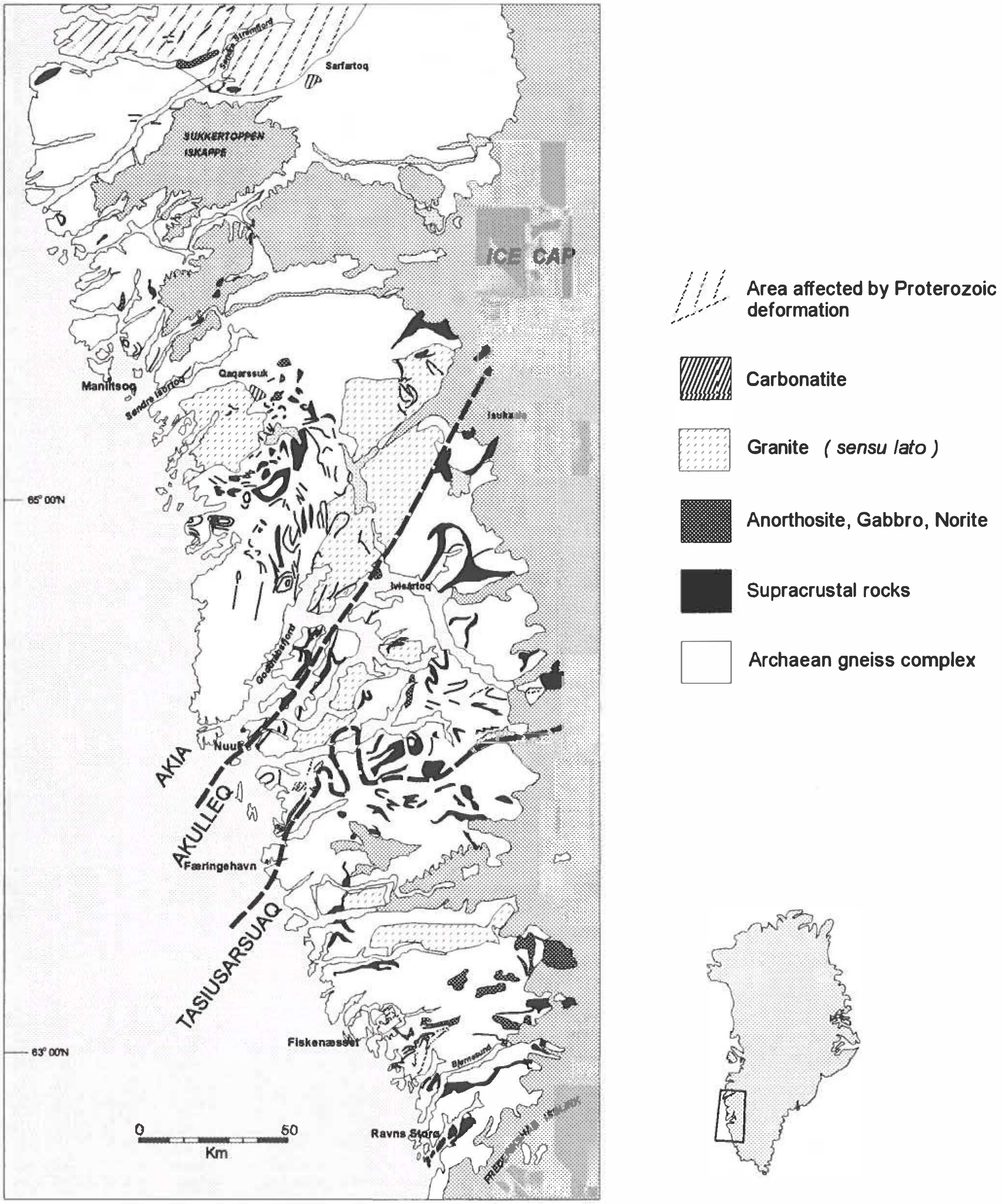

Fig. 2. Proposed terrane boundaries (After McGregor, 1993)

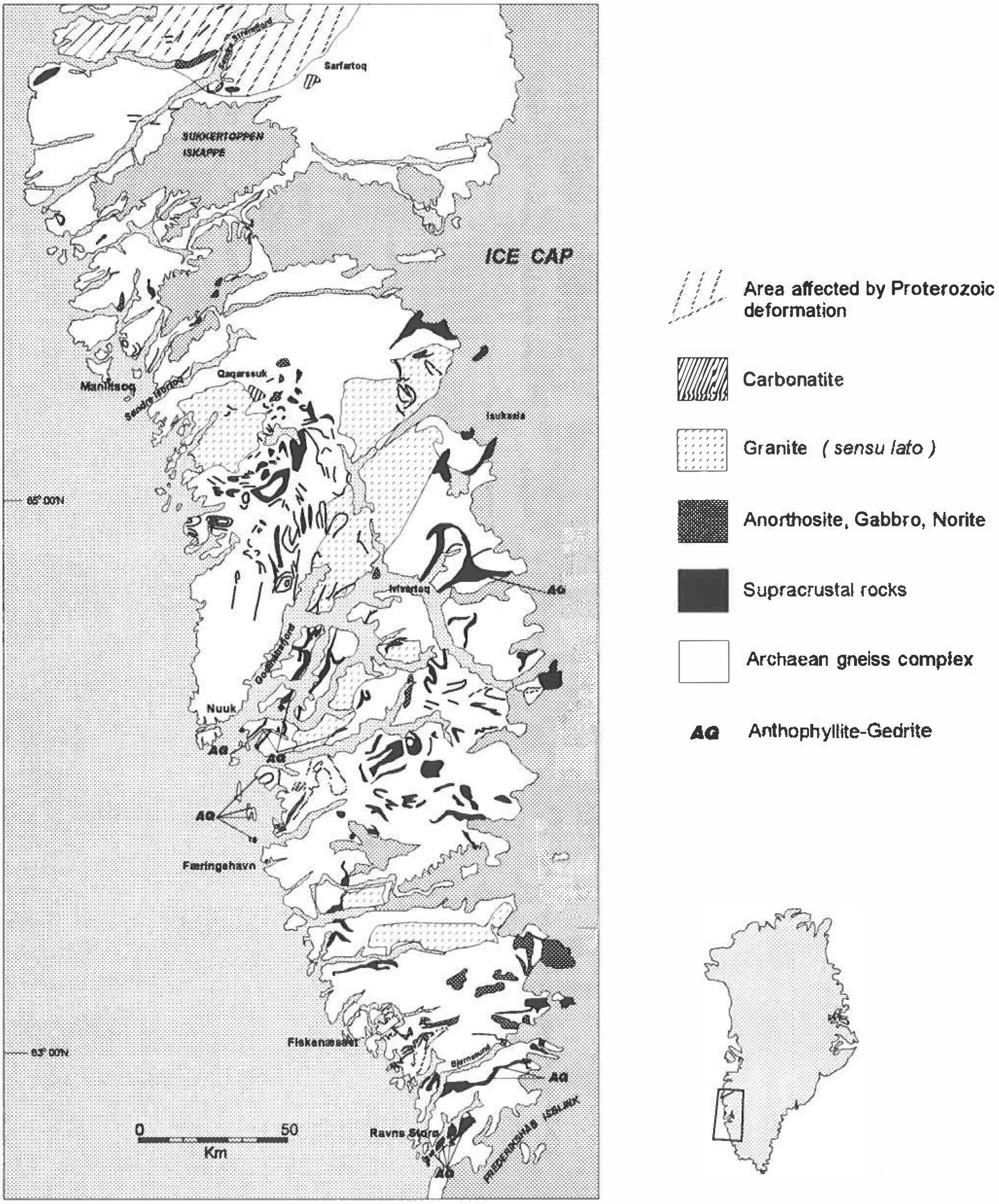

Fig. 3. Locations of anthophyllite-gedrite occurrences (After Appel, 1990b)

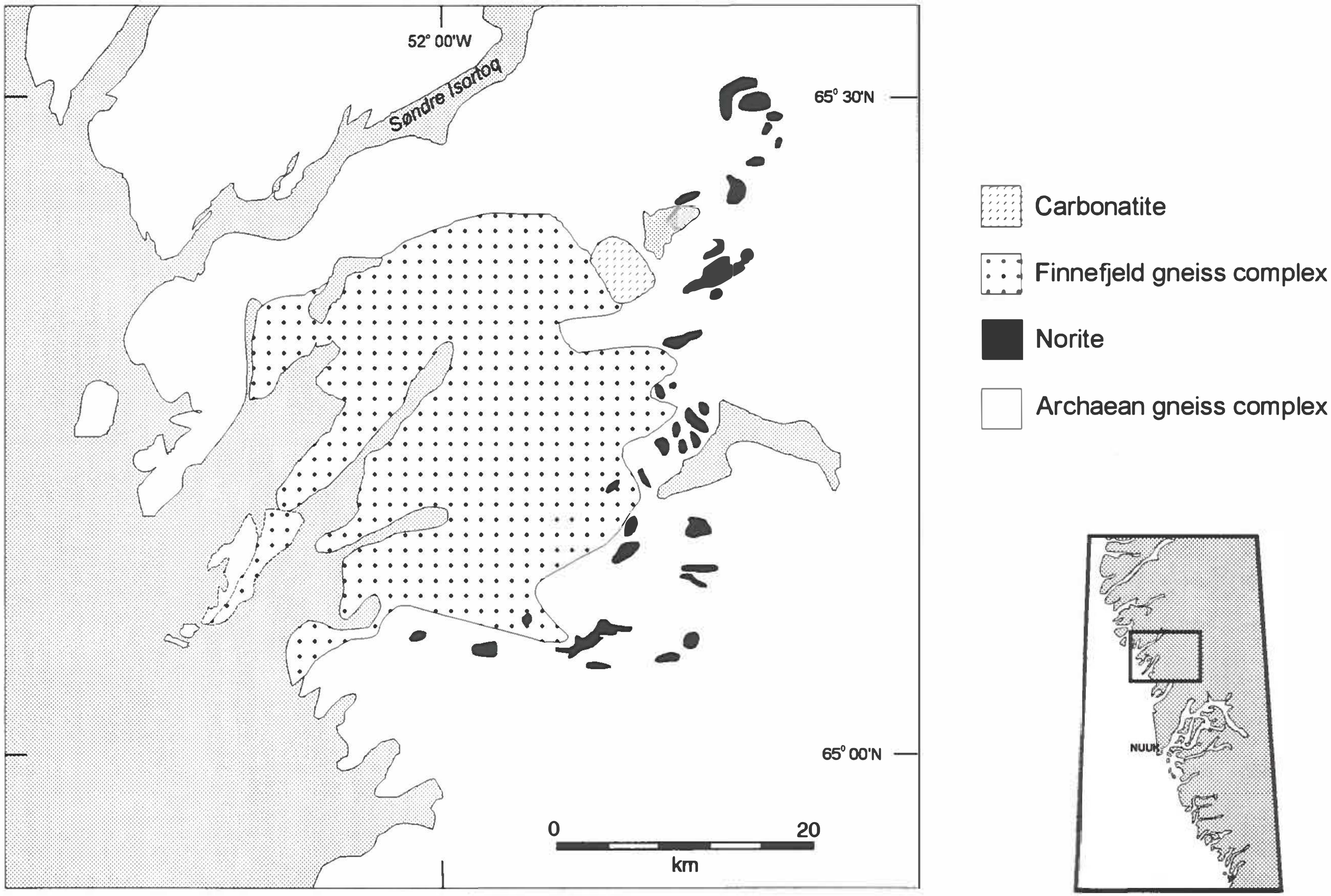

Fig. 4. Location of the Norite Belt (Adapted from Kalsbeek & Garde, 1989)

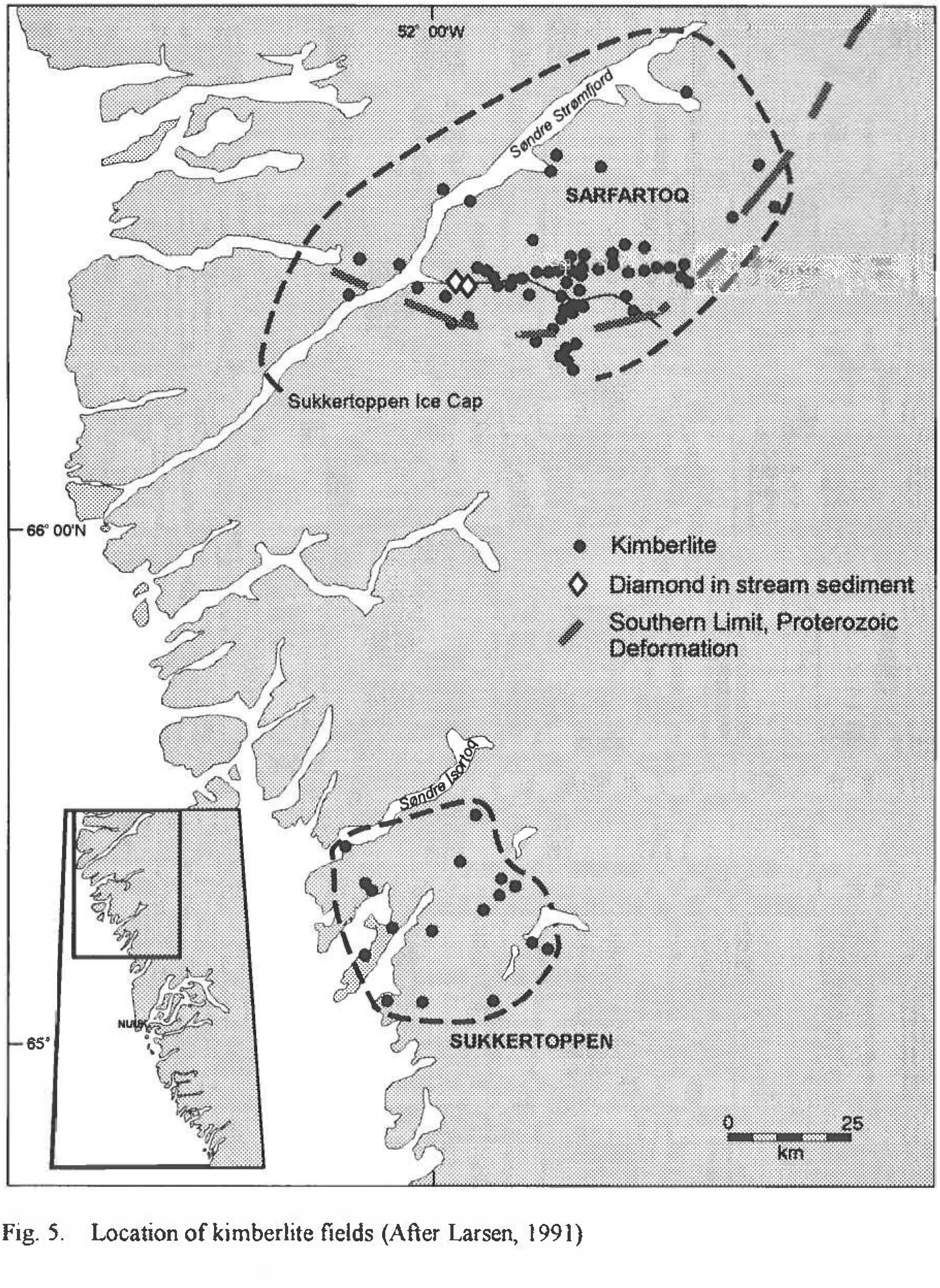

Fig. 5. Location of kimberlite fields (After Larsen, 1991)

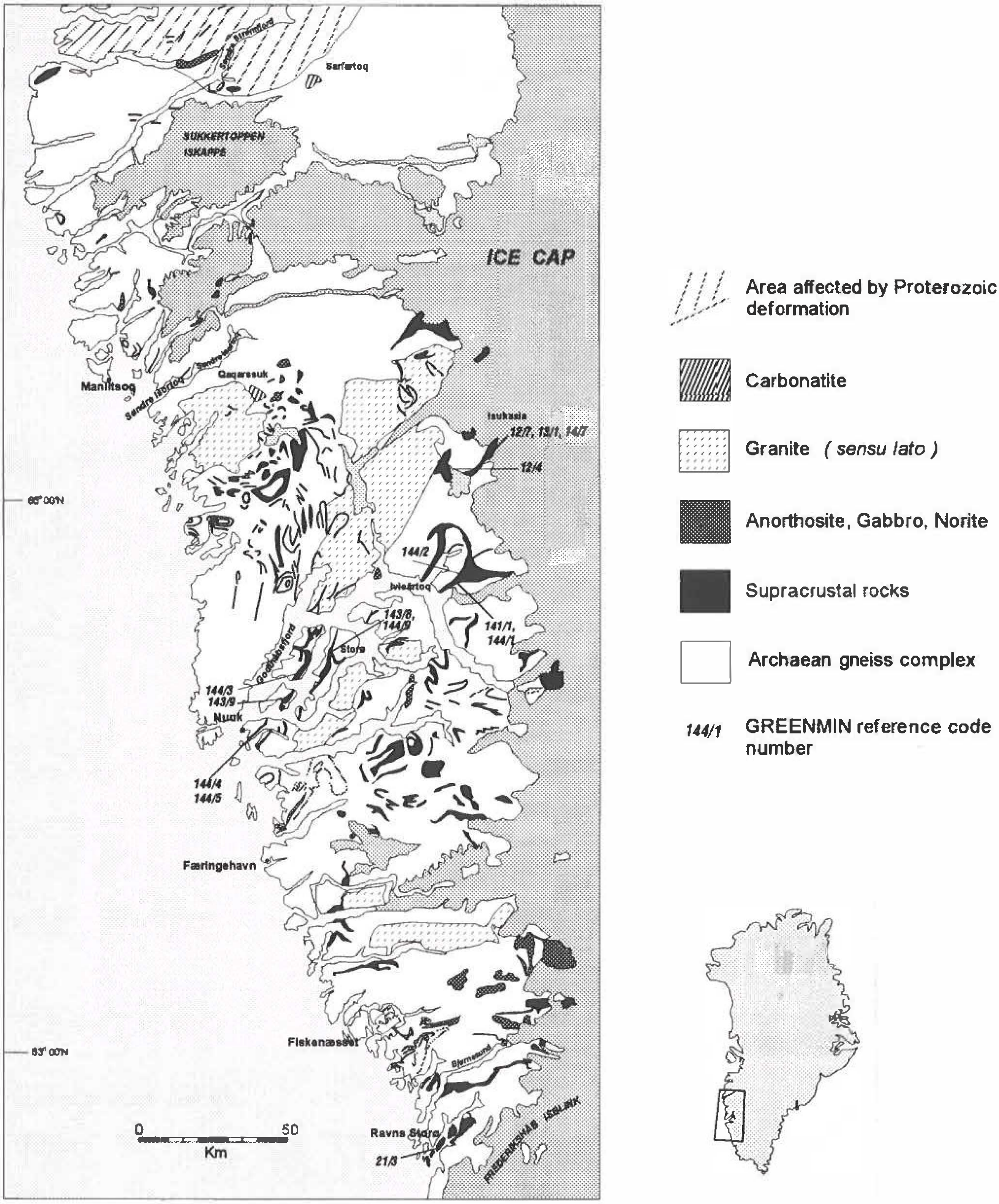

Fig. 6. Locations of gold occurrences referred to in text (After Appel, 1990c)

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