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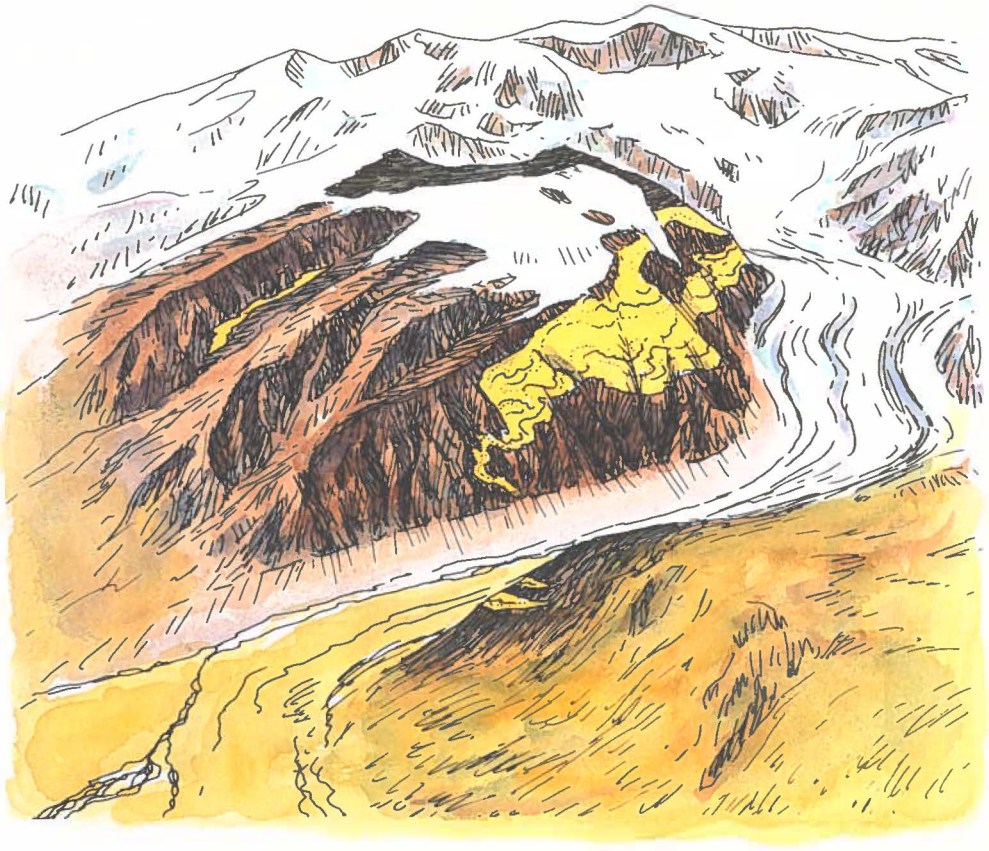
Structural and economic aspects of the Proterozoic marble on Nûgssuaq, West Greenland



Adam A. Garde and Bjørn Thomassen

June 1990

GRØNLANDS GEOLOGISKE UNDERSØGELSE
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ISSN 0903-7322

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ABSTRACT

The Archaean gneisses of central Nûgssuaq host a number of marble occurrences which probably belong to the Lower Proterozoic Mârmorilik Formation. The largest marble occurrence is c. 150 m thick and exposed for c. 4 km along strike in a steep, 500-700 m high mountain cliff. Field work carried out in 1989 suggests that the marble forms a south-west facing recumbent isoclinal fold with a horizontal fold axis trending c. 135°. Horizons of massive sulphides, mainly sphalerite, are known from two localities within this marble occurrence. The mineralisation resembles the ore of the Black Angel mine situated some 80 km further north-east. A chip sample across a c. 1 m thick sulphide horizon returned 45% Zn and 1% Pb. The structural model presented here implies a potential for a significant zinc-lead deposit of the Black Angel type in central Nûgssuaq.

Front cover: The Kanâkip auvfâ mountain in central Nûgssuaq viewed towards the north-west, with marble outcrops shown in light yellow. Drawn by Bodil Sikker Hansen from an oblique aerial photograph. The scale approximates 1:25 000 in the central part of the picture.

CONTENTS

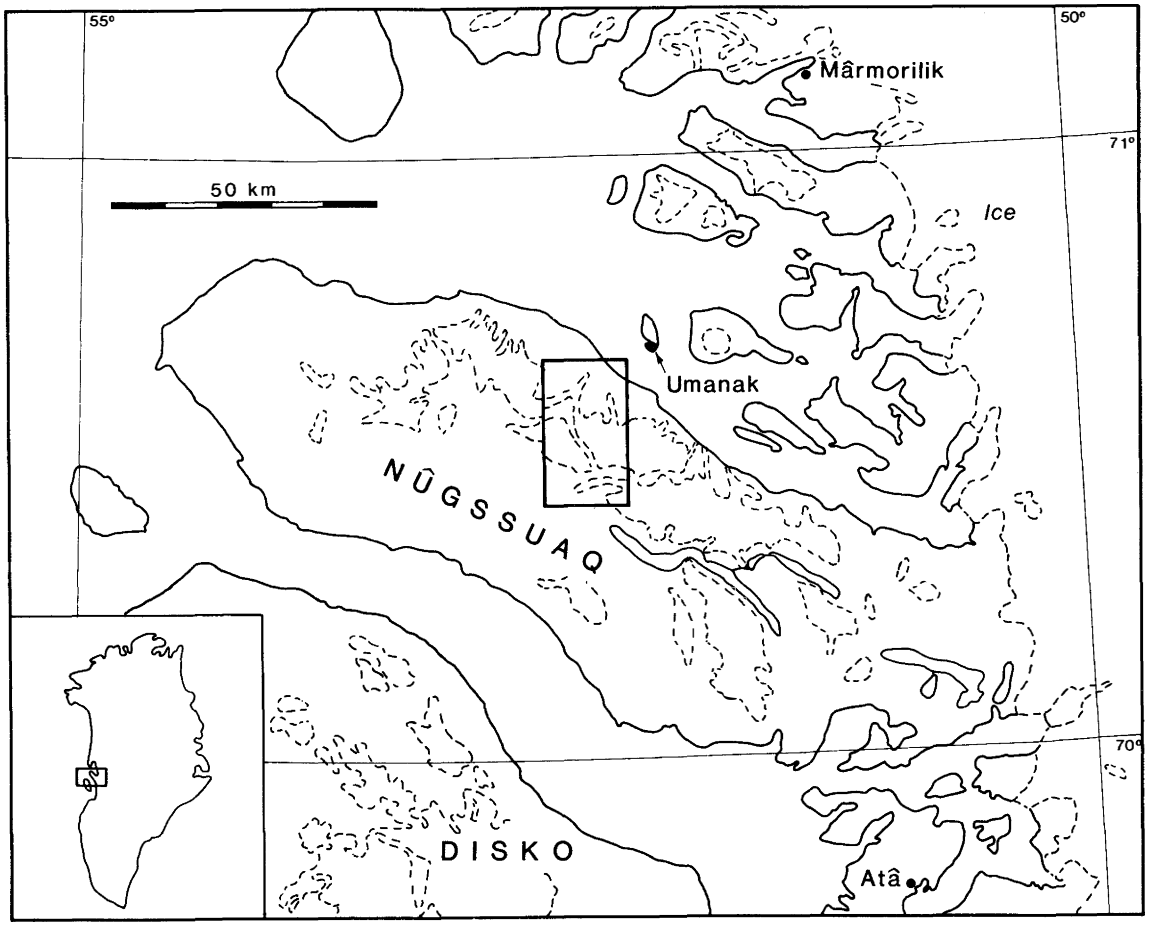


Fig. 1. Index map. The studied area is framed, cf. fig. 2.

1. INTRODUCTION

Scattered outcrops of marble occur in the central parts of Nûgssuaq peninsula in West Greenland (figs 1, 2). They are believed to belong to the Lower Proterozoic Mârmorilik Formation of the Umanak district (Garde, 1978; Henderson & Pulvertaft, 1987). This formation contains the exploited Black Angel zinc-lead deposit at Mârmorilik as well as several other occurrences of massive zinc-lead sulphides, which are invariably concentrated in the hinge zones of large fold structures (Pedersen, 1980). At Nûgssuaq zinc mineralisation was located in the largest marble outcrop by Greenex A/S in 1982 (King, 1983). Based on their structural interpretation, Greenex A/S concluded that the preserved volume of marble is too small to host a base metal deposit of economic size (Kurt Christensen, pers. comm., 1989).

During a geological reconnaissance in 1989 of the Disko Bugt area (Kalsbeek, 1990), some of the marble outcrops in central Nûgssuaq were visited by

the Geological Survey of Greenland (GGU) (Thomassen, 1989). The marbles are exposed on steep cliffs in alpine terrain, and most of the exposures are only accessible at the base and top of the cliffs. Therefore a substantial part of the conclusions presented here are based on observations made from a helicopter under favourable light conditions.

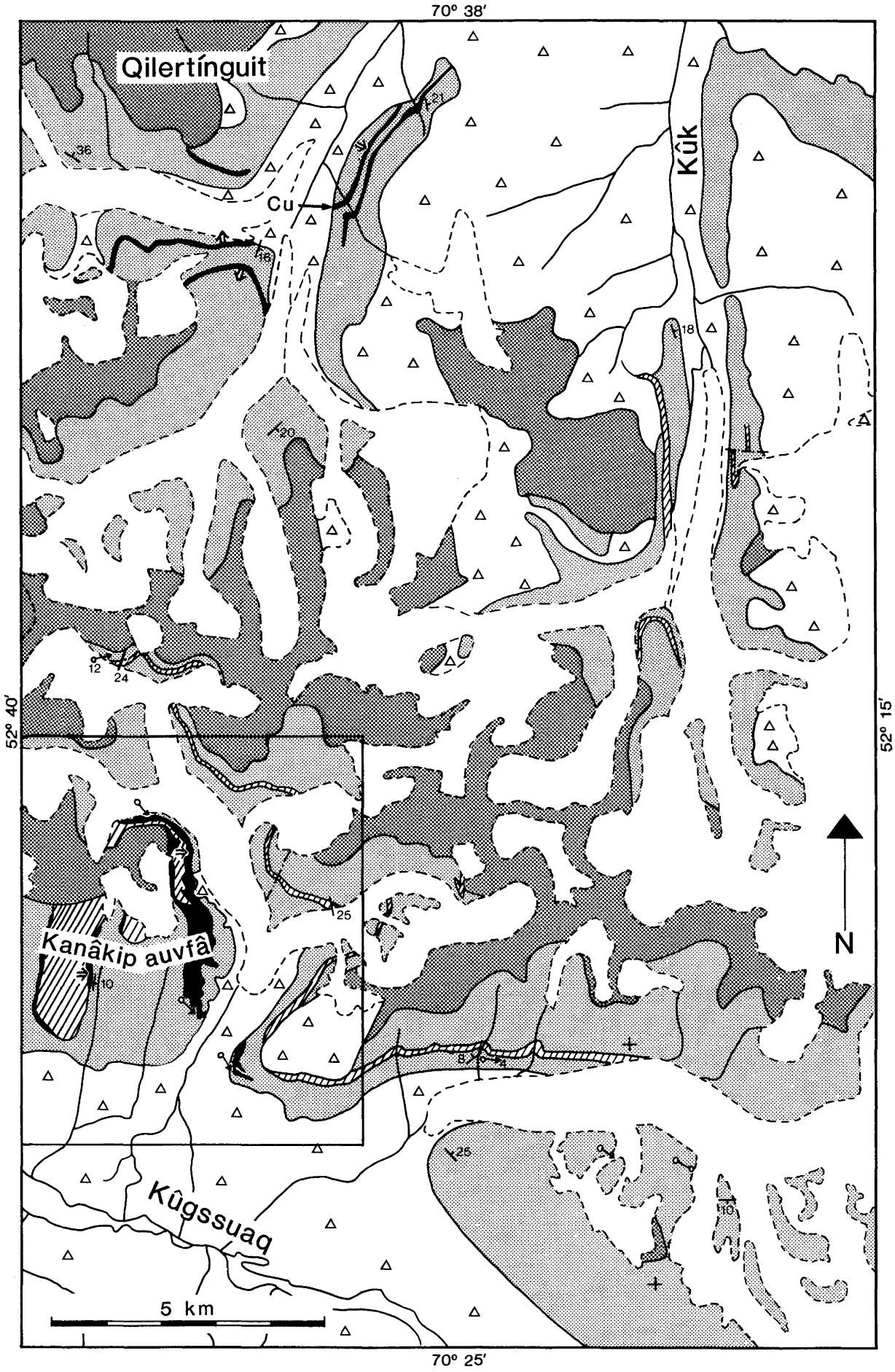
This report presents a new structural interpretation of the main marble occurrence at Nûgssuaq, and assesses its implication for the ore potential of the area.

2. GENERAL GEOLOGY

Fig. 2 is a simplified map of part of central Nûgssuaq, showing all the known marble occurrences of presumed Proterozoic age. The marbles are white to yellowish weathering and contain a few thin horizons of semipelite. They are often accompanied by a 5-10 m thick layer of quartzite, which is tentatively correlated with the basal clastic unit of the Mârmorilik Formation (Garde & Pulvertaft, 1976; Garde, 1978). As the individual marble layers in Nûgssuaq either rest on, or are overlain by the quartzite, it is inferred that some of the layers are right way up, and others inverted. The marble layers may thus form lower or upper limbs of disrupted recumbent folds.

The marbles at Qilertínguit in the northern part of fig. 2 form 10-40 m thick, conformable, flat-lying layers bounded on both sides by flat-lying (presumably Archaean) quartzo-feldspathic orthogneisses, which are capped by Cretaceous sediments (in the north) and Tertiary plateau basalts. The structural relations between the individual marble bands in this area are not known. The marbles at Kanâkip auvfâ in the southern part of fig. 2 comprise thin layers and a complex recumbent isocline. Also these marbles are intercalated between older orthogneisses.

In several places layers of dioritic, biotite-rich gneisses and amphibolitic rocks occur in the orthogneisses and sometimes delineate recumbent isoclines. In the Umanak district north of Nûgssuaq, Henderson & Pulvertaft (1987) and Grocott & Pulvertaft (in press) have described Proterozoic tectonic interleaving of Archaean gneiss and Proterozoic metasediments, involving large-scale thrust nappes and rotation of fold axes into parallelism with SE-NW transport directions. Similar tectonic processes could have been operating in central Nûgssuaq in order to account for the marble-gneiss relations found in this area. The precise structural relations between all the marbles in central Nûgssuaq are not known.



Ice and snow

Quaternary

Basalt (Tertiary)

Marble (Proterozoic)

Gneiss (Archaean)

Mafic gneiss (? Archaean)

3. STRUCTURE OF THE MARBLE AT KANÂKIP AUVFÂ

At the Kânakip auvfâ mountain there are five separate marble occurrences (fig. 3). It is stressed that whereas the map on fig. 3 is a factual presentation of the marble exposures, the profiles A-A′ to F-F′ are an attempt to illustrate what these marble exposures may look like in three dimensions, based on the outcrops and structural orientations (measured on ground and estimated from helicopter).

The three westernmost exposures are 0-20 m thick, flat-lying and discontinuous. The middle of these exposures displays several SW-vergent overturned folds with subhorizontal east-south-east trending axes. The middle exposure is probably inverted, as a thin quartzite occurs on top of it; the two other exposures have not been visited.

The fourth and largest marble occurrence is exposed along the east- and north-facing sides of Kanâkip auvfâ. Greenex A/S geologists regarded this outcrop as a stack of east-facing "cascade" folds with a horizontal, 012-025° striking axis. According to this model the hinge zone of a major, east facing isoclinal fold has been eroded away, restricting the tectonically thickened marble to a thin fringe along the exposure (King, 1983; Kurt Christensen, pers. comm., 1989).

In our opinion, the cliffs of Kanâkip auvfâ exhibit a complex, south-west facing recumbent isoclinal fold with a horizontal fold axis trending c. 135°. The hinge zone of this fold is well exposed in the south-eastern part of Kanâkip auvfâ, see frontispiece and fig. 4. The hinge zone is also shown on profile C-C′, fig. 3. The axial direction of the isocline, estimated at a distance from a helicopter, is supported by measurements on the ground of several smaller folds in the marble, which trend c. 120-135°, and is similar to regional trends of fold axes and lineations measured during the GGU reconnaissance in eastern and central Nûgssuaq. The flat-lying limbs of the isocline are about 150 m thick. The lower limb appears to be inverted, since it is overlain by a thin quartzite layer at section E-E′. The fold is highly asymmetric and non-cylindrical, and contains many smaller internal folds, some of which are

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Fig. 2: Simplified geological map of part of central Nûgssuaq, with the position of the map area covered by fig. 3. Inferred directions of younging are shown by short open arrows. The thicknesses of thin marble layers are exaggerated. Cu indicates copper mineralisation.

recumbent, others overturned to the south-west (fig. 5). The closure zone of the large isocline is likely to continue for some distance towards north-west behind its outcrop in the eastern part of the mountain, but it does not reappear on the north-west facing cliffs in the northern part of the mountain. Here only the lower limb is exposed.

The fifth marble outcrop occurs on the mountain east of Kanâkip auvfâ. This outcrop, which is c. 100 m thick, consists of several recumbent isoclines with south-east trending axes. It probably pinches out (without fold closures) towards the east, but exposure is poor on the south-facing cliff face. The fifth outcrop may be linked structurally to the pinched lowermost part of the large marble fold; compare profiles B-B′ and C-C′ on fig. 3.

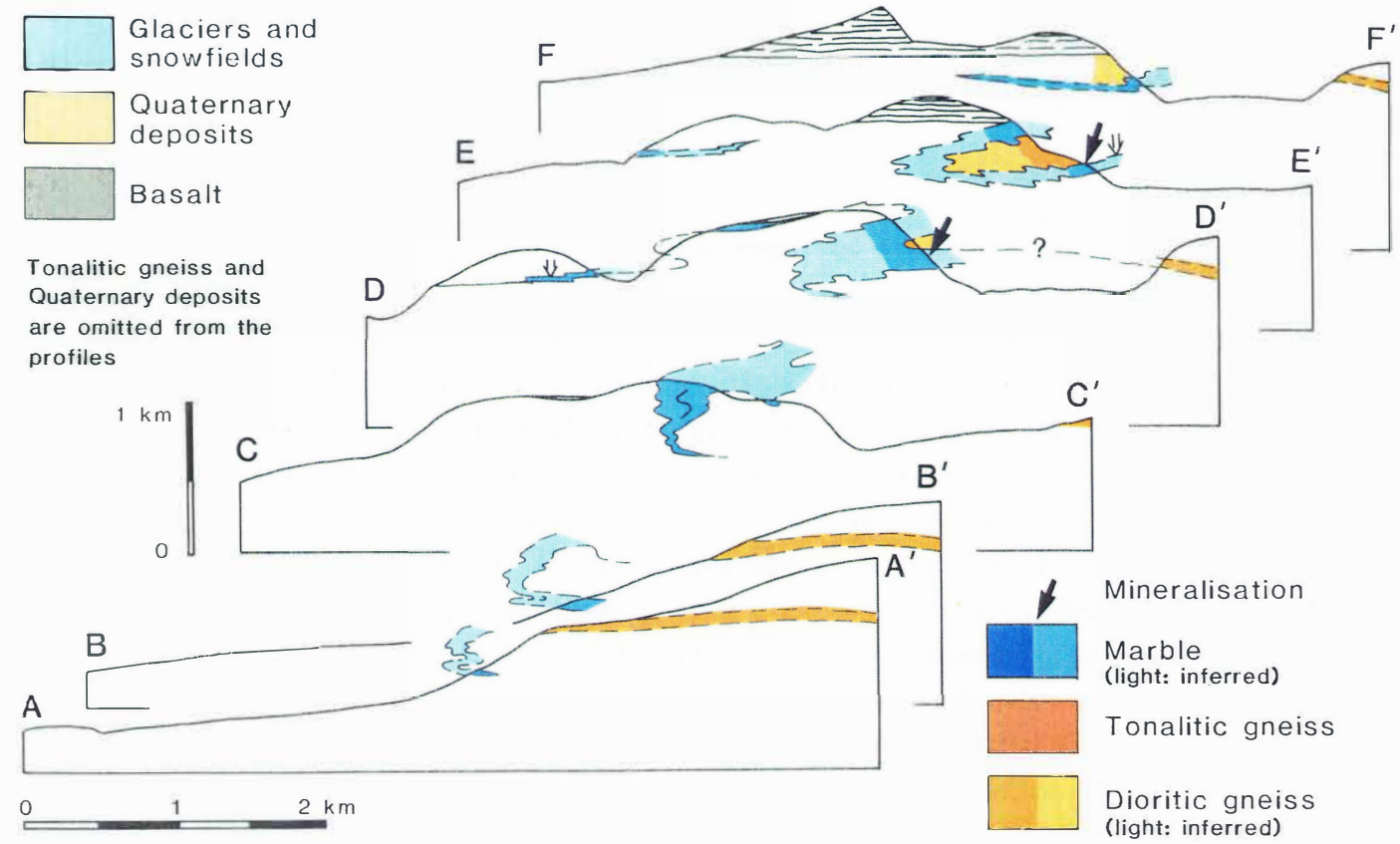
The approximate distribution of dark, brown-grey, biotite-rich gneisses of dioritic composition is also shown on fig. 3. The outcrops of this rock type are only known on appearance from a distance, supported by a couple of ground checks. It is possible that the dark gneiss in the core of the large marble fold belongs to the same lithological/structural unit as the flat-lying dioritic gneiss layer in the eastern part of fig. 3, as suggested on the profile D-D′.

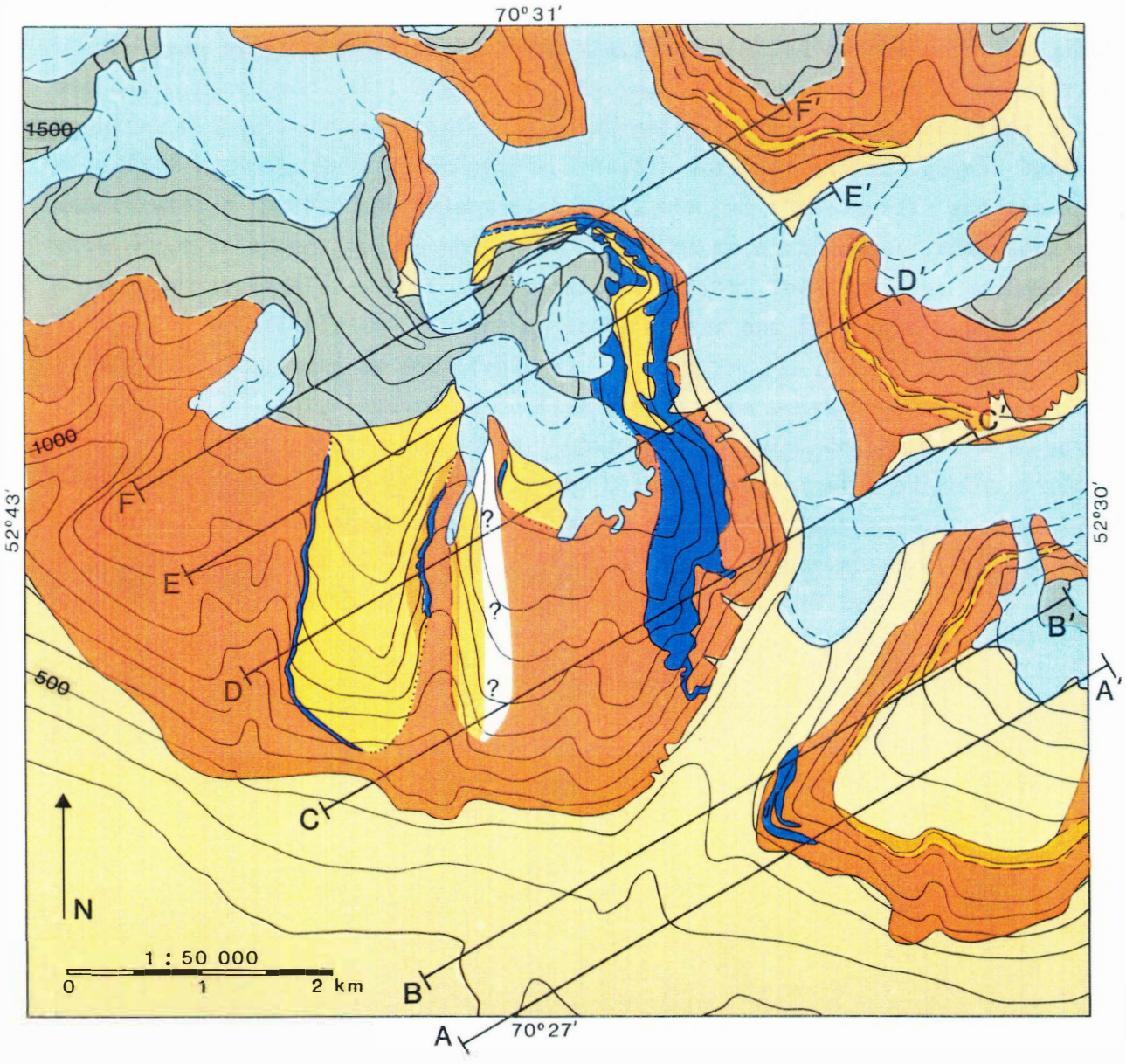
4. MINERALISATION

The basal quartzite unit of the Mârmorilik Formation often weathers rusty brown and contains a few per cent disseminated pyrrhotite and traces of chalcopyrite. Analysis of three samples (table 1) indicates slightly elevated contents of barium (max. 1.1%), copper (max. 328 ppm), gold (max. 11 ppb), palladium (max. 15 ppb) and platinum (max. 12 ppb).

A copper mineralisation was encountered at one locality in the lowermost marble band in the eastern part of the Qilertínguit area (fig. 2). At this locality an intensely folded, c. 0.7 m thick marble zone immediately above the basal quartzite contains minor disseminated chalcopyrite. A grab sample returned 2500 ppm Cu and 206 ppb Au. The lateral extent of the mineralised zone is not known.

Fig. 3. Geological map of Kanâkip auvfâ, central Nûgssuaq. The thicknesses of thin marble layers are 2-3x exaggerated for clarity. The accompanying profiles (horizontal and vertical scales identical) show the authors' interpretation of the marble structure in light blue colour. Short open arrows indicate inferred direction of younging.


Glaciers and snowfields
Quaternary deposits
Basalt
Tonalitic gneiss and Quaternary deposits are omitted from the profiles
1 km
0
F
F′
E
E′
D
D′
C
C′
B
B′
A
A′
?
0
1
2 km
Mineralisation
Marble
(light: inferred)
Tonalitic gneiss
Dioritic gneiss
(light: inferred)


70°31′
70°27′
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1500
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2 km

Horizons of massive sulphides have been reported from two localities 1 km apart at the steep eastern escarpment of the Kanâkip auvfâ mountain (King, 1983). These are referred to below as the northern and southern localities. The mineralisation occurs in the strongly small-folded upper part of the lower limb of the large recumbent isocline (fig. 3, sections D-D'and E-E).

Northern locality. Thîs was briefly visited in 1989. It is accessible at 1170 m a.s.l. between the main valley and an east-west orientated gully (fig. 5). Here the sulphide horizon is flat lying and c. 1 m thick (fig. 6). Towards the west it thins to 5 cm over 30-50 m and peters out. Towards the north the horizon thins to c. 0.5 m over the distance of 10-15 m where it is accessible, but the mineralisation is seen to continue further north in the inaccessible, near vertical cliff face. From a helicopter flypast it is estimated to continue with variable thickness for more than 100 m. A thinner sulphide horizon situated 10 m below the main horizon was observed through binoculars by King (1983). It may be the same horizon, repeated by folding.

The main sulphide horizon exhibits sharp, tectonized contacts to the marble and has a pinch-and-swell structure. The weathered surface is dull brown with a white coating and very faint malachite staining. The horizon consists mainly of medium-grained, dark brown sphalerite with some marble inclusions. Pyrite constitutes c. 5 vol% and galena c. 1 vol%, whereas chalcopyrite and tennantite occur in trace amounts only. The sulphides form anhedral, irregularly intergrown aggregates with a sparse calcite matrix. The high zinc content of c. 43% and relatively low content of lead, silver and iron reported by King (1983) were confirmed by GGU (table 2).

Southern locality. According to King (1983), the southern mineralised locality comprises an inaccessible, upper massive sulphide horizon with an estimated strike length of c. 60 m, and a lower semi-massive sulphide horizon (perhaps the former horizon repeated by folding). The latter occurs over 10-15 m thicknesses with a strike length of 50 m. Three grab samples from this horizon assayed 8.3-15.2% Zn, 0.03-1.4% Pb and 5.4-27.3% Fe.

Table 1. Metal contents in the basal quartzite unit of the Mârmorilik Formation at Qilertínguit.

GGU No.	Sample type	Width m	Cu ppm	Zn ppm	Pb ppm	Au ppb	Pt ppb	Pd ppb	Ni ppm	As ppm	Mo ppm	Ba ppm	Fe pct
350928	chip	0.5	202	90	7	11	12	14	63	4	24	11200	9.0
350929	chip	2.5	33	29	11	<5	-	-	59	2	12	680	5.0
352386	grab	-	328	129	27	<1	<5	15	130	<1	25	5600	1.8

Analysed by Bondar-Clegg & Co. Ltd.: neutron activation (Ni, As, Mo, Ba, Fe), fire assay (Au, Pt, Pd) and atomic absorption (Cu, Zn, Pb).

Fig. 4. The Kanâkip auvfâ mountain viewed towards the north-west from the helicopter. The photo shows the large south-west facing recumbent isocline, outlined by marble, which is discussed in the text.

Fig. 5. The northern part of the large marble isocline at Kanâkip auvfâ viewed towards north-west. The position of the northern mineralised locality is indicated.

Fig. 6. Close up of the northern mineralised locality at Kanâkip auvfâ. The massive sphalerite horizon is c. 1 m thick.

Fig. 4

Fig. 5

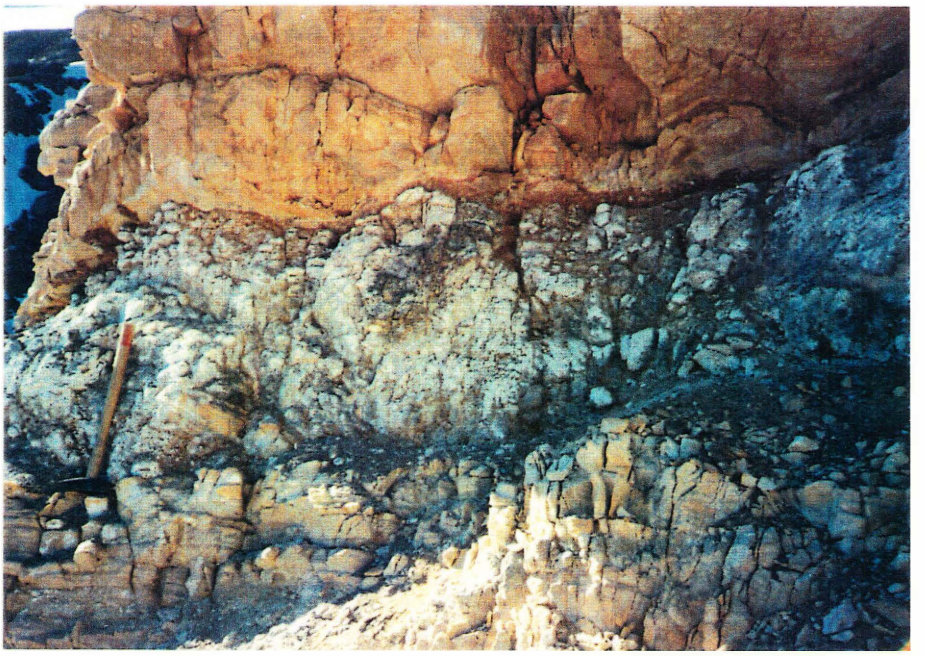

Fig.6

Table 2. Metal contents in the northern zinc showing of Kanâkip auvfâ. Based on chip samples collected by Greenex A/S (9 samples) and GGU (1 sample).

		Width m	Zn pct	Pb pct	Cu ppm	Ag ppm	Fe pct
Greenex	Weighted average	0.67	42.5	0.65	939	9	4.4
	Range	0.20-1.07	35.5-46.6	0.22-1.20	650-1270	5-13	2.7-5.8
GGU No. 350930[x]		0.90	45.3	1.0	1100	10	3.0

x) assayed by Bondar-Clegg & Co. Ltd.

5. ECONOMIC ASPECTS

The type of mineralisation encountered at Kanâkip auvfâ is comparable to some ore types of the Black Angel deposit situated 80 km to the north-east. The main ore bodies of this deposit, the Angel Zone (6.6 mill. tons grading 4.8% Pb and 14.2% Zn) and the Cover Zone (4.0 mill. tons grading 2.8% Pb and 10.5% Zn) each cover an area of c. 0.4 km^2. According to the structural model presented here, the thick marbles of eastern Kanâkip auvfâ extend over an area of 2-3 km^2 and thus have potential for a major ore body of the Black Angel type. Furthermore, the Black Angel ores are characterized by rapid shifts in thickness due to complicated folding patterns in the marbles. Therefore the modest thickness of the main sulphide horizon of Kanâkip auvfâ could possibly change laterally into greater thicknesses in the hinge zone of the large recumbent isocline.

A continued investigation of the zinc-lead sulphide showings at Kanâkip auvfâ should comprise detailed mapping and sampling of all mineralised outcrops by a group of mountaineering geologists, combined with study of the local structure in the mineralised area and its relation to the closure zone of the large recumbent isocline.

6. ACKNOWLEDGEMENTS

The authors thank Feiko Kalsbeek, Agnete Steenfelt and Tapani Tukiainen for cooperation in the field. Bodil Sikker Hansen and Bente Thomas drew the illustrations.

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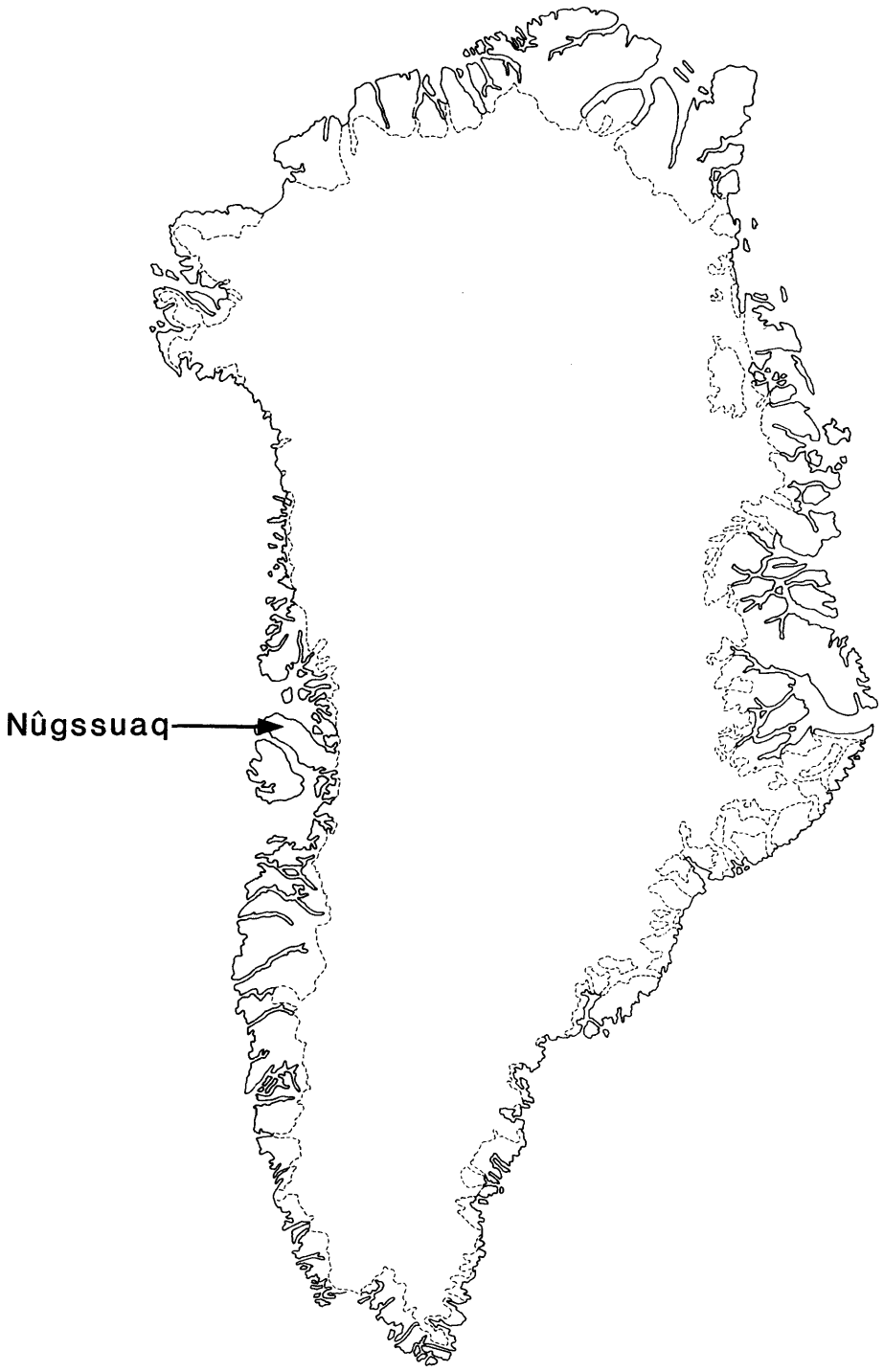

ISSN 0903-7322