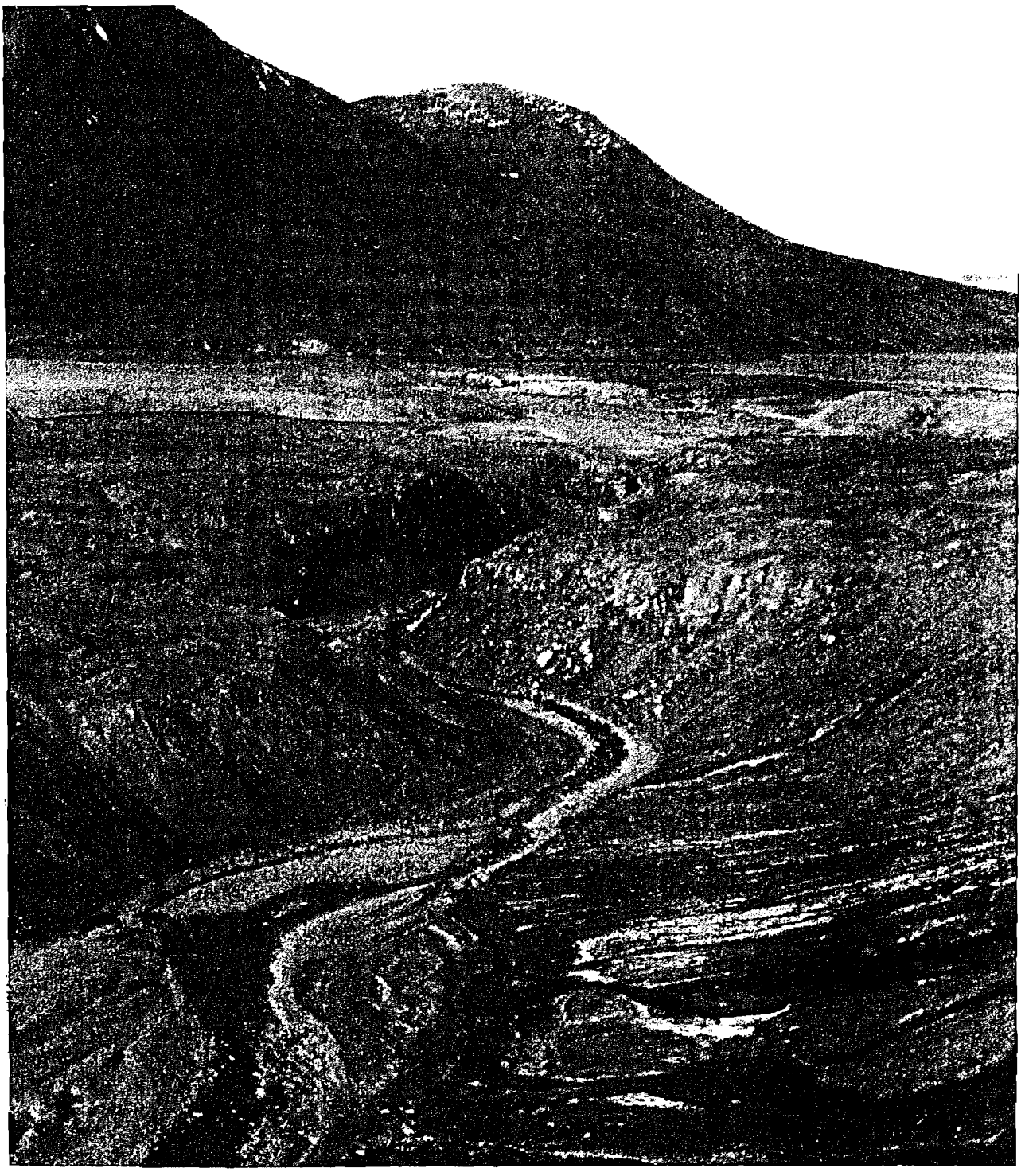
Reconnaissance in the Citronen Fjord Area, North Greenland

August 1993



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Cover photo: Eastern river flowing against NW into Citronen Fjord - August 25, 1993.

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1. SUMMARY

This report describes the field work and results of a reconnaissance study carried out August 1993 in the area around Citronen Fjord in Peary Land, North Greenland. The study was carried out by Hans Christian Langager (Greenland Field Investigations) and Christian Glahder (Greenland Environmental Research Institute) on behalf of the Mineral Resources Administration for Greenland. Initiated by exploration activities for base metals by Platinova A/S the purpose of the reconnaissance study was to gather information to design a back ground study to be set in operation in due time before an eventually mineral exploration in the area.

During the reconnaissance period daily observations of weather conditions indicated that air-temperature is higher than would be expected and also, as would be expected, the local winds through the valleys can reach considerably speeds. A position for the location of a weather station was pointed out.

Preliminary soundings of Citronen Fjord was carried out by means of an instrument with maximum depth range of 80 metres. No sills with water depths less than 80 metres was observed. The western side of Citronen Fjord has steeper slope than the southern and eastern sides.

Estimates and measurements of water flow in the two rivers draining the area indicates that the hydrology is controlled by ablation of local glaciers and melting of the active layer, while surface run-off from precipitation seems to have a minor importance in this arid part of the north.

The terrain consist of sediments of varying thickness with scattered rock showings apart from the mountains surrounding the entire area. Contents of fine materials are widespread in the area resulting in landslips, solifluction, frost boils etc. when combined with moisture over the permafrost table and topographic slope conditions. Areas of permeable soils with considerable bearing capacity are found as well. Wetlands due to melting of the underlying active layer do occur in limited numbers.

Surprisingly, earthquakes of varying magnitude were felt several times daily throughout the entire period. Almost all of the earthquakes were heard and all followed by rock falls on the steeper mountain sides.

Well within the high-arctic climate the Citronen Fjord area is a harsh place to survive for plants and animals.

On land 48 higher plant species were found. The vegetation is sparse with approximately only 5 % covered with continuous vegetation. Because of this big, grazing mammals like the Musk oxen can not subsist here in larger numbers. But the few spots of vegetation are important to the wandering Musk oxen as well as to the Arctic hare and the Collared lemming.

Populations in the area of other land mammals such as Polar wolf, Arctic fox, Arctic hare, Ermine and Collared lemming are most years rather small, but some years, like in 1993, lemmings reach high numbers, which affects populations of predating mammals and birds.

Birds breeding inland such as Red-throated diver, Ptarmigan, waders and passerines are probably only breeding in very few numbers.

The stationary form of the Arctic char is found in the lake at the base camp, while the bigger migrating form is probably not present in the two rivers in the area, because they dry out in winter.

Turning to the Citronen Fjord, the general impression of a poor representation of species and numbers is the same as seen inland: only one seaweed species and only shells from two mussel species are found, one fish species, the Fourhorned sculpin, is caught, and a few numbers of four bird species, King eider, Glaucous gull, Ivory gull and Arctic tern, one Ringed seal and one Polar bear are seen.

But investigations in Jørgen Brønlund Fjord in the southern part of Peary Land suggests that Citronen Fjord is probably richer in species and numbers of seaweed, mussels and fish.

The sea water and fresh water samples show that there is an important chemical weathering of metal-sulphides in the rock-showings up the eastern river. The dissolved metals: zinc, lead and copper, can be found in elevated concentrations both in the eastern river and in the Citronen Fjord.

Liver, muscles and bones from three fourhorned sculpins are analysed for the metals: zinc, lead, cadmium and copper, and no elevated concentrations are found.

A few sediment samples were taken in the Citronen Fjord but not yet analysed.

A proposal to a programme for a back ground study is included in chapter 13.

2. RESUMÈ

Rapporten beskriver resultaterne af en rekognoscering udført i Citronen Fjord-området i Peary Land, Nordgrønland, i august 1993. Undersøgelsen er foretaget af Hans Christian Langager (Grønlands Forundersøgelser) og Christian Glahder (Grønlands Miljøundersøgelser) på vegne af Råstofforvaltningen for Grønland. Baggrunden for denne undersøgelse er Platinova A/S´ mineralefterforskning i foråret og sommeren 1993 i Citronen Fjord området og formålet med undersøgelsen er bl.a. at udarbejde forslag til en baggrundsundersøgelse. Denne skal igangsættes flere år før en eventuel mineraludnyttelse i området.

I rekognosceringsperioden blev der dagligt foretaget observationer af vejret, og disse antyder, at lufttemperaturen er højere end forventet, og at de lokale vinde i dalene som forventet kan blæse med betydelige hastigheder. Der blev under rekognosceringen udpeget en mulig placering af en automatisk vejrstation.

Foreløbige pejlinger blev udført i Citronen Fjord med et ekkolod, der maksimalt kunne nå 80 meters vanddybde. Der blev ikke funderet tærskler på vanddybder lavere end 80 meter. Bunden falder stejlt på den vestlige side af Citronen Fjord, mens den på syd- og østsiden falder mere jævnt udad mod midten.

Målinger og skøn over vandføringen i de to elve i Citronen Fjord-området tyder på, at vandføringen kontrolleres af ablation fra de lokale gletschere samt optøning i det aktive lag. Derimod synes overfladeafstrømning af nedbør kun at være af mindre betydning i dette tørre område.

Citronen Fjord-området er omgivet af relativt høje fjelde. Terrænet består overvejende af sedimenter af varierende mægtigheder med spredte synlige fjeldpartier. Det udbredte indhold af finstof i sedimenterne kombineret med fugtindhold over permafrostspejlet og hældningsforhold resulterer i jordskred, solifluction, "frost boils" etc. Der findes endvidere mere veldrænede områder med betydelig bæreevne - samt få fugtige områder.

Jordskælv af varierende styrke blev følt adskillige gange om dagen i hele rekognosceringsperioden. Næsten alle rystelser kunne høres, og de blev fulgt af stenskred på de stejlere fjeldsider.

Det højarktiske, tørre klima der findes i Citronen Fjord-området gør det til et barskt sted at overleve for planter og dyr.

Der er fundet 48 arter af højere planter. Vegetationen dækker kun ca. 5% af landområderne hvilket betyder, at store, græsædende dyr som moskusokser ikke kan overlede her i større antal. Derimod er de små områder med sammenhængende vegetation vigtige for de moskusokser der vandrer igennem området, og for områdets arktiske sneharer og halsbåndslemminger.

Populationerne af landpattedyr som f.eks. polarulv, polarræv, arktisk snehare, hermelin og halsbåndlemming er små i de fleste år, men i nogle år, som f.eks. 1993, optræder halsbåndslemmingerne i meget store antal, hvilket påvirker populationerne af rovdyr og -fugle.

I området yngler der sandsynligvis kun ganske få par af f.eks. rødstrubet lom, fjeldrype, vadefugle og spurvefugle.

Den stationære form af fjeldørred er fundet i søen ved base campen, mens vandreformen formodentlig ikke findes i de to elve, fordi de tørrer ud om vinteren.

Det samme indtryk af få arter i ringe antal som det blev set i indlandsområderne, synes at gentage sig i selve Citronen Fjord. Her blev der kun fundet en art af tang og kun skaller af to muslingearter. Den eneste fiskeart der blev fanget var hornulk. Desuden blev der set få individer af fire fuglearter: kongeederfugl, grågås, ismåge og havterne, og af havpattedyr blev der set én ringsæl og én isbjørn.

Undersøgelser i Jørgen Brønlund Fjord i den sydlige del af Peary Land antyder dog, at Citronen Fjord er rigere på arter og antal af tang, muslinger og fisk.

Havvands- og ferskvandsprøverne viser, at der er forhøjede koncentrationer af opløst zink, bly og kobber både i fjorden og i den østlige elv. Disse koncentrationer skyldes en betydelig udvaskning af metalsulfider fra blotningen ved den østlige elv.

Lever, muskel og ben fra tre hornulke er analyseret for metallerne bly, zink, cadmium og kobber, og der er ikke fundet forhøjede koncentrationer.

Der er endvidere taget få sedimentprøver i Citronen Fjord, men de er endnu ikke analyseret.

I kapitel 13 er et forslag til et baggrundsundersøgelsesprogram beskrevet.

3. IMAQARNERSIUINERIT AAPPAAT

Nalunaarusiami nassuiarneqarput Avannaani Peary Landimi Citronen Fjordip eqqaatalu aggustusimi 1993 misissuiffiginerani angusat. Misissuineq Atortussiassalerinermi Kalaallit Nunaannut Qullersaqarfik sinnerlugu Hans Christian Langagerimit (Misissueqqaarnerit) Christian Glahderimillu (Kalaallit Nunaanni Mingutsitsisarnernik Misissuisut) ingerlanneqarpoq. Misissuinermut tamatumunnga tunuliaqutaavoq Platinova A/S-ip 1993-ip upernaavani aasaaneranilu Citronen Fjordimi aatsitassanik nassaarniarnera misissuinermilu ilaatigut siunertaavoq tunngavissarsiorluni misissuinissamut siunnersuusiorniarnissaq. Tamanna piffimmi tamaani aatsitassarsiulersinnaaneq ukiunik arlalinnik sioqqullugu aallarnerneqartussaavoq.

Piffissami paasisassarfiusumi ullut tamaasa silasiorneq ingerlanneqartarpoq, tamatumuunalu maluginiarneqarpoq silaannaq ilimagisaniit nillernerusoq, aammalu qooqquni anoraasuasarnerit naatsorsuutigisatut sakkortoorujussuusinnaasut. Paasisassarsiornermi silasiorfeqarfimmut immineerluni ingerlasumut inissiiviusinnaasoq toqqarneqarpoq.

Itissusersiut, immap itissusiani annerpaamik 80 meterinik angusisinnaasoq, atorlugu Citronen Fjordimi misiligutaasumik naleqersaasoqarpoq. 80 meteriniit ikkannerusoqarfiusunik nassaartoqanngilaq. Immap naqqa Citronen Fjordip kimmut sammernani qutaarluusumik itiseriarneqarpoq, kujammut kangimullu sammernani kangerluup qeqqata tungaanut nalimaarnerusumik itisiartortillugu.

Kuuit marluk Citronen Fjordimiittut ingerlaarfiinik uuttortaanerit missingiinerillu naapertorlugit erngup kuunnera tamaani sermit sisoortut nassataannit ujaqqanit sisoornerillu aannerinit aqunneqarsorinarpoq. Akerlianik nittaalanit sialummillu pinngortutut nunap qaavani kuugaarnerit nunami panertumi tamaani suunngitsuinnaapput.

Citronen Fjord qaqqanit portungaatsiartorsuarnit ungalusaavoq. Nunap qaavata qalliutai tassaanerupput kinnerit assigiinngitsunik issussusilikkuutaartut tamatigut tamaana saqqumiinnartunik qaarsortarasaartut. Kinneqarfinni akuuneruppput seqummarissut qeriuaannartup nalaani isugutannersaqartiterlutillu kussariarnerni sisoornertallit, qaarnersaqarfillit issip assigisaasalu piliaannik. Aammattaaq nuna ilaqarpoq panernerusoqarfinnik qajannaannerujussuarnik - annikitsualunnilu isuguttattunik.

Piffissami misissuiffiusumi tamarmi ullormut arlaleriartumik nunap sajunnera assigiinngitsunik sakkortussusilik maluginiarneqartarpoq. Sajuallannerit tamangajammik tusaaneqarsinnaasarput, qaqqallu sivingarnini qutaarluunerusuni sisoortoqarneranik malitseqartarlutik.

Issinnerpaap silaannaa, panertoq Citronen Fjordimi atuuttoq pissutaalluni tamanna naasuisallunilu uumasuisattuuvoq.

Naasut annertunerusut pissuseqatigiiaat 48-it nassaarineqarput. Naaffiusartoq nunatat 5%-iinnaraat tamannalu isumaqarpoq uumasut ivigartortut angisuut soorlu umimmaat amerlanerullutik tamaani uumasinnaanngillat. Akerlianik umimmannut tamaana aqqusaarsillutik ingerlaartunut issittullu ukaliinut avinnganullu (narlumukaanut)pingaarutilinnik ataqatigiiaanik annikitsukkuutaanik naasoqarfeqarpoq.

Miluumasut nunamiutat s.ass. amaqqut, terianniat, issittup ukalii, ukaliatsiaat avinngallu ukiuni amerlanerpaani ikittuararsuusarput, ukiulli ilaanni s.ass. 1993, avinngat amerlalluinnarlutik, taamalu qaasuttunik uumasoqarneranut timmiaqarneranullu sunniuteqarlutik.

Tamaani piaqqiortartut qularnanngitsumik taamaallaat tassaasarput qarsaat, aqissit, timmissat naloraarusillit qupalorarsuillu nuliariikkuutaat ikittuinnaat.

Eqallut sisujuitsut tatsimi tammaarsimaffiup eqqaaniittumi nassaarineqarput, kuuilli marluk ukiuunerani paqqertarnerat pissutaalluni ingerlaarfiusarsimagunaratik.

Nunap timaaniittutulli Citronen Fjordimi namminermi aamma taamatulli amerlanngitsuinnarnik uumassusilinnik peqarsorinarpoq. Tamaani qeqqussat assigiiaat ataasiinnaat nassaarineqarput uillullu assigiinngitsut marluinnaat qaleruakui. Aalisakkanit pisarineqartutuaq tassaavoq kanajoq, hornulk. Tamakkua saniatigut timmissat assigiinngitsut sisamat: Mitit siorakitsut, naajarsuit, imeqqutaallat amerlanngitsuinnaat kiisalu miluumasunit imarmiunit natseq ataaseq nanorlu ataaseq takuneqarput.

Jørgen Brønlund Fjord-imi Peary Landip kujasissuaniittumi misissuinertigut taamaattoq maluginiarneqarpoq Citronen Fjorden qeqquarasaarnerusoq, uiloqarnerulluni aalisagaqarnerullunilu.

Immap ernganit imiinnarmillu misiligutinik misissuinerit takutippaat zinkip, aqerlup kanngussaallu arrornerinik kangerluk kuullu kangilleq akoqarluartut. Taamatut akoqarnerat pissuteqarpoq kuup kangilliup eqqaani saqqumiinnartutut aatsitassaqarfiusup annertuumik imermik errortorneqartuarneranik.

Kanassut pingasut tingui, nerpii saarnilu saffiugassanik aqerlumik, zinkimik, cadmiumimik kanngussammillu akoqarnissaat misissoqqissaarneqarpoq annertuumillu akoqanngitsut paasineqarluni.

Aammattaaq Citronen Fjordimi kinnikuneersunik misissugassanik tigusisoqarpoq, sulili misissoqqissaarneqanngitsunik.

Kapitali 13-imi tunngavissarsiorluni misissuinissat ingerlannissaannut siunnersuut allaaserineqarpoq.

4. INTRODUCTION

In May 1993 Platinova A/S was granted an exclusive exploration licence for areas around Frederick E. Hyde Fjord in Peary Land, North Greenland. In May and June, 1993 geological mapping and sampling field work was carried out as a continuation of a major programme for base metal covering North Greenland from west to east.

The field observations and preliminary results were very encouraging and already in July an extended exploration programme in the area around Citronen Fjord was started. The field work comprised additional mapping and sampling, geophysical investigations and diamond drilling.

In mid September 1993 after accomplishment of several kilometres of geophysics and some 1500 metres of drilling the activities were broken off and the personnel left the area for this season.

As the exploration activities in Citronen Fjord are moving rather fast the MRA, Greenland Environmental Research Institute (GM) and Greenland Field Investigations (GFU) decided to carry out a biological-technical reconnaissance programme in Citronen Fjord in August 1993. The purpose of the study was to prepare for a back ground study and to obtain a knowledge of the licence area to be used in connection with future applications, approvals etc..

During the reconnaissance study the following was performed: In the Citronen Fjord soundings were done, the tide was measured, water- and sediment samples were taken, fishing was done with pound nets, and seaweed, mussels, birds and sea mammals were recorded. In the eastern river and in the lake at the base camp water samples were taken and angling for arctic char was done. Also in the eastern river measurement of water flow was performed. In the terrain materials and processes were observed as well as vegetation, birds and mammals.

Conditions pertaining to transportation, infrastructure, disposal etc. for a possible future mineral operation at Citronen Fjord were not included in this preliminary study.

In this report, prepared jointly by GFU and GM, the above mentioned preliminary studies are described, and where possible compared with literature and other material covering the Peary Land area.

5. LOGISTICS AT THE RECONNAISSANCE STUDY

The reconnaissance study was carried out in the Citronen Fjord area from August 15 - 26, 1993 by Hans Christian Langager (GFU) and Christian Glahder (GM). During the entire period Platinova A/S was working in the area on prospecting, geophysics and diamond drilling.

In the beginning of August 200 kg of equipment was sent with a military Hercules airplane from Værløse (Denmark) to Station Nord. The equipment included rubber boat, outboard motor, echo sounder, bottom sampler, current meter, fishing nets, camp and safety equipment. Persons and additional equipment flew by scheduled route from Copenhagen to Akureyri in North Iceland on August 10 and continued August 11 by a split charter Twin-Otter to Daneborg in northeast Greenland.

After a three day stay in Daneborg persons and equipment continued on the same split charter Twin-Otter to Station Nord with arrival on August 14 late. The next day persons and all equipment were transported by a Platinova A/S charter Twin-Otter from Station Nord to Citronen Fjord.

In the Citronen Fjord area transportation was mostly by foot while for investigations in the fiord a small rubber boat was used. Lifts of the equipment from the airstrip at the head of Citronen Fjord to the base camp some two kilometres away was done by a Hughes - 500 helicopter chartered by Platinova and permanently based in the area. Also a reconnaissance trip to Esrum Sø was carried out with the Platinova helicopter on August 25.

Most of the equipment was transported back to Station Nord from Citronen Fjord by the Platinova Twin-Otter on the evening of August 22 while personnel and the rest of the equipment left Citronen Fjord on August 26 for Station Nord. On August 28 all equipment and personnel were transported by military Hercules from Station Nord to Værløse (Denmark).

Accommodation at Daneborg and at Station Nord was in houses while accommodation in Citronen Fjord area was in tents and sleeping bags at the base camp established by Platinova. During the daytime a tent set up at the head of Citronen Fjord was used.

The decision to investigate the possibilities for carrying out the reconnaissance study was made in June, 1993, so on this short notice and considering the remote part of the world in question the outcome naturally was depending on good-will and help from all involved. Credits for the successful accomplishment of the reconnaissance study are extended to the following:

- Danish Polar Center.
- The Danish Defence Command.
- Flugfelag Nordurlands.
- Sledge Patrol Sirius.
- Personnel at Station Nord.
- Platinova A/S.

Everyone involved in Platinova´s field work around Citronen Fjord during the reconnaissance study will be remembered for their positive attitude and good spirits that contributed to our most profitable and enjoyable stay.

Back in Copenhagen, Christian Bay of the Botanical Museum identified the collected plant species and prepared a list of 48 higher plants. G. Høpner Petersen of the Zoological Museum identified the shells from the two mussels species.

6. DESCRIPTION OF THE AREA

6.1. The Citronen Fjord area

The area covered by the reconnaissance is situated around Citronen Fjord on the southern coast of Frederick E. Hyde Fjord in Peary Land, North Greenland. The latitude is around 83°N and the longitude is around 28°W. The area is situated in the National Park of Greenland which covers an area of 972.000 square kilometers of uninhabited land except for a few manned stations. Closest to the Citronen Fjord area is Station Nord some 200 kilometres to the southeast. This station maintains a military gravel runway allowing for landings with large aircrafts.

The name Citronen Fjord has been suggested by Eigil Knuth in honor of a rather famous member of the danish resistance movement during the Second World War.

The terrain consist of mountains with steep slopes, high dissected plateaus and highly dissected morainal hills. In the lower parts alluvial valleys, undissected plateaus and coastal flats are the dominant components (Davies 1972).

The topographic relief is sketched out on map no. I from where it appears that most of the area is below 600 m with scattered levels between 600-900 m and higher mountains reaching over 900 m crowned by local glacier caps. The uppermost marine limit in this part of Greenland is expected to be around 130 m (Weidick 1972).

The normal transforming processes affecting the landscape through erosion and transportation in this area seems to be accelerated through a notable seismic activity and spectacular wind transportation. Fresh signs of rock fall-out and widespread aeolian deposits are evident many places in this sparsely vegetated, arid region.

At these latitudes with an annual mean temperature around -17°C permafrost naturally exist to considerable depths of several hundred metres (depending on distance to sea etc.). In the terrain evidence of permafrost is visible with solifluction, frost boils, patterned ground etc..

On figure 1 sunrise and - set conditions are indicated in a chart made for Station Nord giving length of day throughout the year. The chart has been calculated for the geoide which means that local topographic conditions have not been considered. The chart has been made in the geographical time zone (GMT -1) but for practical reasons the time used at Station Nord is GMT. At the Citronen Fjord the operator used the correct geographical time of GMT -2.

This high-arctic part of Greenland is well-known to hold potential for archaeological findings although no ruins or artifacts have been located in the area around Citronen Fjord so far.

The magnetic deviation in the area around Citronen Fjord is some 40-45°W.

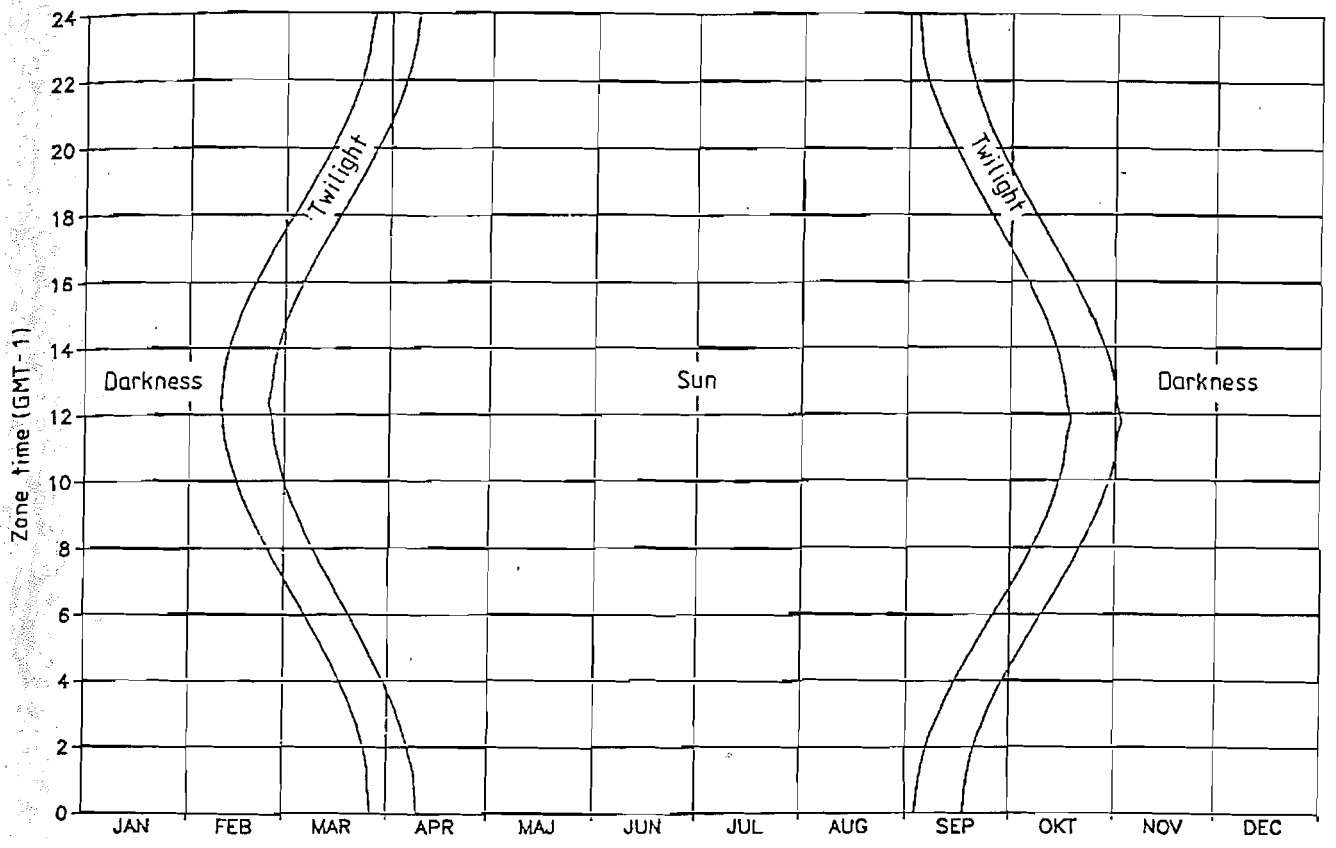

Figure 1: Sunrise, sunset and twilight at Station Nord (81°36'N / 16°40'W).

6.2 Maps and aerial photos

The best topographic map series of the area is published by National Survey and Cadastre, Denmark as ortophotomaps of the scale 1:100.000. Other maps of different scales are known to exist but these maps are not available (Anon. a).

Aerial photos of the area have been taken around 1960 at a scale of approximately 1:60.000 and in 1978 at a scale of 1:150.000. Normally aerial photos can be blown up 5 times at the most without losing to much information thus giving a photographic coverage of the area at approximately 1:12.000 and 1:30.000 (Anon a).

The Geological Survey of Greenland has published a geological map in a scale of 1:500.000 (sheet 8) in 1992 with a full descriptive text (Henriksen 1992).

Apart from the technical maps a number of historic and descriptive maps are know to exist in this remote corner of the world which holds evidence of settlements several thousand years back and furthermore holds enigmas from this century.

The maps at the end of this report display copies of a blown up photo section, the geological map and a reduced section of the topographic maps. The copies do not quite do the original maps full justice.

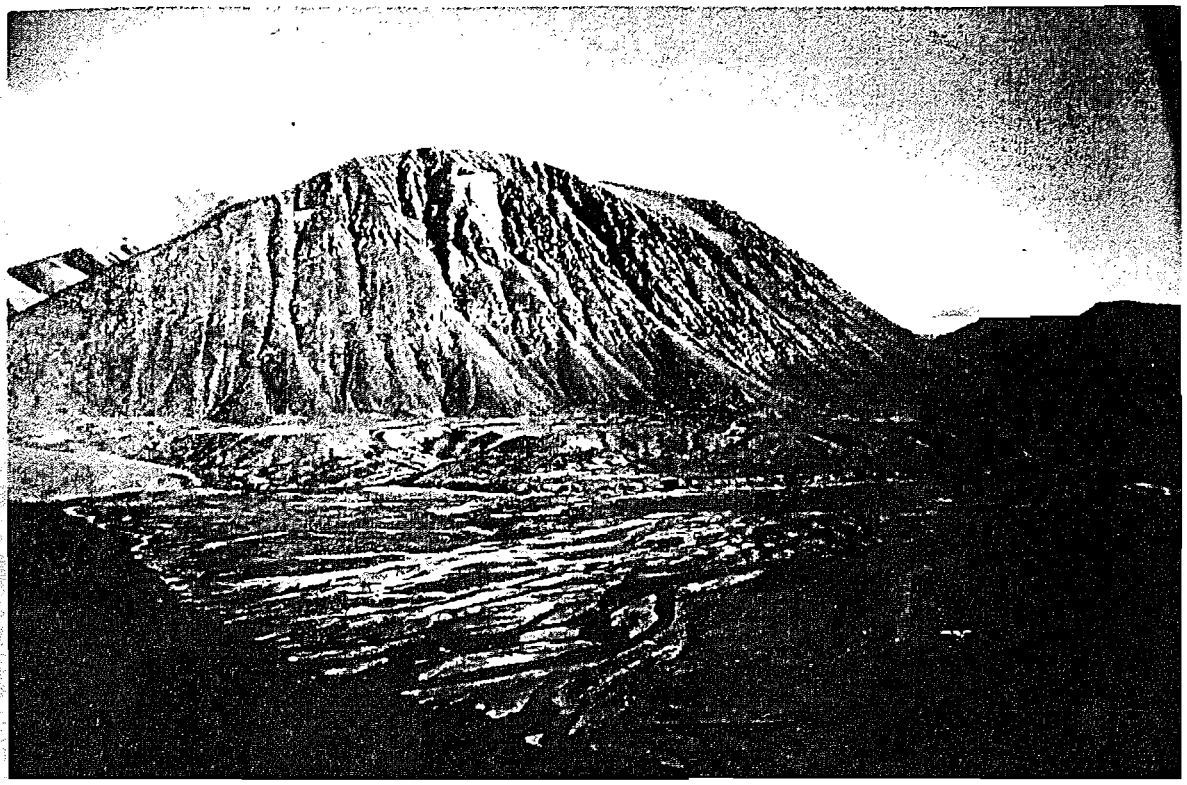

Photo 1: Head of Citronen Fjord and the eastern river delta. Looking eastward, August 15.

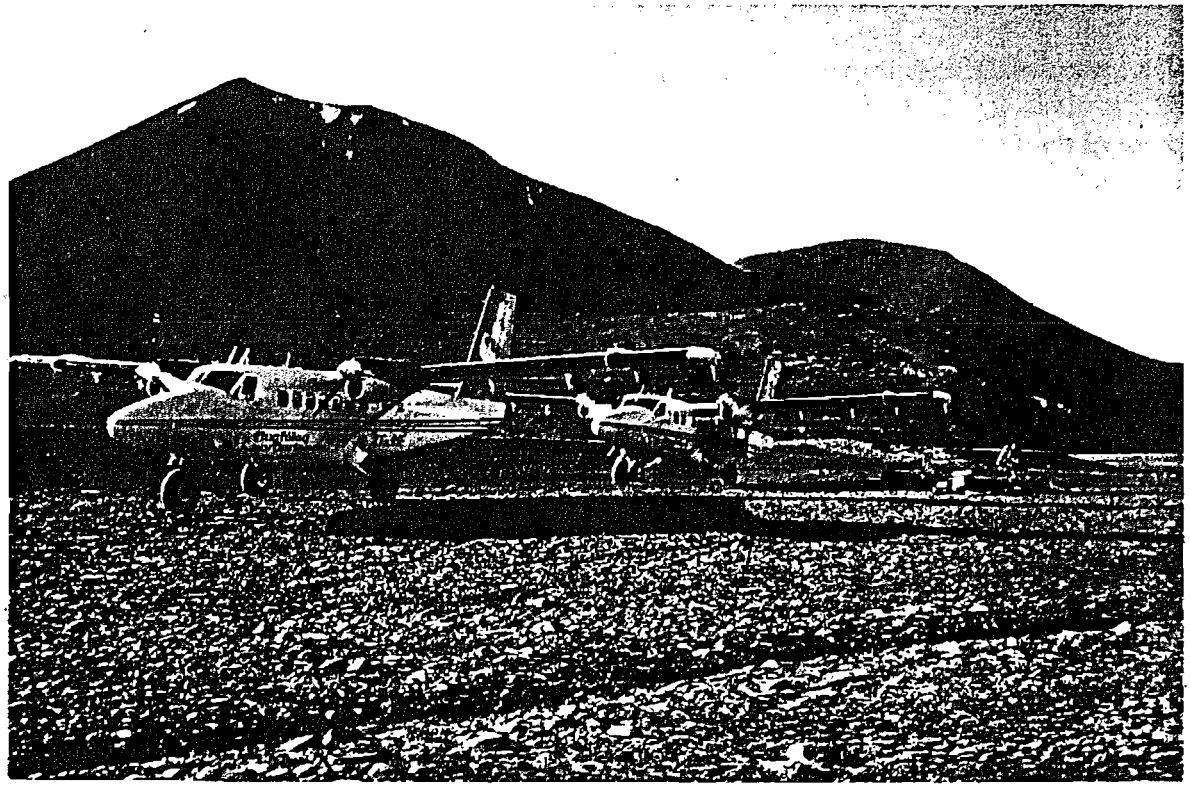

Photo 2: Twin-Otters on the airstrip. Looking toward northwest, August 15.

7. WEATHER AND CLIMATE

During the field work period Platinova A/S had established a transportable automatic weather station at the base camp. The position is shown in map no. II. Data from this station was used for met-reports in connection with flights in and out of the area but also daily readings of 4 parametres were taken regularly at 8 and 17 (GMT -2). At the end of the reconnaissance study on August 26, 1993 a print-out of the daily readings were available covering the period from July 26 - August 26, 1993.

The 4 parametres measured at Citronen Fjord were:

Pressure - Millibars at elevation 50 m (normal pressure 1007), instantaneous value.
Air temperature - °C, instantaneous value.
Wind speed - knot (0,51 m per second), instantaneous value.
Wind direction - 360° true north (magnetic deviation ~ 40°), instantaneous value.

In figure 2 these values have been plotted against time. Also plotted on the figure are readings at Station Nord (elevation 35 m a.s.l.) at 12 and 18 (GMT).

The measurements of pressure is seen to follow the same pattern and are pretty much alike considering the topographic difference of 15 metres giving measurements at Station Nord around 2 millibars higher. The temperature is seen to be distinctly higher at Citronen Fjord due to the more in-land climate here and the constantly cooling ice surrounding Station Nord.

From the wind speed and direction plot it appears that the strongest winds at Citronen Fjord in the period came from southeast blowing out through the valley heading for the fiord. Slightly less strong winds appeared from north going in through the fiord.

Comparison with the data from Station Nord indicates a larger orographic sheltering effect at Citronen Fjord of winds from the inland ice. Especially registrations of south westerly winds is of considerably less speed at Citronen Fjord than at Station Nord which in general is more exposed.

On figure 3 the daily registrations at 12 and 18 (GMT) from 1983-1992 at Station Nord are shown. The daily temperature variation is seen to be on a rather limited scale during spring- and summertime. Melting temperatures appears from end May until beginning of September. The annual mean air temperature at Station Nord is just around -17°C.

Climatic data collection has been carried out at Station Nord since 1961 (by automatic station from 1978). Also at Brønlund Fjord (from 1973) and at Kap Morris Jesup (from 1980) data are being collected. At Kap Harald Moltke a data series from 1983 - 1991 exist. All the stations record barometric pressure, air temperature, wind speed and direction, while precipitation is only measured at Station Nord. In figure 4 precipitation data at Station Nord from 1957, 1960-76 and 1978-81 have been plotted.

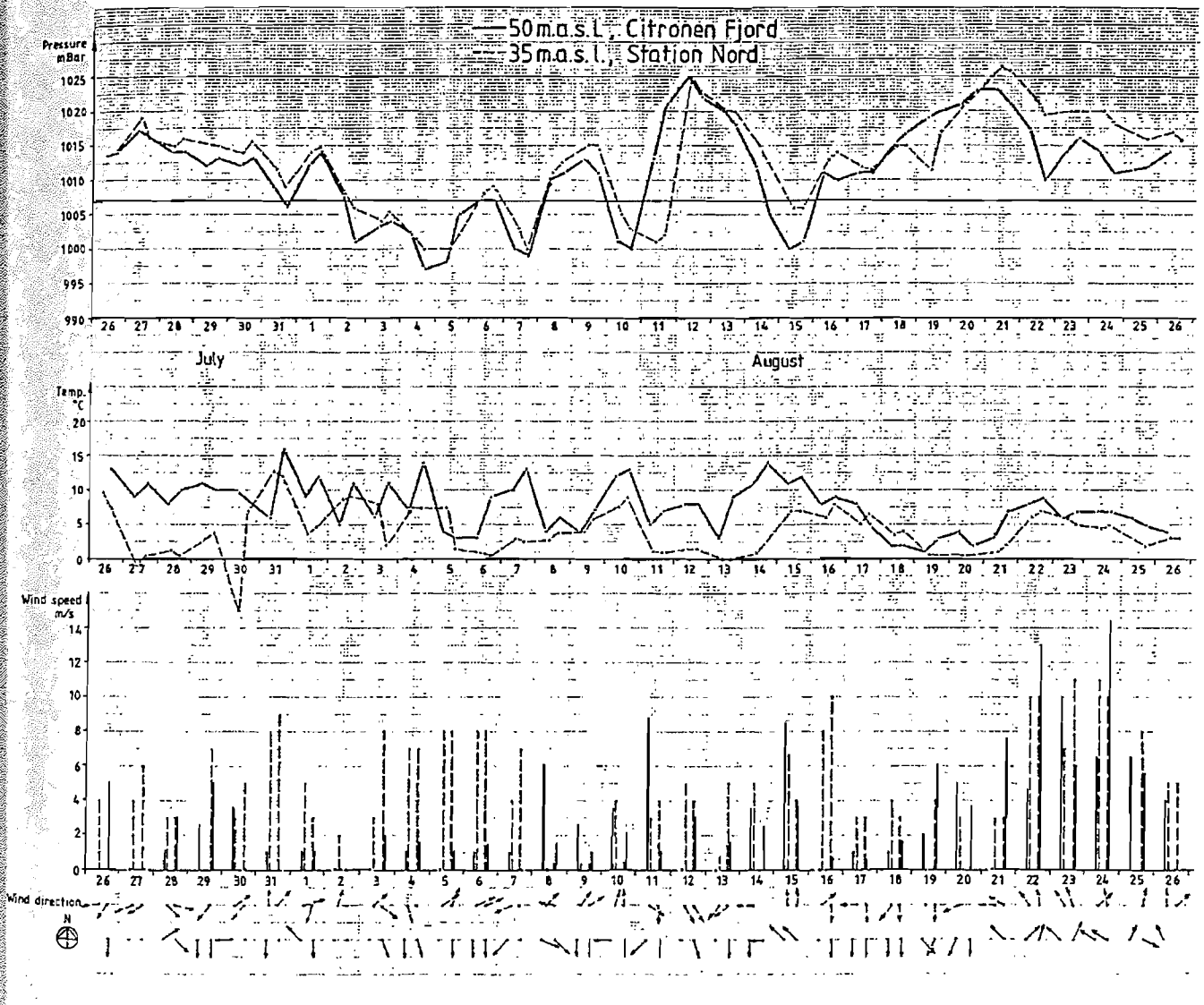

Figure 2: Registrations at base camp/Citronen Fjord and Station Nord of barometric pressure, air temperature and wind speed/direction. July 26 - August 26, 1993. (Source: Platinova A/S & DMI-Denmark).

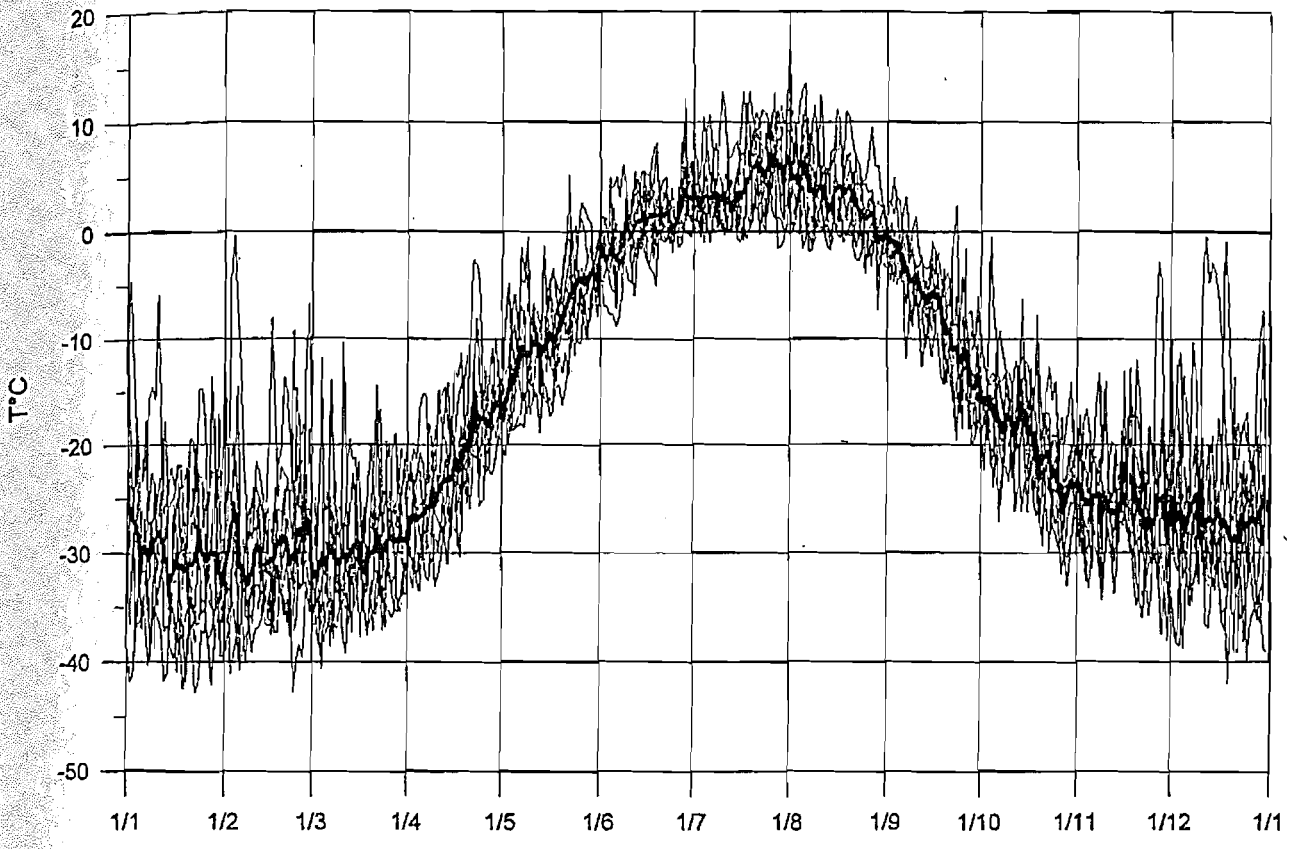

Figure 3: Airtemperature (12, 18 GMT) at Station Nord 1983-1992. (Source: DMI-Denmark).

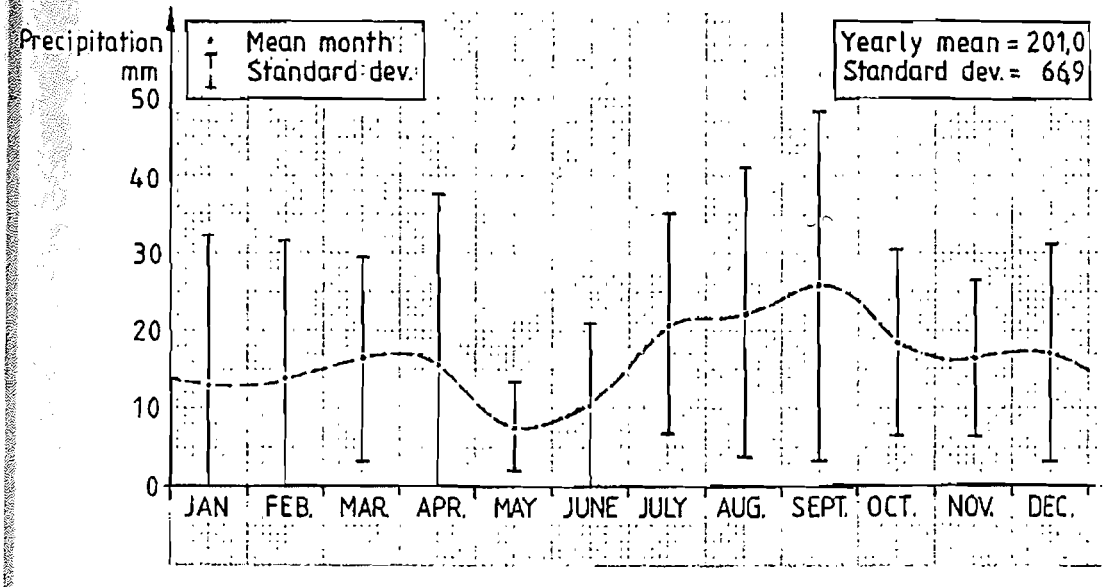

Figure 4: Precipitation at Station Nord 1957, 1960-76 and 1978-81. (Source: DMI-Denmark).

With an eye to a situation with need for specific weather and climate data for the area around Citronen Fjord a position has been located where data collection could be carried out by an automatic weather station all year round. As an option such a station could be equipped with devices allowing for access to actual weather conditions through radio link or satellite. The position is shown on map no. II and has been surveyed by GPS to 83°05.04'N / 28°20.66'W. The elevation is approximately 100 m a.s.l.

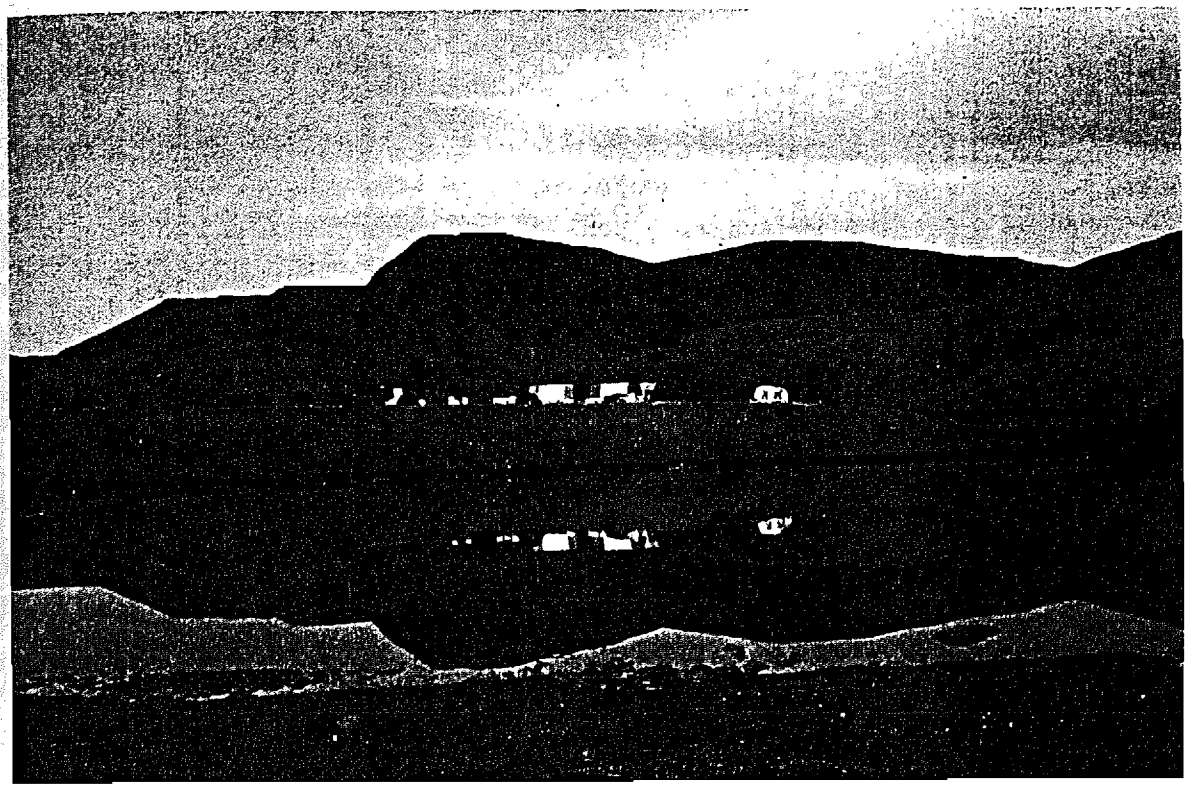

Photo 3: Base camp at the fresh water lake. Looking eastward, midnight August 16.

Photo 4: Strong wind from southeast rising dust in the base camp, August 24.

8. CITRONEN FJORD

8.1 Bathymetry

To get a first impression of the bathymetry of Citronen Fjord a preliminary sounding was carried out on August 21 - 22, 1993. Measurements were carried out with a handheld Furono LE-4000 instrument from a rubber boat. Readings were taken directly from the display with the rubber boat going at low, steady speed navigating for natural fixpoints on land. The maximum range of the instrument was 80 metres.

Working conditions were rather favorable with slight wind, calm sea and good visibility - only 2 minor areas were inaccessible due to floating fiord ice.

The result of the preliminary sounding is shown on figure 5 where routes are indicated with depth readings. Contourlines of 20,50 and 80 m are suggested based on the depth readings. No correction of the depth values for tide is done as this is meaningless compared to the overall uncertainty in positioning the depth measuring points.

Due to the instrumentation and procedure the results of this sounding should be regarded as preliminar. The following can be concluded - see figure 5:

- No sills (of water depths less than 80 m) were observed in Citronen Fjord.
- Maximum depth in Citronen Fjord was not measured but is expected to be well beyond 80 metres.
- The western side of Citronen Fjord has steeper slope than the eastern.
- Depths at the head of Citronen Fjord may indicate a continuation of the outlet from Esrum Elv.

More detailed and accurate soundings should be carried out to verify and detail the very general impression of the depths in Citronen Fjord resulting from this reconnaissance.

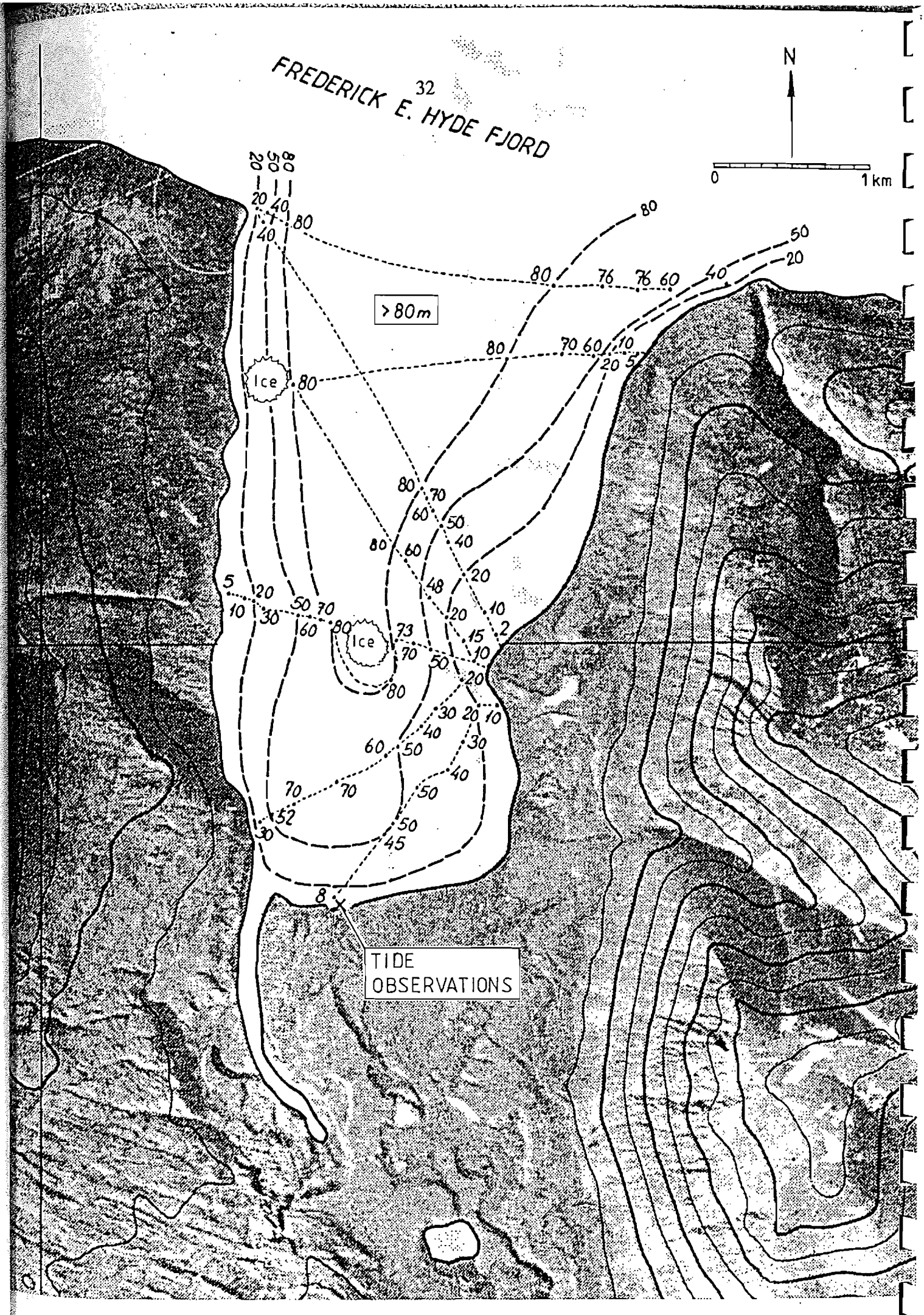

Figure 5: Preliminary soundings in Citronen Fjord, August 21 & 22 1993.

8.2 Tide observations

In order to get a first impression of the tidal variation measurements of the water level in Citronen Fjord was carried out in the period August 16 - 22, 1993.
Readings were taken from a tide staff at the head of Citronen Fjord at irregular intervals. The position is shown on figure 5 and on map II.

The result appears from figure 6, where the readings have been plotted against time. It should be noted that readings have not been corrected for variations in the atmospheric pressure - and that new moon took place on August 17.

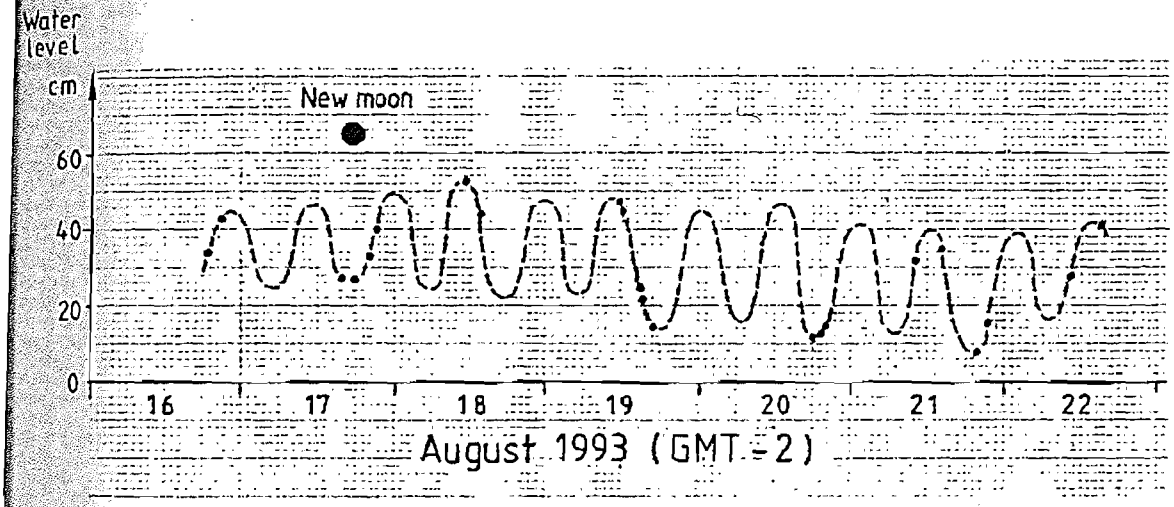

Figure 6: Water level observations in Citronen Fjord.

The measured range of 45 cm together with the roughly sketching of oscillation indicates a tidal range of about half a metre during the measuring period in this sheltered fiord. The barometric pressure measured at the base camp (50 m a.s.l.) is shown in figure 2 from which it appears that August 16 - 22 was a high pressure period (2-15 millibars, locally). This may have suppressed the water level locally.

The tidal range at Danmarkshavn and Mestersvig for the same period both were around 1.6 m, close to the maximum value of range at these places.

Although modest in size the tidal range covers a significant area of the gently sloping shore land at the head of Citronen Fjord.

The tidal range in Jørgen Brønlund Fjord is about 40 cm according to Lundbak (1962).

8.3 Ice conditions

In general the ice conditions in Citronen Fjord were rather light during the entire period of the reconnaissance study, August 15 - 26, 1993. No icebergs occurred and navigation was possible although local congregations of ice floes necessitated minor deviations or "ice breaking". New ice started to form at the end of the period, but the ice vanished as soon as clear, calm situations were succeeded by more windy conditions.

The occurrence of ice in Citronen Fjord was controlled by the breaking up and melting of fiord ice in Frederick E. Hyde Fjord combined with an apparent flow of ice out of Frederick E. Hyde Fjord.

The distribution and intensity of ice in Citronen Fjord was controlled by wind which gave ice concentrations along the western side, the eastern side or at the head of Citronen Fjord from the predominant winds of northwest to northeast. In situations with southern winds from the valleys Citronen Fjord was completely free of ice. Positions of ice floes were very dynamic and conditions were experienced to change completely within a few hours.

Photo 5: Sounding in Citronen Fjord. Looking toward northwest, August 21.

Photo 6: Preparing the tide staff at the head of Citronen Fjord. Looking northward, August 16.

8.4 Sea water samples

Water samples gives the concentrations of substances at the time when the water was sampled. The more samples taken, the more precise informations are obtained. The concentrations of the substances in the water samples depends on direction and speed of current, tidal movement, wind, salinity, temperature, characteristics of the substances etc.

In Citronen Fjord three water samples were taken all from the surface. Water sample no. 8 was taken near the mouth of the eastern river (83°06.29´N / 28°20.25´W), no. 7 on the east coast 1.5 km north of the head of the fiord (83°07.03´N / 28°16.69´W) and no. 5 in the middle of the fiord, see map II. Surface temperatures at the three stations were the following: +2.0°C (no. 8), +0.7°C (no. 7) and +0.5°C (no. 5).

The results of the analyses are seen in Table 1:

Sample no.	Zinc	Lead	Copper	Cadmium	Sample date
5	4.4	0.64	6.6	0.028	Aug. 21
7	21.5	1.78	5.8	0.025	Aug. 22
8	77.7	0.83	3.5	0.096	Aug. 22
NASS-4	0.12	0.013	0.23	0.016	
NASS-3	0.18	0.039	0.11	0.029	

Table 1: Sea water samples from Citronen Fjord showing concentrations of zinc, lead, copper and cadmium (μg/kg). NASS-3 and -4 certified values are examples of unpolluted sea water samples.

As it can be seen from the above Table 1, sea water samples from Citronen Fjord show elevated concentrations of zinc, lead and copper compared to the NASS sea water samples. Especially sample no. 8 just outside the mouth of the eastern river shows highly elevated concentrations of zinc.

8.5 Sediment samples

Sediment samples are often taken as part of back ground and monitoring studies. If sedimentation exists in the study area, it is possible to calculate concentration gradients as described in chapter 8.6 (Seaweed and mussels). The best samples can be obtained from a as silty or clayey sediment. If back ground studies have not been performed it is possible, in sedimentary areas, to go back through the years by analysing changes in concentrations in the sediment cores.

In Citronen Fjord three sediment samples were taken. In most places the sediment was silty and therefor good for sampling; but outside the eastern river the content of sand made it impossible to collect a sediment sample. As our bottom sampler was a handhold Kajak sampler, sampling will probably be improved by using a HAPS bottom sampler.

Two samples, no. 1 and no. 2, were taken 1.5 km from the head of the fjord on the east side (83°07.03´N / 28°16.69´W).The third, no. 3, was sampled 1 km to the south on the same side (83°06.59´N / 28°19.89´W), see map II. Water depths were between 4 and 13 metres.

The samples are not yet analysed for heavy metals.

8.6 Seaweed and mussels

Seaweed and mussels are essential parts of the GM back ground studies and monitoring programmes in South and West Greenland. Some of the reasons for sampling these organisms are, that they are fixed to the substrate, they are able to concentrate many different substances which in turn can be excreted if water concentrations of the substances decreases, they are abundant in many places in Greenland, and blue mussels are edible, so that polluted mussels can cause human health risks. By measuring concentrations of different substances in seaweed and mussels, concentration gradients can be calculated showing the areas influenced by the pollutant.

Normally, the Seaweed or Bladder wrack (*Fucus vesiculosis*), and Blue mussel (*Mytilus edulis*) are the species sampled. In East Greenland, however, these species are rapidly decreasing when going northward.

The only species of **seaweed** found in Citronen Fjord was a few individuals of *Desmarestia* sp washed ashore. Sailing along most of the Citronen Fjord coastline looking for seaweed on the shore and out to depths of four to five metres was without result. At a few places on the east coast at depths of two to three metres scraping after seaweed was done with no result.

In Peary Land seaweed is only sampled in Jørgen Brønlund Fjord: during the 1. Peary Land Expedition in 1947-50, 22 species of seaweed were sampled from depths of 8 to 30 metres. Among these species are two *Desmarestia* species (see Appendix 15.2). At the 4. Peary Land Expedition in 1966 another seaweed species was added to the above list. Different groups of seaweed were found at depths from 2 to 15 metres, where brown algaes were found from 7 to 12 metres and red algae from 5 to 15 metres. At the Danmark Expedition in 1907 a *Laminaria*, probably *saccharina*, was found on the ice of Frederick E. Hyde Fjord (Dietz & Andersen 1984).

In Citronen Fjord no alive **mussels** were found in the course of the reconnaissance study. We looked for mussels along most of the coast from the shore out to depths of four to five metres, and scraped at depths of two to three metres.

Shells from the mussel *Hiatella striata* (=*H. byssifera*) were found at the coast in creeping soils both on the east and the west coast of Citronen Fjord. The length of the shells were two to three cm's. The shells were very abundant in these soils, and probably their origin are not recent.

Shells from another mussel, *Astarte borealis*, were found only on the east shore and not in the creeping soils, so their origin can be recent.

From Peary Land, mussels have only been sampled in Jørgen Brønlund Fjord on the 1. and the 4. Peary Land Expedition in 1947-50 and 1966, respectively (Dietz & Andersen 1984). In total, 28 species are described (see appendix 15.3). Shells of two species are found on Oodaaq Ø (83°40´32´´N / 30°40´10´´W) by the Geological Survey of Greenland (GGU) and the Geodetic Institute (GI). These mussels are also included in appendix 15.3.

The two species of mussels found in Citronen Fjord are found alive in Jørgen Brønlund Fjord, and shells from *Hiatella striata* were found on Oodaaq Ø. According to G. Høpner Petersen (per. com.) the two species are probably living in the fiord and the shells can be of both recent and ancient origin.

8.7 Fish

As with seaweed and mussels, fish also represents important organisms in back ground and monitoring studies. Fish are not fixed to the substrate as seaweed and mussels, but some species, especially the sculpins, are rather local, moving only little about. Many of the fish species, among these the sculpins, are abundant along most of the Greenland coastline, and as fish are part of the human diet, it is important to know if concentrations of different substances in fish muscles and other tissues can cause human health risks.

Normally, fish such as the Shorthorn sculpin (*Myoxycephalus scorpius*), Greenland cod (*Gadus ogac*), Greenland halibut (*Reinhardtius hippoglossoides*), Spotted wolffish (*Anarchichas minor*) and Capelin (*Mallotus villosus*), are sampled. At this reconnaissance study there was especially fished for sculpins, as the pound nets were set in shallow waters (approximately at depths of one metre) along the shore. The length of a net was 50 metres with a mesh width of 2.6 cm.

Nets were set at three localities (stations) in the Citronen Fjord: in the mouth of the Esrum Elv (station 1, (83°06.24´N / 28°22.12´W)), and 1,5 km from the head of the fiord to the west (station 2, (83°07.09´N / 28°23.87'W)) and to the east (station 3, (83°07.06´N / 28°15.64´W)), see map II. Nets at station 1 and 2 were set August 16, in the evening, while the net at station 3 was not set until the next day.

At station 1 the net was tended the next day, August 17. Eight Fourhorned sculpins (*Myoxycephalus quadricornis*) were caught in the net. The net was left in the same position and tended again August 18, now with three Fourhorned sculpins in the net. The net was then packed up as the station had proved to be satisfactory. The medium length of the 11 sculpins was 19.7 $\pm$ 3.1 cm (range 14-25 cm). Four sculpins were killed and in two of them a few segmented worms of approximately 8 mm were found in the stomachs. One of the sculpins had roe with the size of a pin head. Three sculpins were frozen and brought to Denmark for analysis (see table 2).

The net at station 3 was tended after two days, on August 19. Twelve Fourhorned sculpins were caught, their medium length being 21.3$\pm$ 2.5 cm (range 17-26 cm). Two of the sculpins had a red belly (maybe males) and the one measuring 26 cm had a distended stomach (probably a female with roe). The net was removed, and also here the station was satisfactory, even though ice floes caused some problems.

At station 2 the net was not tended the next day, August 17, because a big ice floe was laying over more than half of the net. As no sculpins were observed, it was decided to return the next day, hoping the ice floe had gently moved away and the net had caught some sculpins. It was not until the 21. we returned, only to discover that the anchor rope was broken and the net had disappeared. So, under these ice conditions the station was not satisfactory.

:, it is possible to catch Fourhorned sculpins in good numbers at different stations Fjord. Fourhorned sculpin can be used in an eventually back ground study for purposes. The main obstacle is the ice conditions changing rapidly in the fiord. .tions proved to be those accessible on foot, i.e. stations 1 and 3. The reason for when ice floes blocks the rubber boat "harbour" for a longer period the nets can nyhow. It was not possible to walk to station 2, because of to much water in the see map II and chapter 9.2.

ɛrvations of fish in Peary Land are only made in Jørgen Brønlund Fjord and in Fjord (82°52´N / 23°00´W) during the 1.(1947-50), 4. (1966), 5. (1968) and 20. ry Land Expedition (Dietz & Andersen 1984). In total 12 species of fish are see Appendix 15.4. Five of the species are sculpins, and one of these is the l sculpin. Fry from the Fourhorned sculpin was collected in 1968 and is stored at ical Museum in Copenhagen.

rhorned sculpins are analysed and the results are seen in table 2:

Tissue	Zinc	Lead	Copper	Cadmium	% DW
liver	98.6	0.27	4.63	1.68	26.28
muscle	62.4	0.08	2.15	0.02	17.97
bone	103.2	0.13	1.74	0.02	25.37*
muscle	77.8	0.07	4.01	0.08	20.20
bone	110.1	0.14	1.68	0.04	25.37*
muscle	86.6	0.07	3.41	0.04	17.76
bone	109.3	0.32	1.19	0.02	25.37*

Fish samples from Citronen Fjord (station 1) showing concentrations of zinc, lead, copper and cadmium in μg/g dry weight (% DW). * Value for % DW from small Shorthorn sculpin (*Myoxocephalus scorpius*) are used, as Citronen Fjord samples were to small. It must be noted that tissues can be contaminated as fish were opened at station 1.

ıpared to reference stations (Riget et al 1993), no elevated metal-concentrations can n the preliminary study in Citronen Fjord.

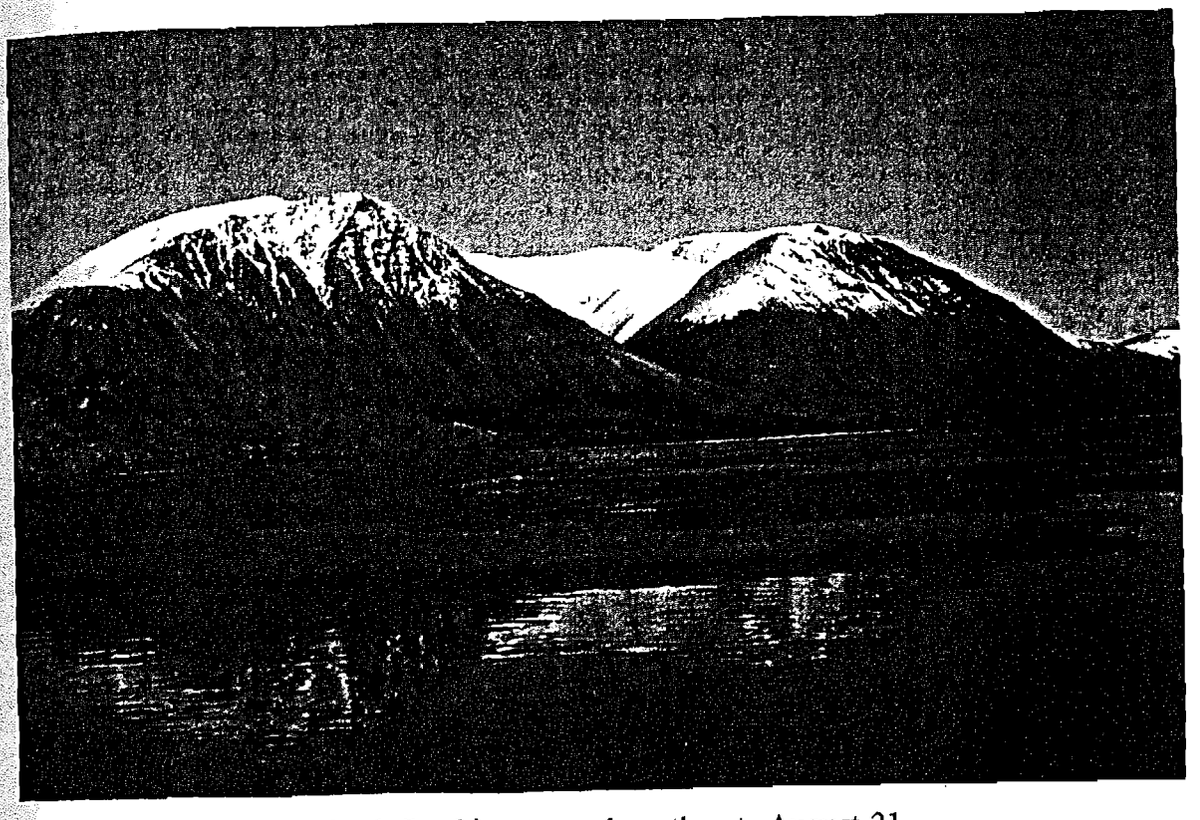

Photo 7: Citronen Fjord. Looking toward southeast, August 21.

Photo 8: Fourhorned sculpin, August 17.

8.8 Birds

Normally, birds are not collected in back ground studies or for monitoring purposes. The reason for this is, that birds are very mobile, often covering large areas when foraging in the summertime, and migrating out of the area in the wintertime. So, if birds are used to evaluate the impact of different substances from a mine for example, it is important to collect birds from areas situated far apart. As a lot of bird species are used in the human diet, the knowledge of the concentration of different substances is important in inhabited areas.

Another reason to study birds is because of their sensibility to disturbances during certain periods, for example when they are breeding and during moult.

During the reconnaissance study birds seen on the fiord or on the shore were recorded, to give an idea of what kind of species are living here. It must be noted, that the area was visited rather late in the season, so the breeding season was over and some species had already left the area. As it can be seen only four species related to the fiord were seen and in very small numbers.

King eider (*Somateria spectabilis*). One adult female was often seen at the head of the fiord. King eider is frequently observed in Peary Land (Dietz & Andersen 1984). Birds are seen in Frigg Fjord and at Kap København, and breeding birds are seen in Jørgen Brønlund Fjord. The King eiders arrive early in June, and should be leaving Peary Land early in September (Johnsen 1953).

Glaucous gull (*Larus hyperboreus*). Two adult gulls were seen a few times at the head of the fiord. Glaucous gull are seen in small numbers in many localities in Peary Land (Dietz & Andersen 1984). In the Jørgen Brønlund Fjord area a few breeding pairs are observed. A single bird was seen in Citronen Fjord 1979.

Ivory gull (*Pagophilia eburnea*). Two adults were only seen shortly in the inner fiord. Ivory gull is not noted in Peary Land according to Dietz & Andersen (1984). However, Ivory gull is breeding at Station Nord not far from Peary Land.

Arctic tern (*Sterna paradisaea*). Only once an Arctic tern was seen hovering over the delta for about ten minutes. Many observations on Arctic tern has been made in Peary Land, such as in Citronen Fjord, Frigg Fjord and Jørgen Brønlund Fjord, where breeding pairs are found (Dietz & Andersen 1984). Birds arrive in the beginning of June and leave by the end of August.

According to Dietz & Andersen (1984) Sabine's gull (*Larus sabini*) is the only other bird species mostly related to sea water, that has been observed in Peary Land.

For observations of other birds in the Citronen Fjord area refer to chapter 10.3, Birds in the terrain. In that chapter birds such as for example waders are described, because their breeding habitat are inland, even though they in spring and autumn mostly are seen at the shore of the fiord.

8.9 Sea mammals

As with birds, sea mammals are not normally collected in back ground studies or used in monitoring studies. Sea mammals are often as mobile as birds using large foraging areas and migrating out of the area in question in certain periods. Probably the Ringed seal (*Phoca hispida*) is the sea mammal best suited for these kind of studies, and especially the adults, because they are rather local. Also, the Ringed seal is common all over Greenland year round. In inhabited areas information on concentrations of different substances in seal tissues is important when assessing human health risks. Seals and other sea mammals represents in general the highest trophical level in the food web and therefore possess the potential for the highest concentrations of pollutants.

At certain times of the year, for example when Polar bears (*Ursus maritimus*) hibernate, when Ringed seals have pups and Walruses (*Odobenus rosmarus*) haul out on sandy banks, sea mammals are sensitive to disturbances.

Ringed seal (*Phoca hispida*). In Citronen Fjord the only sea mammal observed during the reconnaissance period was one individual of the Ringed seal seen twice in the middle and in the mouth of the fiord.

The Ringed seal is common all over Peary Land, and in some places it is seen in rather high numbers. In Frederick E. Hyde Fjord about 50 were seen in 1969 and at the head of Independence Fjord more than 40 were seen in 1947-50 (Dietz & Andersen 1984, Johnsen 1953).

Polar bear (*Ursus maritimus*). Tracks from one Polar bear was seen June 2 on the ice of Frederick E. Hyde Fjord between Frigg and Citronen Fjord, and on June 6 this (?) Polar bear was seen in Frederick E. Hyde Fjord just outside Citronen Fjord (map III, Frank van der Stijl, per. com.). It was medium sized and probably an adult female; she was looking for the Ringed seal´s birth lairs. Polar bears are seen occasionally in Peary Land, with about 25 observations of bears and tracks since 1900 (Dietz & Andersen 1984). In Frederick E. Hyde Fjord five Polar bears and some tracks were seen between 1969 and 1982.

The only other sea mammal observed in Peary Land is the Bearded seal (*Erignatus barbatus*). One was seen in Frigg Fjord in 1953 and one at Kap Morris Jesup in 1968 (Dietz & Andersen 1984).

9. RIVERS AND LAKES

9.1 Depths and ice

In the Citronen Fjord area lakes are not a very dominant element in the terrain. Only two lakes of very different nature are situated within the reconnoitred area, one at the base camp and one (Esrum Sø) in the upper parts of Esrum Elv valley.

The lake at the base camp is a rather small, rounded local depression fed by precipitation and melting of the active layer surrounding the depression. The lake is icefree in summer and the outlet is to the eastern river, that cuts through the sulfide showings. The contribution to the run-off is limited due to the small supply of annual precipitation (approximately 200 mm) from the small catchment area, minus evaporation. The origin of the lake could be melting of stationary ice (kettle hole/thermocast) in a local depression in the substratum. The thickness of winter ice cover could be around three metres whilst the volume of the lake is difficult to estimate, although the bottom is not expected to reach very large depths.

The lake in Esrum valley is a very long (15-20 km) partly ice dammed lake. It is situated on the floor of a valley separating two local glacier caps on top of higher mountain plateaus. The lake is fed primarily by ablation from the surrounding glaciers and the outlet of Esrum Sø is to Citronen Fjord through Esrum Elv. The water shed to the south was not reached during the reconnaissance but from the topographic map the outlet to Citronen Fjord should be the only one. This outlet was identified during the reconnaissance to follow the eastern edge of the glacier, probably in combination with intra/sub glacial waterways. The lake was ice covered during the reconnaissance and is expected to be so all year round. The depth of the lake could reach several hundred metres and the variation of the water level is considerable due to the irregular outflow mechanism imposed by the ice damming and supply from minor ice dammed lakes along the edges of Esrum Sø.

9.2 Water flow

In the area of interest two major water ways are actively draining precipitation, melting snow, ablation from local glaciers and ground water from melting of the active layer. A limited number of wet areas do occur where the local slope and material conditions retain water, from melting ice in the upper layers, from running off on surface.

In map IV the hydrological catchment areas around the two water ways have been sketched out based on maps and aerial photos.

In map II measurements and estimates of actual discharges observed in the field are shown.

As the amount of precipitation is small the direct run-off from rain events is limited and the important parametres appears to be air temperature and solar radiation controlling melting, evaporation and sublimation processes.

This is especially apparent in the eastern river where no lakes retain and "prolong" the water flow. In this river the discharge is varying considerably which was experienced during the reconnaissance study as indicated by the two measurements on August 18 and 20, giving respectively 6.3 and 1.4 m^3 per second. The measurements were carried out with an OTT-C2 Flügel current meter giving a total accuracy on the discharge figure of $\pm$ 10%.

The 6.3 m^3 per second was measured at water level below the high level marks along the river, so maximum discharge in this river could reach at least 10 m^3 per second. The fresh water in the river was perfectly clear throughout the reconnaissance period.

The river draining Esrum Sø and surrounding areas differ from the eastern river with respect to amounts of water, color, and variations in the discharge. In map II an estimate on August 25, 1993 of 1-2 m^3 per second is shown. In the beginning of the reconnaissance period a very uncertain estimate of the discharge was made (50 m^3 per second - August 20) and the environment around the river indicated a much higher capacity of the system. This may origin from higher activities in the past but also points to the important feature of Esrum Sø being ice dammed. This causes irregularities in the outlet and may cause surges. The supply for this river is dominated by ablation of glacier ice and the fresh water in the system was silty and very unclear throughout the period. An indication of maximum discharge in this system can not be made due to the unknown ice damming mechanism of the supply and of the lake, but it holds potential for very large amounts of water.

Photo 9: Esrum Sø. Looking southward, August 25.

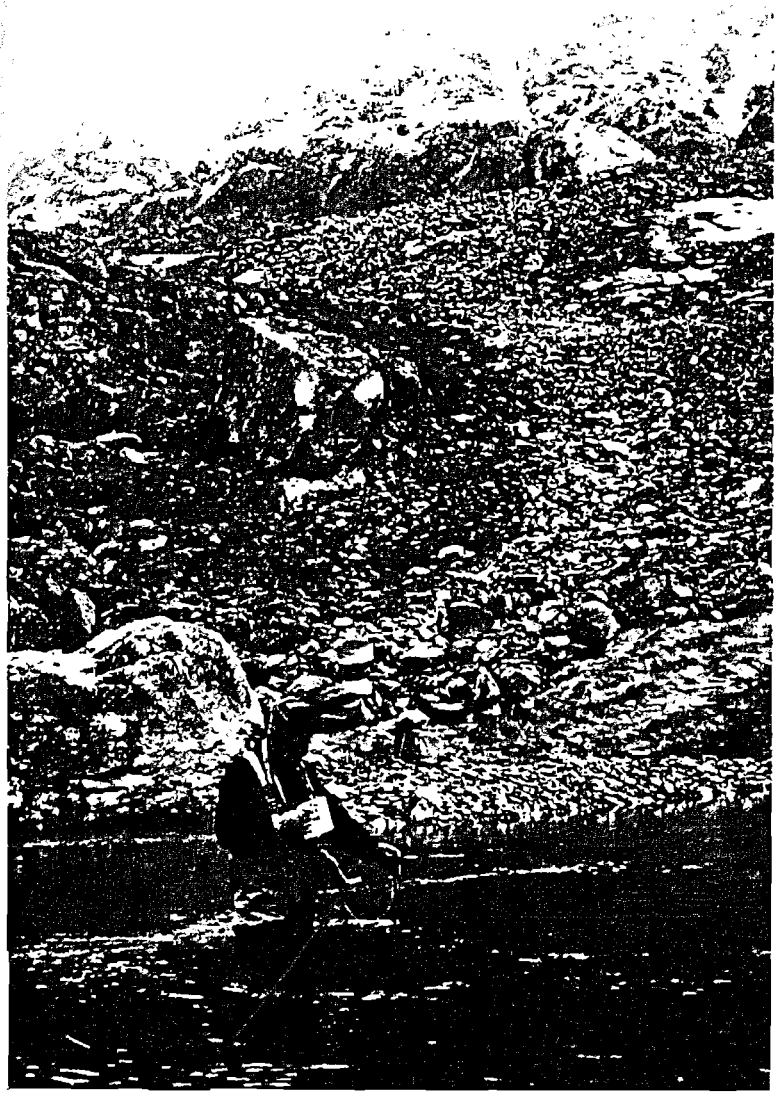

Photo 10:
Discharge measurement
in the eastern river,

9.3 Fresh water samples

What is said about sea water sampling in chapter 8.4 is in general also valid for fresh water samples. In running waters the concentrations of different substances depends mostly on the water flow, which can change markedly due to snow melting, glacier ablation and precipitation. In lakes concentrations depends among other things on the river feed, precipitation and evaporation.

In the Citronen Fjord area six fresh water samples were taken, see map II. Four were taken in the eastern river, i.e. numbers 1-4. They were taken so that no. 1 should be prior to the showings, no. 2 within the showings and no. 3 and 4 after the showings. Sample no. 10 was taken in a creek running slowly from one of the showings and into the eastern river, prior to sample no. 2. The last fresh water sample was taken in the lake at the base camp.

The results of the analyses are seen in Table 2:

Sample no.	Zinc	Lead	Copper	Cadmium	pH	Sample date
1	5.2	1.0	23.8	<0.025	7.7	Aug. 18
2	2.1	0.15	1.5	<0.025	7.7	Aug. 18
3	68.	0.34	2.8	0.115	7.8	Aug. 20
4	105.	0.88	22.3	0.28	7.8	Aug. 20
10	119000.	350.	27.	319.	3.1	Aug. 23
11	0.7	0.12	1.3	<0.025	1.8	Aug. 23

Table 3: Fresh water samples from the Citronen Fjord area showing concentrations of zinc, lead, copper and cadmium (μg/kg). The pH is measured in the laboratorium. No.´s 1-4 are from the main eastern river, no. 10 from a creek slowly flowing through one of the showings to the river, and no. 11 is from the base camp lake (refer to map II). Water flow was 6.3 m^3/sec when samples no. 1 and 2 were taken, and 1.4 m^3/sec when samples no. 3 and 4 were taken.

Table 3 shows that concentrations of heavy metals have increased after the river has passed the showings (refer to samples no. 2 to no. 4). Sample no.4 corresponds well to the surface sea water sample no. 8 (se chapter 8.4) just outside the mouth of the eastern river. Lower concentrations were expected in sample no. 1 compared to sample no. 2, as no. 1 is prior to the visible showings. But obviously, there must be a source carrying dissolved metals, especially copper, to the eastern river upstream sample station no. 1. The high concentrations of heavy metals in the creek sample no. 10 is not surprising, as the sample was from a pond with a very low pH and with a red precipitate, probably of iron compounds. So, the sample no. 10 must be heavily affected by oxidation of pyrite (iron sulphide), sphalerite (zinc sulphide), and galena (lead sulphide), producing sulphuric acid, heavy metals in solution and a partly soluble iron residue. Concentrations in the lake sample, no. 11, is comparable to sample no. 2.

It must be noted that samples no. 1 and 2 are from August 18 where the water flow was 6.3 m^3/sec, while samples no. 3 and 4 are from August 20 with a water flow of 1.4 m^3/sec. Therefore the samples are not directly comparable.

9.4 Arctic char

There was fished for Arctic char (*Salvelinus alpinus*) with a fishing rod in the eastern river and in the fresh water lake at the base camp. No Arctic char was caught or seen in the eastern river, but in the lake two Arctic chars were caught, approximately 10 cm´s long and with par marks on the sides indicating young fish. Also fry was observed in the lake.

Arctic char was found in Jørgen Brønlund Fjord on the 4. (1966) and the 5. (1968) Peary Land Expedition (Dietz & Andersen 1984). Anadrome, i.e. migrating, Arctic chars are also reported from Jørgen Brønlund Fjord, and a family of Red-throated divers were seen on a small lake in Frigg Fjord, probably fishing Arctic char (Aastrup et al 1986).

Anadrome Arctic chars are as a matter of course seldom in Peary Land because the rivers normally dry out in the Autumn. On the other hand stationary Arctic chars are probably rather common in the lakes of Peary Land.

10. TERRAIN

10.1 Materials and processes

In the area around Citronen Fjord freezing and thawing in the uppermost active layer of the permafrozen zone are the dominating mechanisms with respect to natural processes in the terrain. For assessment of the surface vulnerability to physical impact it is therefore important to gain knowledge of materials (permeability, water/ice-content, susceptibility to frost action), moisture (precipitation, surface water) and topography (slope of strata and of surface).

During the reconnaissance study observations of surface materials, moisture conditions and natural processes in the terrain were done.

The content of fine materials (i.e. silt) is very variable in both the morainal and the stream sediments due to varying degree of outwashing. Even where the surface judged by texture appears coarse grained and stable, from surface washing and eventually an aeolian deposit carpet, frost boils and landslips on steeper sides revail a content of fines. Roughly the lower contents of fines appear in the highest, today exposed, plateaus and along the river beds where recent outwashing takes places.

Moisture content in flat areas stems from freezing and thawing of the active layer topping the permafrost table and even in very gently sloping areas from melting and transportation of water in the moving active layer. Evidence of ground ice is visible on freshly uncovered slopes. Also precipitation contributes to the moisture content of the upper layers, mostly through accumulation and subsequent melting of snow in cracks, depressions and other lee side traps for drifting snow. An evenly distributed snow cover is not likely to dominate this area.

In excess of the above mentioned processes affecting the terrain other natural processes were observed in this active permafrost environment: extensive areas of patterned ground, stone-rings, sand (ice?) filled frost cracks, land slides, creeping soil and solifluction on most of the slopes towards Citronen Fjord on both eastern and western side.

All of the information above stem from scattered visual observations as systematic mapping or sampling was not attempted during this reconnaissance study.

10.2 Vegetation

Collecting higher plants, lichens and mosses are performed in some back ground and monitoring studies, especially where dust, containing heavy metals, are thought to be or become a problem. Species from the above mentioned different groups are sampled in the mine site surroundings to assess dust dispersal and concentration gradients of heavy metals.

Mapping plant communities in the surroundings can be used to assess important areas for animals, for example grazing areas for Musk oxen.

Species of higher plants have been collected in the Citronen Fjord area to compare it with other areas in Peary land. Also, areas with closed vegetation have been mapped in the Citronen Fjord area.

Higher plants were sampled in the Citronen Fjord area, both by Christian Bay of Botanical Museum of Copenhagen, at a visit on August 15, 1993, and during the reconnaissance study. Christian Bay identified the collected species and prepared a list of 48 plant species, see Appendix 15.1. This list is thought to represent a minimum. The number of species in four well investigated areas in Peary Land ranged from 74 to 80 species (Bay 1992), so the Citronen Fjord area is likely to be poorer in species even when better investigated.

Areas with closed vegetation in the Citronen Fjord area are mapped in map V. These areas appear to be very small, and cover approximately 5 % of the map area. Outside the map, on the east side of the Esrum Elv, a rather big marshy area of approximately 500x100 m^2 was observed.

Lichens were only found as flat species growing on stones and no reindeer moss species were discovered. Mosses were found at many places.

10.3 Birds

In this chapter, birds related to inland localities during the summer, are described. Some of the bird species, such as the waders and the Long-tailed skua (*Stercorarius longicaudus*), are breeding inland during the summer; the rest of the year they are mostly related to the sea or the sea shore. The Red-throated diver (*Gavia stellata*) is breeding on lake shores and winters at sea. As in chapter 8.8, Birds at the fiord, bird species inland are seen only in small numbers.

Red-throated diver (*Gavia stellata*). Only one Red-throated diver was seen at different places in the area: in the base camp lake, in the mouth of Esrum Elv and in the head of Citronen Fjord. An other Red-throated diver was seen on August 14 in the lake east of Depot Bugt by Frank van der Stijl. A pair of breeding birds were seen in the Citronen Fjord area in 1979. In other places in Peary Land the diver is seen frequently but scattered, and a few breeding pairs are observed. Red-throated diver appears in Peary Land early June and disappears early September (Dietz & Andersen 1984).

Snow goose (*Anser caerulescens*). Two adults with goslings were discovered in the lake area east of Depot Bugt on August 14 by Frank van der Stijl. Also, a lot of goose droppings were found here and a flock of flying geese were seen. In Peary Land the Snow goose is seldom seen. A pair was seen at Børglum Elv in 1949, one in Brønlund Fjord in 1968 and one north of Frederick E. Hyde Fjord in 1969 (Dietz & Andersen 1984).

Ptarmigan (*Lagopus mutus*). One female with 15 chickens were seen on the slopes west of Citronen Fjord on August 7, and approximately 10 Ptarmigans were seen in the Esrum Elv valley (Frank van der Stijl, per. com.). In the Citronen Fjord area a few droppings were found. Ptarmigan is common all over Peary Land and most breeding pairs are found north of Frederick E. Hyde Fjord. Ptarmigan migrates southwards during the coldest months and is not recorded in Peary Land from late October to late February (Dietz & Andersen 1984).

Ringed plover (*Charadrius hiaticula*). Three were running along the shore in the delta area. This wader has been observed in many localities in Peary Land, among these in the Citronen Fjord. Breeding pairs are found in Jørgen Brønlund Fjord and at the head of Frederick E. Hyde Fjord. The Ringed plover arrives late May and leaves by the end of August (Dietz & Andersen 1984).

Turnstone (*Arenaria interpres*). During the whole reconnaissance period 2 to 6 young Turnstones were living on scraps just outside the kitchen tent. Turnstone is common all over Peary Land and is reckoned number two or three after Sanderling and Ringed plover. It arrives late in May or early June (Frank van der Stijl saw the first Turnstones in Frigg Fjord May 26). Adult birds leave by the end of July, whereas the young birds stay until the middle or the end of August (Dietz & Andersen 1984).

Sanderling (*Calidris alba*). Four in summer plumage were seen on the shore at the head of the fiord. Many observations of Sanderling, including breeding pairs, have been made in Peary Land. Bids are for example seen in Citronen Fjord. It arrives late in May and migrates south early September (Dietz & Andersen 1984).

Long-tailed skua (*Stercorarius longicaudus*). One family of 2 adults and 2 young birds were often seen during the reconnaissance study in the eastern river valley north of the base camp lake. The adult birds were actively attacking possible predators, i.e. four Arctic foxes on August 15 and two Glaucous gulls on August 18. According to the Platinova helicopter pilot, they had their nest site right down on the east side of the eastern river. The Long-tailed skua is common in Peary Land, and most observations of breeding pairs are from Frederick E. Hyde Fjord, among these one pair recorded from the Citronen Fjord. The skua arrives early June (Frank van der Stijl observed the first bird at Midtkap, Frederick E. Hyde Fjord, on June 2) and leaves probably by the end of August (Dietz & Andersen 1984).

Snowy owl (*Nyctea scandiaca*). One adult was seen in Nansen Land on August 12 (map III, Frank van der Stijl, per. com.). Snowy owl is not very common in Peary Land, but is seen occasionally. It is recorded breeding in the Kap København area, east Peary Land, and in the northwest Peary Land. It is seen from the middle of April to the middle of October (Dietz & Andersen 1984).

Arctic redpoll (*Carduelis hornemanni*). Two young birds were seen south of the base camp lake on August 23. Arctic redpoll is, according to the very few recorded observations, a rare bird in Peary Land, and no signs of breeding have been reported earlier (Dietz & Andersen 1984).

Snow bunting (*Plectrophenax nivalis*). One was heard at the base camp on August 18, and on August 25 seven flew west over the base camp and a male and a female were seen in the Esrum Elv valley. Snow bunting is described by all visitors to Peary Land as the most common bird. Snow buntings arrive normally by the end of April (Frank van der Stijl saw the first on May 18) and disappear late in September (Dietz & Andersen 1984).

Dietz & Andersen (1984) describes eight more bird species recorded more or less frequently in Peary Land: Light-bellied brent goose (*Branta bernicla hrota*), Long-tailed duck (*Clangula hyemalis*), Gyrfalcon (*Falco rusticolus*), Knot (*Calidris canutus*), Dunlin (*Calidris alpina*), Curlew sandpiper (*Calidris ferruginea*), Grey phalarope (*Phalaropus fulicarius*) and Red-necked phalarope (*Phalaropus lobatus*).

10.4 Mammals

Terrestrial mammals are not normally caught in back ground studies or for monitoring purposes. In hunting areas mammals should be analysed for example for heavy metal concentrations in their tissues to assess the human health risks. In areas influenced by mineral exploration or exploitation, the numbers and distribution of mammals are studied to evaluate if protection is needed, for example in certain sensitive periods, such as the calving time for Musk oxen (*Ovibos moschatus*) and Caribou (*Rangifer tarrandus*).

During the reconnaissance study terrestrial mammals and their different tracks were observed. Also, observations made by Frank van der Stijl, Platinova A/S, in 1993, both from the Citronen Fjord area and from other parts of Peary Land, are included in this report.

Musk ox (*Ovibos moschatus*). At the reconnaissance study, only one Musk oxen was seen. It was grazing on the slopes of the west coast of Citronen Fjord, and probably, it was an old male.

Frank van der Stijl has observed two flocks in the area and a single animal. Some kilometres up the eastern river a flock of 7 adults, 3 calves from 1993 and 1 calf from 1992 was seen May 28 (map III). The other flock was observed west of Citronen Fjord August 15 and consisted of one bull, 3 cows and 3 calves from 1993 (map III & V). The single adult was seen on the western side of Citronen Fjord August 1, and is probably the same as we saw (map III & V).

Many tracks and droppings from Musk oxen are seen in the Citronen Fjord area, among these north of the base camp lake and along the eastern river, on the shores of the lake, south of the lake and on the east side of Esrum Elv. At many of these places tracks from a cow and her calf were seen. Also, skeletons of Musk oxen were found on the east coast of Citronen Fjord, at the lower parts of the eastern river, south of the base camp near the showings, near Esrum Elv (a skeleton from a calf) and on the east side of Esrum Elv (see map V).

Other observations of Musk oxen from Peary Land in 1993 are the following (map III, Frank van der Stijl, per. com.): At the head of Frederick E. Hyde Fjord a flock of 10 adults and two calves from 1992 and 93, respectively, was seen May 25 and August 12; 3 adults were seen west of Frigg Fjord May 22, 23 and August 12 (it could also be two to three different flocks) and many tracks appeared on the east side of Frigg Fjord; two adults were observed May 29 on the south coast of Frederick E. Hyde Fjord between Frigg and Citronen Fjord; and two adults were seen at Midsommer Sø on August 12.

The total population of Musk oxen in Peary Land was estimated to be 500-700 in 1985 (Aastrup et al 1986). In 1950 the population was estimated to be 2.000-3.000 by Johnsen (1953), but according to Aastrup et al (1986) 1.300-1.600 is more likely. It is possible the population declined until 1960, where after it remained stable (Boertmann 1992).

Polar wolf (***Canis lupus***). Fresh tracks from probably only one Polar wolf were observed in the Citronen Fjord area during July and August 1993. Tracks were seen at the east coast of the fiord, around the base camp lake and south of the lake, but not the wolf. In other parts of Peary Land Polar wolfs are reported from Frigg Fjord, where a flock of 4 were seen on the ice at the mouth of the fiord on May 24, and 5 adults with 3 whelps were observed in the middle of the area on August 12 (map III, Frank van der Stijl, per. com.).

Scattered observations of Polar wolf are reported from many places in Peary Land over the last hundred years (Dietz & Andersen 1984, Dawes et al 1986). In 1892 and 95 Peary found wolf tracks in the head of the Independence Fjord, and up until 1921 explorers such as I. P. Koch, K. Rasmussen and L. Koch saw single wolfs and their tracks in Peary Land. In the following 25 years Peary Land remained unvisited. It was not until 1953 a wolf again was discovered in the northern Peary Land, in spite of the fact, that the 1. Peary Land Expedition over wintered from 1947 to 1950. In the 1960s and early 1970s members of the Sirius Sledge Patrol recorded fresh tracks in several parts of Peary Land. Up until today wolfs or their tracks are seen almost every year.

Most often only single wolfs are seen, but in the summer of 1985 6 wolfs were seen at the head of Frigg Fjord, and later this year 1 wolf with 3 whelps were seen in the same area. This is the first registered observation on breeding Polar wolfs in North Greenland (Aastrup et al. 1986). Some of the places where wolfs often appears are Frigg Fjord and Frederick E. Hyde Fjord.

The fluctuations of the Polar wolf population in Peary Land (and the whole North Greenland) as indicated above are probably due both to the fact that wolfs only can be seen when humans appear in the area and to the harsh conditions of life in North Greenland.

Arctic fox (***Alopex lagopus***). In the area around the base camp lake up to 5 foxes were seen several times in the course of the reconnaissance study (map III). One fox was seen actively hunting on the west side of Esrum Elv on August 25. On the west coast of Citronen Fjord at the fishing station no. 2 a fox had urinated and faecated on what was left of the fishing net.

The Arctic fox is common all over Peary Land and a lot of observations of foxes and their tracks are documented by Dietz & Andersen (1984).

Arctic hare (***Lepus arcticus***). Many Arctic hares were seen in the Citronen Fjord area during our stay. On the slopes on the west side of Citronen Fjord 8 hares were grazing together. South of the base camp 3 to 5 were seen frequently, and in the marshy area on the east side of Esrum Elv 11 Arctic hares were seen in small groups. According to Frank van der Stijl Arctic hare numbered 1 to 4 in the places visited elsewhere in Peary land.

Arctic hare is common all over Peary Land, and the highest number recorded is 392 hares counted north of Frederick E. Hyde Fjord on the Joint Services Expedition in 1969 (Dietz & Andersen 1984).

Photo 11:
Fresh Polar wolf tracks behind the base camp, August 20.

Photo 12: Arctic hare and the Citronen Fjord area. Looking northward, August 23.

Collared lemming (*Discrostonyx torquatus*). Lemmings and their holes were seen all over the Citronen Fjord area, also up the Esrum Elv valley. More than ten lemmings were actually seen. Lemming holes were abundant in polygon cracks rich in vegetation such as Purple saxifrage (*Saxifraga oppositifolia*) and Arctic willow (*Salix arctica*). Also, holes were found on slopes of sand, silt and gravel. Nests from the winter and large amounts of pellets were seen in some places. Frank van der Stijl saw lemmings or their holes in most places he visited during the summer, and a few were seen during spring in May or June.

Collared lemmings are observed by most expeditions in Peary Land, but little is published, probably because of it´s insignificant size and lack of value for humans (Dietz & Andersen 1984). Johnsen (1953) notes that it is seldom seen even in years where it is numerous.

Ermine (*Mustela erminia*). Ermine was seen by Frank van der Stijl in the Esrum Elv valley in August and 1 to 2 were seen west of Frigg Fjord on May 22 (map III).

Ermine is seen in many places in Peary Land, but most often only foot prints are seen (Dietz & Andersen 1984).

11. EARTHQUAKES

Throughout the entire period of the reconnaissance study earthquake was a daily phenomenon. The earthquakes occurred two or three times daily with smaller or larger intensity. All of the earthquakes were clearly felt and almost all were heard. All earthquakes were followed by rockfalls on the steeper mountain sides.

The operator gave information on a first major earthquake event on August 10, followed by daily earthquakes throughout the entire period until September 15 were the field activities stopped and all the people involved left the area around Citronen Fjord. The Icelandic cook in the base camp had the very personal opinion that the major earthquake on August 10 had a magnitude of approximately 5.

The northern and especially the northeastern part of Greenland is well known for seismic activity. Based on data processed in the past the earthquakes in this region is generally not expected to exceed magnitude 4-5 in the local magnitude scale (Gregersen 1982) as seen from figure 7 below:

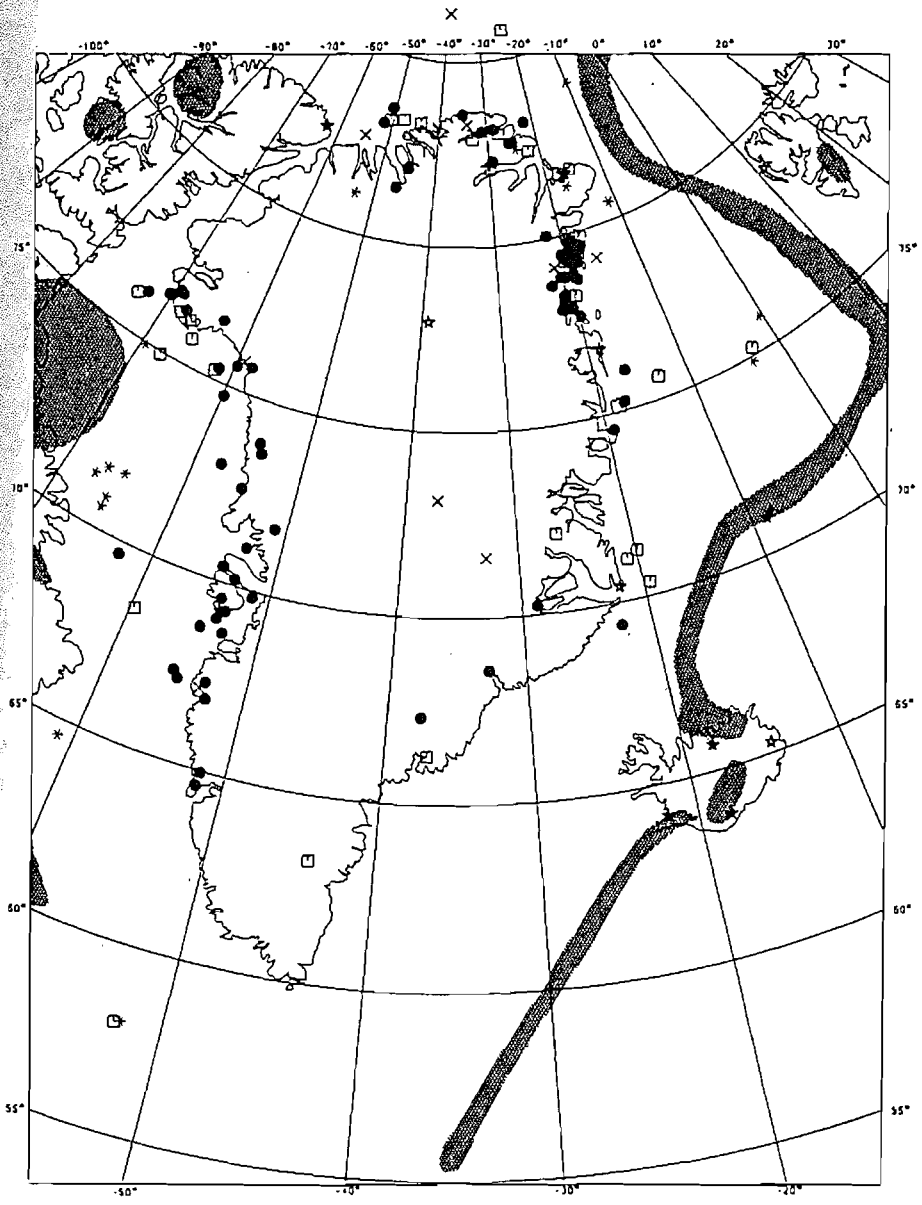

Figure 7:
Earthquake locations in Greenland 1940-1985. Grey cross-hatched areas are zones of seismicity in areas neighbouring Greenland. Earthquakes in Greenland: Squares of magnitude above 4, black dots of magnitude between 3 and 4, crosses of magnitude below 3, pinstars of unknown magnitude. Five-point-stars are seismograph stations. All locations based on seismograph records.
(Gregersen & Basham 1989).

As the frequency of these natural processes in the area of exploration activities was a surprise to everyone the phenomenon should be looked further into. These aspects of the physical environment impose considerations with respect to operational safety, design criteria for constructions, pits or openings in the mountains etc.

Although earthquakes are unpredictable and no reliable method exist today to estimate the coming of such events, a better understanding of earthquakes in the area should be attained if the exploration activities proceed further. This could be done by processing the existing data from Alert, Danmarkshavn, Ittoqqortoormiit and Qeqertarsuaq, where seismic activity is continuously recorded. Another two stations at Station Nord and Ittoqqortoormiit have a project working on micro seismic activity and background noise. Recordings from Station Nord in the actual period indicate an abnormal high level of events (Anon. a). Paper roles with data from Ittoqqortoormiit, Danmarkshavn and Qeqertarsuaq are stored at National Survey and Cadastre-Denmark in Copenhagen where also magnetic tapes from Station Nord are stored. Data from Alert are stored at the Geological Survey of Canada, Ottawa.

For detailed registration in the actual area field activities in the future could involve registration of seismic activity on a portable recorder. This field equipment is easy to carry and handle and establishing involves no earth work only the substratum should be solid rock.

12. DISCUSSION

The general impression of the Citronen Fjord area is, that it is a harsh place to survive for plants and animals. It is dry with low precipitation, ice covered fiords, rivers and lakes for most of the year, permafrost, heavy winds and low temperatures with only two to three months with mean temperatures above 0°C.

On land vegetation is sparse with approximately only 5% covered with closed vegetation. Because of this, big, grazing mammals like the Musk oxen can not subsist here in larger numbers. But the few spots of vegetation are important to the Musk oxen wandering through the area. Also the vegetation spots are important for the Arctic hare and the Collared lemming. This means that activities such as driving in the area should avoid the continuous vegetation areas.

Populations in the area of other land mammals such as Polar wolf, Arctic fox, Arctic hare, Ermine and Collared lemming are most years rather small, but some years, like in 1993, the lemmings reach high numbers; this affects the population of foxes and Ermines, and to some extend the wolfs. Also some bird species benefits from this increase in numbers of lemmings: Snowy owl, Gyrfalcon and Long-tailed skua.

Other birds breeding inland such as Red-throated diver, Ptarmigan, waders and passerines are probably only breeding in very few numbers. There is no sign of breeding or moulting geese in the Citronen Fjord area.

Arctic char is only found in the lake at the base camp, this being the small stationary form. The bigger migrating form is probably not present in the two rivers in the area, because the rivers dry out around September and first starts running in June.

Turning to the Citronen Fjord, the general impression of a poor representation of species and numbers is the same as seen inland: only a few individuals of one seaweed species and only shells from two mussel species are found, one fish species is caught, and four bird species in few numbers, one Ringed seal and one Polar bear are seen.

But, with the knowledge from investigations in Jørgen Brønlund Fjord in the southern part of Peary land, Citronen Fjord is probably richer in species and numbers of seaweed, mussels and fish. Probably because of a fresh water layer in the surface coming from the rivers and the melting ice cover, seaweed and mussels are living deeper than we were able to reach in this preliminary study. In Jørgen Brønlund Fjord 23 species of seaweed and 28 species of mussels were found and 12 species of fish were caught. In Citronen Fjord only pound nets set in shallow waters are used resulting in the catch of 23 Fourhorned sculpins. When preparing for back ground studies, it is important to know that it is possible to catch Fourhorned sculpins in the Citronen Fjord. As seaweed and mussels are important species in back ground studies they must be looked for in deeper parts of the fiord.

With sea birds no bird cliffs or bird colonies are present, and it is not likely that Polar bears hibernate or have breeding dens in the area. Probably only a few breeding lairs from the Ringed seal are present in the Citronen Fjord.

The sea water and fresh water samples show that there is an important chemical weathering of the metal-sulphides in the rock-showings up the eastern river. When water comes in contact with the showings, the water becomes acid and the metals dissolve. The dissolved metals can be found in elevated concentrations both in the eastern river and in the fiord, but probably not in different tissues from Fourhorned sculpins. Sediment samples are not yet analysed. In a back ground study it is important to measure these concentrations in conjunction with water flow measurements, thereby obtaining information about the back ground levels of heavy metals in the area. In this connection the Esrum Elv must be studied as well.

13. PROPOSAL TO A PROGRAMME FOR A BACK GROUND STUDY

Before major activities with potential impact on the surroundings are commenced in an area a local back ground study is carried out to establish the present "before" state of the environment through selected parametres. Below a programme for a back ground study at Citronen Fjord is sketched out. It should be noted that investigations of the physical conditions for technical design and construction of plant etc. are not included in the programme. These investigations should be carried out at a later stage if the overall progress of the mineral project warrant it.

A back ground study should consist of a study in the Citronen Fjord area close to the mining activities, and a study in reference areas farther away from the activities. In the area close to the activities, where higher contamination can be expected, many samples of different species should be taken; in the reference areas 10 to 40 km from the activities, where little or no contamination are expected, only few samples of the same species should be taken.

Samples for the back ground study are taken two or three times, during a period of two to three years prior to an eventually mineral exploitation in the area. If the result of the mineral exploration is a mine, then the samples are analysed for the relevant metals.

As it is not possible to enter into the Citronen Fjord with a research vessel, the back ground study in the sea areas must be performed from a rubber boat and from the sea ice. Some helicopter support for the back ground study must also be expected.

The following elements should enter into the back ground study:

Sea water samples: At 4 stations inside Citronen Fjord and 2 stations just outside the fiord to each side of the mouth into Frederick E. Hyde Fjord, water samples are taken in different depths from surface to bottom. Two reference stations are chosen at the head and at the mouth of Frederick E. Hyde Fjord. Temperature, salinity and heavy metals concentrations are measured.

Sediment samples: Sediment samples are taken at the same stations as the sea water samples, i.e. 6 stations in the Citronen Fjord area and 2 stations in the reference areas. If core samples are taken, the core is divided into 1 cm slices and analysed separately. The slices are analysed for heavy metals.

Seaweed and mussels samples: These organisms are sampled at 6 stations inside the Citronen Fjord and 2 just outside the mouth of the fiord. At the 2 reference stations in Frederick E. Hyde Fjord, as mentioned above, seaweed and mussels are sampled as well. The organisms are analysed for concentrations of heavy metals. It can be difficult to sample seaweed and mussels because they are living deeper than the tidal zone; so, perhaps a diver has to sample the species.

Fish samples: Fourhorned sculpins are caught in pound nets close to the coast at 4 to 6 stations inside the Citronen Fjord and at 2 stations just outside the mouth of the fiord as described above. Also sculpins are caught at the 2 reference stations. Muscles, livers and bones are analysed for heavy metals.

Fresh water samples and water flow measurements: Water samples and water flow measurements are taken at 3 to 4 stations in the eastern river and at 2 stations in Esrum Elv. These parametres are taken very often or continuously over the 3 month period the rivers are running. Accurate flow measurements in Esrum Elv can be difficult because of the powerful discharge. Temperature, pH and concentrations of heavy metals are measured.

Arctic char samples: The two rivers are examined for an eventual population of migrating Arctic char. In the mouth of the eastern river and of the Esrum Elv nets are set, and with electrical fishing equipment there are fished for Arctic char in the rivers. If any chars are caught they are analysed for heavy metals in muscles, livers and bones.

Vegetation samples: In order to measure contamination with heavy metals spread by dust, higher plants or mosses are sampled at 8 stations in the Citronen Fjord area and at 8 stations in reference areas 10 to 40 km from the Citronen Fjord area. The vegetation samples are analysed for heavy metals.

Climate: Prior to a mineral operation automatic registration of weather parametres should be started as part of the back ground study. The data will give parts of the physical conditions for the items sampled during the back ground study. In establishing a registration at an early stage a longer data series will be secured if and when climatic data will be needed for other purposes as well.

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15. APPENDICES

15.1 Higher plants from Citronen Fjord

Higher plants were sampled in the Citronen Fjord area, both by Christian Bay, Botanical Museum of Copenhagen, at a 2 to 3 hours visit the August 15, 1993, and by us during the reconnaissance study from August 15 - 26, 1993. Christian Bay identified the collected species and prepared the following list of 48 higher plant species. The species are presented in alphabetic order.

Alopecurus alpinus
Arctagrostis latifolia
Braya purpurascens
B. thorild-wulffii
Carex misandra
C. nardina
C. stans
Cerastium arcticum
Cerastium regelii
Chamaenerion latifolium
Colpodium vahlianum
Draba arctogena
D. bellii
D. lactea
D. subcapitata
Dryas integrifolia
Elymus hyperarcticus
Equisetum variegatum
Erigeron compositus
Eriophorum scheuchzeri
E. triste
Eutrema edwardsii
Festuca baffinensis
Juncus biglumis
J. triglumis
Kobresia myosuroides
Lesquerella arctica
Luzula arctica
Melandrium apetalum
M. triflorum
Minuartia rossii
M. rubella
Oxyria digyna
Papaver radicatum
Pedicularis hirsuta

Phippsia algida ssp. algidiformis
Poa abbreviata
Polygonum viviparum
Potentilla pulchella
Puccinellia angustata
Sagina intermedia
Salix arctica
Saxifraga cernua
S. oppositifolia
Stellaria crassipes
Taraxacum arcticum
T. phymatocarpum
T. pumilum

15.2 Seaweed from Peary Land

The species below are sampled in Jørgen Brønlund Fjord, primarily on the 1. Peary Land Expedition from 1947 to 1950, and compiled by Lund in 1951. On the 4. Peary Land Expedition in 1966 the type *Lithothamnion-Lithophyllum* was added to the list. The *Laminaria*, probably *saccharina*, was found on the ice of Frederick E. Hyde Fjord in 1907 by the Danmark Expedition (Dietz & Andersen 1984).

Chlorochytrium inclusum
Chaetomorpha melagonium
C. tortuosa
Acrosiphonia sp.

Pylaiella litoralis
Giffordia ovata
Sphacelaria racemosa
Chaetopteris plumosa
Leptonema fasciculatum
Elachista fucicola
Desmarestia viridis
D. aculeata
Stictyosiphon tortilis
Punctaria glacialis
Litosiphon groenlandicus
Corda tomentosa
Laminaria saccharina

Audouinella efflorescens
Phyllophora brodiaei
Ceratocolax hartzii
Polysiphonia arctica
Rhodomela lycopodioides (tenuissima)
R.l. (flagellaris)
Lithothamnion-Lithophyllum type.

15.3 Mussels from Peary Land

The species below are collected in Jørgen Brønlund Fjord during the 1. (1947-50) and the 4. (1966) Peary Land Expedition and compiled by Ockelmann in 1958 and 1983, respectively. Shells from two species also found in Jørgen Brønlund Fjord, *Hiatella striata* and *Mya truncata* were sampled at Oodaaq Ø in 1979 by GGU and GI (Dietz & Andersen 1984).

Nuculoma tenuis
Nuculana pernula
Portlandia arctica
Yoldiella intermedia
Y. lenticula
Y. frigida
Bathyarca glacialis
B. frielei
Dacrydium vitreum
Musculus niger
Cyclopecten imbrifer
Arctinula groenlandica
Limatula hyperborea
Astarte borealis
A. montagui
A. crenata
Thyasira gouldi
T. frigida ?
T. pygmaea
Axinopsida orbiculata
Macoma calcarea
M. loveni
Hiatella striata (=byssifera)
Mya truncata
Thracia devexa
Cuspidaria subtorta
C. arctica
Lyonsiella abyssicola

15.4 Fish from Peary Land

The fish species below are caught in Jørgen Brønlund Fjord on the 4. (1966), the 5. (1968) and the 20. (1983) Peary Land Expedition, and compiled primarily by Muus in 1981. The species *Reinhardtius hippoglossoides* was found dead on the beach in Hellefiske Fjord on the 1. Peary Land Expedition 1947-50 (Dietz & Andersen 1984).

Salvelinus alpinus
Boreogadus saida
Arctogadus glacialis
Gymnelis retrodorsalis
Lycodes sp. (juveniles)
Gymnocanthus tricuspis
Icelus bicornis
Myoxycephalus scorpius
M. quadricornis
Artediellus atlanticus
Cyclopteris macalpini
Reinhardtius hippoglossoides

16. MAP NO. I-V

Map No. I: Location map and topography - 1:500.000 / 1:1.200.000.

Map No. II: Fishing, sampling and water flow - 1:30.000.

Map No. III: Mammals and Snowy owl, 1993 - 1:1.500.000.

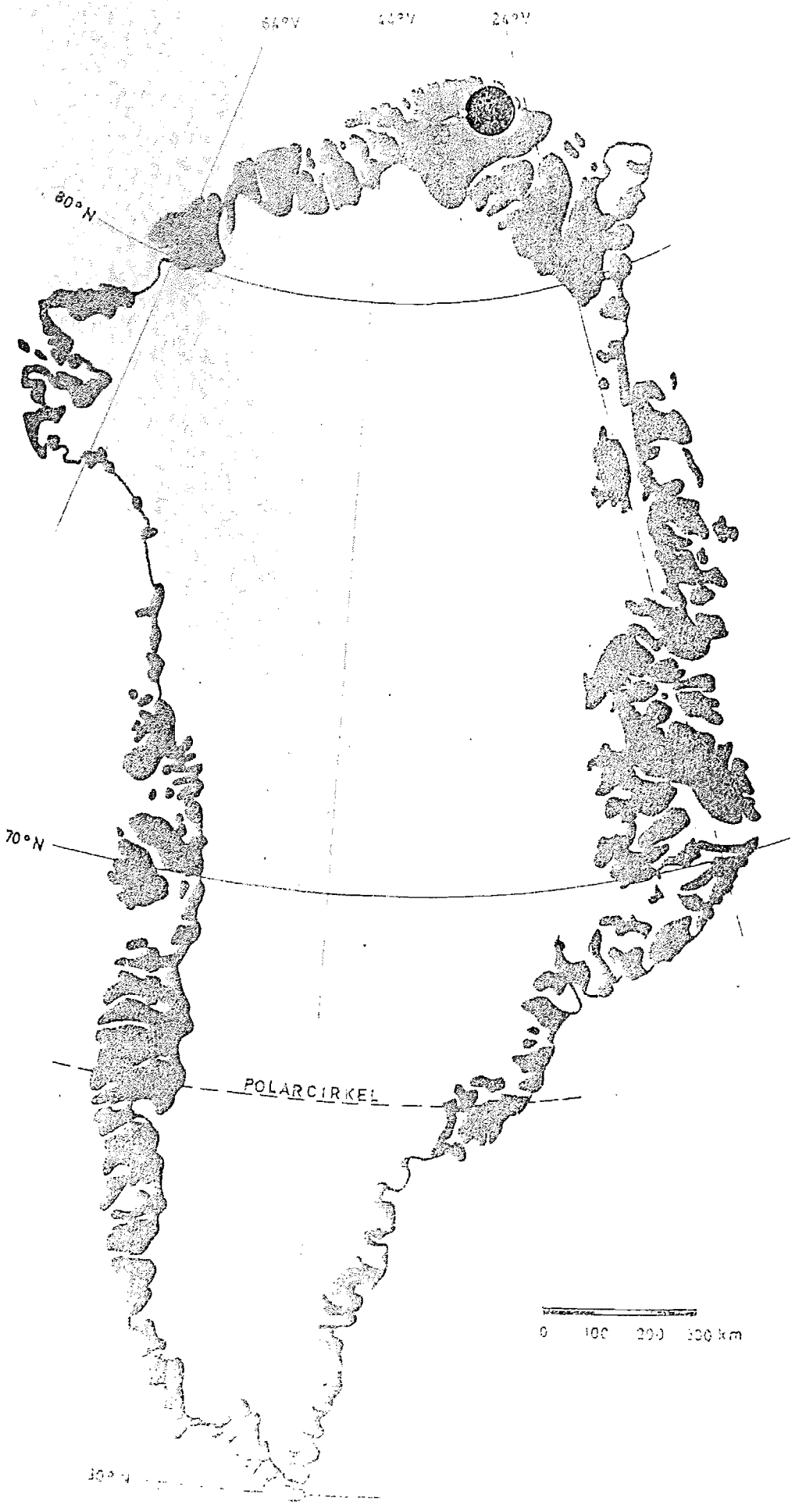
Map No. IV: Hydrological catchment areas - 1:200.000.

Map No. V: Vegetation and Musk oxen - 1:30.000.

Observations of mammals and Snowy owl in Peary Land 1993.

The more specific informations see chapters 8.9, 10.3 and 10.4
(observations made by Frank van der Stijl, Platinova A/S, per. com.)
Map prepared by Eigil Knuth in 1950.

Citronen Fjord	
Reconnaissance, August 1993	
MAMMALS AND SNOWY OWL, 1993	
GM/GFU	Map no. III


80°N
70°N
POLARCIRKEL
0 100 200 300 km

30°

25°

1:500 000

0 25 50 km

Kap Morris Jesup

Oodaaq Ø

Kaffekluben Ø

83°30'

Kap Bridgman

Bertelsen Gletscher

Kap Ole Chiewitz

Paradis Fjeld

JENES V. JENSEN LAND

Sydgletscher

Kap John Flagler

Skagen

FREDERICK E. HYDE FJORD

CITRONEN FJORD

Frigg Fjord

83°00'

HANS EGEDE LAND

HEINRICH WILD ISKAPPE

Nordkronen

G. B. Schley Fjord

Wyckoff Land

Hellefiskefjord

Avlum Elv

Spørrup Elv

PEARY LAND

HERLUF TROLLE LAND

Bærglum Elv

FREDERICK E. HYDE FJORD

CITRONEN FJ.

INDEPENDENCE FJORD

TOPOGRAPHY

- Over 900 m (over 3000')
- 600 - 900 m (2000' - 3000')
- Below 600 m (below 2000')

FORMER ICE MARGINS

- Ice margin position inferred
- Ice margin position defined

0 25 50 75 100

Source: (Henriksen 1992)
(Weidick 1972)

Citronen Fjord

Reconnaissance, August 1993

LOCATION MAP AND TOPOGRAPHY

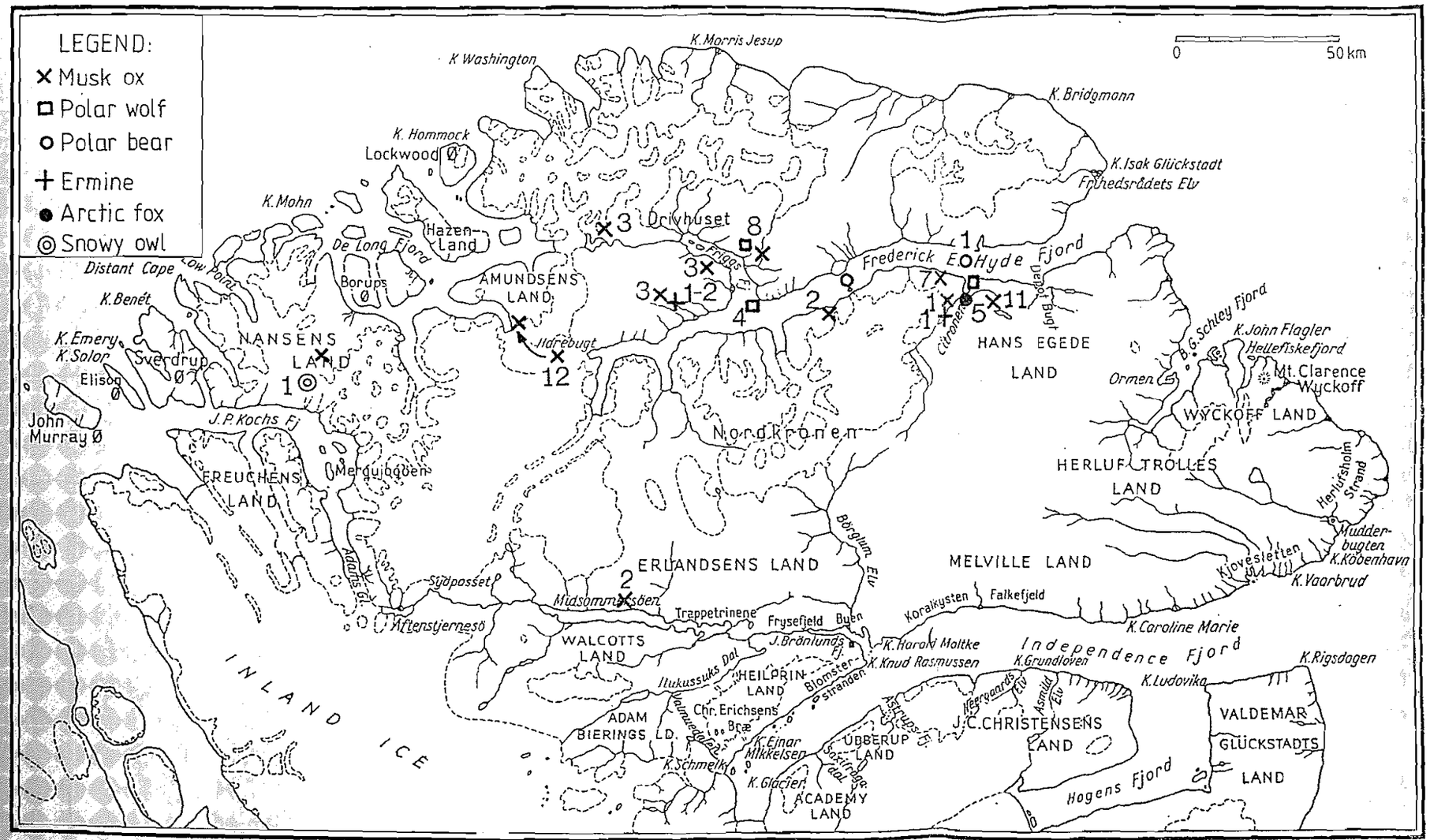
GM/GFU Map no. I

LEGEND:

- Water sample
- Sediment sample
- Fishing net
- Water flow measurement
- Water flow estimate

MAP: Enlarged section of aerial photo no. 874 E/
1:150.000 - July 23, 1978 - KMS.

Citronen Fjord
Reconnaissance, August 1993
FISHING, SAMPLING AND WATER FLOW
GM/GFU Map no. II


LEGEND:
Musk ox
Polar wolf
Polar bear
Ermine
Arctic fox
Snowy owl
0
50 km
K. Morris Jesup
K Washington
K. Bridgmann
K. Hommock
Lockwood Ø
K. Isak Glückstadt
Frihedsrådets Elv
K. Mohn
Hazen Land
Drivhuset
De Long Fjord
Frigg
Distant Cape
Low Point
Borups Ø
AMUNDSENS LAND
Frederick E. Hyde Fjord
K. Benét
K. Emery
K. Solor
Sverdrup Ø
Eliseø Ø
NANSENS LAND
Aldrebugt
HANS EGEDE LAND
G. Schley Fjord
K. John Flagler
Hellefiskefjord
Mt. Clarence Wyckoff
Ormen
John Murray Ø
J.P. Kochs Fj.
Nordkronen
WYCKOFF LAND
FREUCHENS LAND
Merquiaqden
HERLUF TROLLES LAND
Herlufsholm Strand
Mudderbugten
K. København
ERLANDSENS LAND
MELVILLE LAND
Kjovesletten
K. Vaarbrud
Adams Gl.
Sydposset
Midsommersøen
Trappetrinene
Frysefjeld
Buen
Koralkysten
Falkefjeld
K. Caroline Marie
Independence Fjord
K. Rigsdagen
WALCOTTS LAND
J. Brönlunds Fj.
K. Harald Moltke
K. Knud Rasmussen
K. Grundloven
K. Ludovika
Itukussuks Dal
HEILPRIN LAND
Blomsterstranden
VALDEMAR
GLÜCKSTADTS LAND
ADAM BIERINGS LD.
Chr. Erichsens Bræ
J.C. CHRISTENSENS LAND
ÜBBERUP LAND
K. Einar Mikkelsen
K. Schmelck
K. Glacier
ACADEMY LAND
Hogens Fjord
INLAND ICE

FREDERICK E. HYDE FJORD

CITRONEN FJORD

N

0

HEINRICH WILD

ISKAPPE

HANS EGEDE LAND

JENS JARL ISKAPPE

Citronen Fjord

Reconnaissance, August 1993

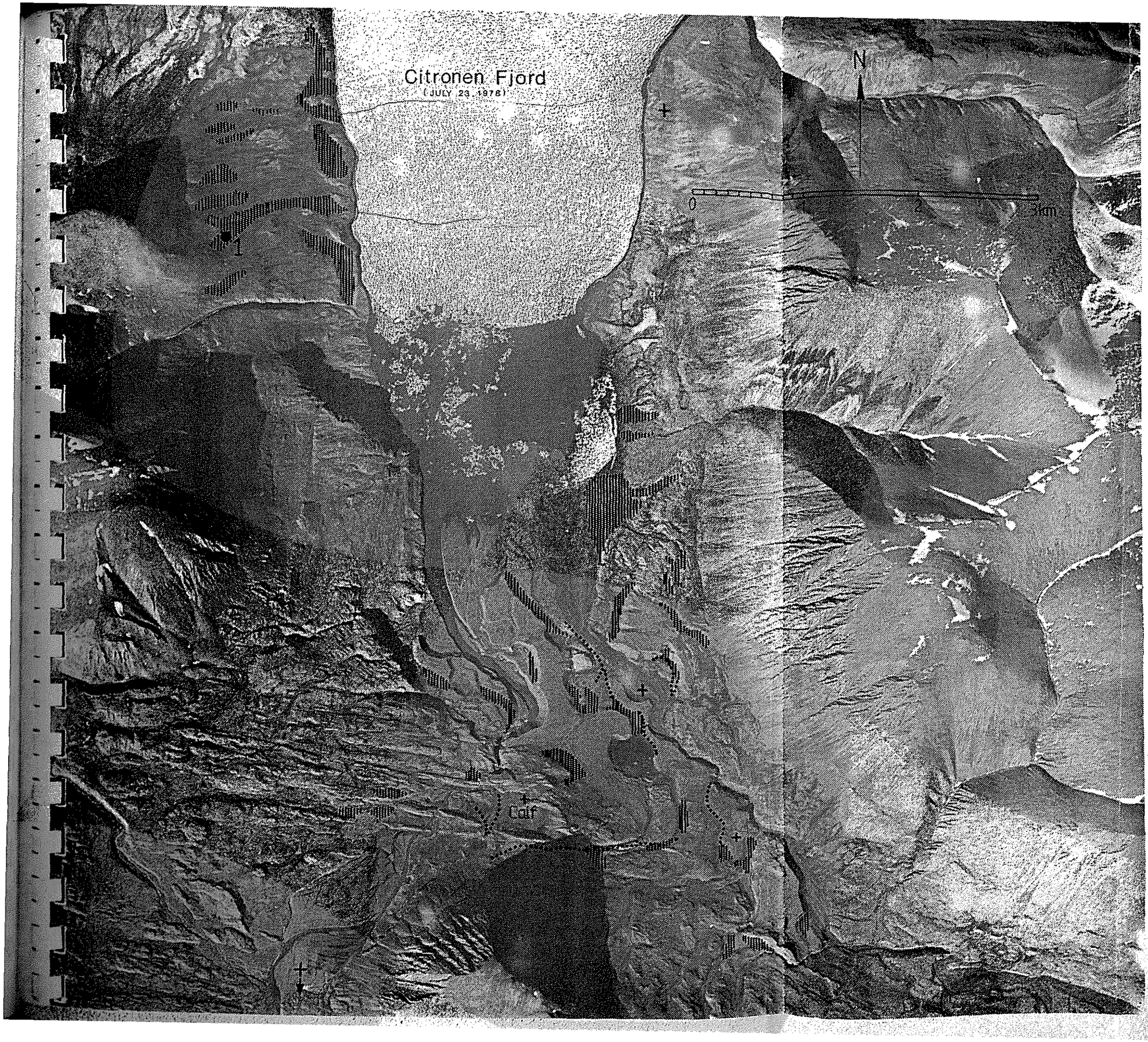
HYDROLOGICAL CATCHMENT AR

GM/GFU

Map no.

MAP:
Reduced sections of orthoj
maps 82 0 2 NØ and 83 0 2
1:100.000 - KMS 1987/ 19

Contour interval is 100 metr



LEGEND:

- Area with closed vegetation
- ..... Musk ox, tracks
- \+ Musk ox, skeleton
- 1● Musk ox, observation, 1 seen

MAP. Enlarged section of aerial photo no. 874 E
1:150.000 - July 23, 1978 - KMS.

Citronen Fjord
Reconnaissance, August 1993
VEGETATION AND MUSK OXEN
GM/GFU Map no. V