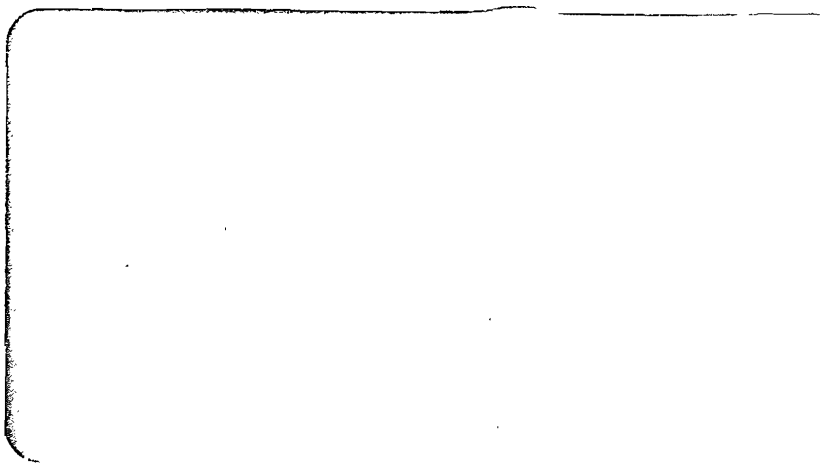
Baseline study
in the CITRONEN FJORD area

North Greenland
1994

Teknisk Rapport

Grønlands Miljøundersøgelser



Grønlands Miljøundersøgelser (GM) vurderer virkningerne på miljøet af efterforskning og udnyttelse af mineralske råstoffer og vandkraft i Grønland. I forbindelse med råstof - projekter undersøger GM de miljømæssige forhold og medvirker ved råstofforvaltning - ens behandling af projekterne. GM udfører undersøgelser af, hvordan påvirkningen af miljøet kan begrænses, og overvåger påvirkningen. GM udfører desuden egne mere forskningsmæssige undersøgelser, som er af betydning for vurderingen af de miljømæs - sige forhold ved de konkrete projekter.

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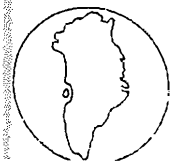

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Greenland Environmental Research Institute, January 1995

CONTENT

1. SUMMARY

The report describes the environmental baseline studies that were conducted at Citronen Fjord July/August 1994 in the area where Platinova A/S is prospecting intensively for zinc. Samples were collected of marine sediments, river sediments, seaweed, four horned sculpins, Arctic willow, entired-leafeed mountain avens, meadow grass and faeces from collared lemming, Arctic hare and muskox. These samples have been prepared for storage, and are now stored at the Greenland Environmental Research Institute.

Seawater and riverwater were sampled and analysed for dissolved zinc, cadmium, lead, copper and mercury.

One river, Eastern River, that passes through the known zinc outcrop, had an extremely high concentration of zinc (2445 µg/kg) at the beginning of the summer season. The concentration rapidly fell between 1 and 10 µg/kg. The annual flow in this river is roughly estimated to 70 mill m^3 containing 1471 kg zinc.

Compared to Uummannaq Fjord the surface of the Citronen Fjord had a slightly enriched concentration of zinc originating from Eastern River on July 29. At depth the Citronen Fjord had a possible enrichment of zinc, no enrichment of cadmium, and indications of an enrichment of lead.

Some seaweed and sculpin samples have been analysed for Zn, Cd, Pb, Cu and Hg. It appears that the Zn and Pb level in seaweed is elevated.

2. RESUMÉ

Denne rapport bekriver de prøver, som blev indsamlet i Citronen Fjord området i juli/august 1994, hvor Platinova A/S udfører et intensivt efterforskningsprogram for zink. Endvidere er der foretaget observationer af plante- og dyreliv i området.

De indsamlede prøver er: havsediment, flodsediment, tang, ulke, arktisk pil, dryas, og en græsart, desuden afføringsprøver af lemming, hare og moskusokse. Disse prøver er forberedt til langtidslagring og opbevares nu på Grønlands Miljøundersøgelser.

Havvand og elvvand er prøvetaget, og prøverne er alle analyseret for opløst zink. Enkelte prøver er desuden analyseret for opløst cadmium, bly og kobber. En enkelt prøve er analyseret for kviksølv.

En elv, Østlige Elv, som passerer de kendte blotninger af zinkforekomsten, havde et ekstremt højt zinkindhold i begyndelsen af sommeren (2445 µg/kg). Koncentrationen faldt hurtigt til mellem 1 og 10 µg/kg. Det skønnes, at der årligt strømmer 70 mill m^3 vand i denne elv, og at dette medbringer 1471 kg opløst zink.

Overfladen af Citronen Fjord havde 29. juli en lettere forhøjet zinkkoncentration. Zinken ser ud til at stamme fra den Østlige Elv.

De dybere vandlag i Citronen Fjord havde et forhøjet indhold af zink og bly, men målingen var ikke signifikant. Cadmium var ikke forhøjet. Sammenligningsgrundlaget er Uummannaq Fjord.

Udvalgte prøver af tang og ulkelever er anlyseret for Zn, Cd, Pb, Cu, og Hg, og der ser ud, som om zink- og blyniveauet i tang er forhøjet.

3. INTRODUCTION

During 1994, from early May to late August, Platinova A/S continued exploration in its Citronen Fjord license area. This was the second year of exploring the zinc mineralization discovered May 1993. In 1994 the exploration consisted of geophysical investigations and diamond drilling of 9,600 meters in 43 holes.

In spring 1994 Platinova A/S, the Mineral Resource Administration for Greenland (MRA) and Greenland Environmental Research Institute (GERI) agreed to initiate a baseline study in the Citronen Fjord area in 1994. The baseline study program was based upon a reconnaissance study performed in 1993 (Glahder & Langager 1993) and consisted of studies of sea water, fresh water, sediments, mussels, seaweed, fish and vegetation.

This report describes the work done in the Citronen Fjord area in July and August 1994, and the results of the analyses of the water samples and a selection of the fish and seaweed samples.

4. LOGISTICS

The baseline study was carried out in the Citronen Fjord area from 28 July to 13 August 1994 by Gert Asmund and Christian Glahder from GERI.

In April 1994 approximately 100 plastic bottles of 1 liter together with simple equipment for water level measurement were sent to Citronen Fjord via Spitsbergen and Station Nord. This material should be used to follow the daily metal flow in the Eastern River from the day when it starts running; in 1994 it was on June 8.

On July 26 the Glahder and Asmund and approximately 350 kg of equipment were transported with a military Hercules airplane to Station Nord via Keflavik, Iceland. The equipment included a rubber boat, outboard motors, bottom samplers, water samplers, fishing nets, survival suits and tents.

With a Twin Otter from Station Nord, Citronen Fjord was reached 28 July. From the airstrip in the delta area the equipment was transported by a Yamaha 4 wheel Big Bear to the Field Camp fiord. Accommodation was in a Weatherhaven tent in the Platinova A/S Base Camp 2 km from the fiord at the fresh water lake.

Transportation in the field was on foot and in the fjord with the rubber boat. No helicopter was available, as it had left the area earlier in July. Equipment was transported with the Big Bear.

Samples and most of the equipment was flown to Station Nord 10 August. The remaining equipment and the authors left Citronen Fjord for Station Nord 13 August. A few hours later we flew back to Denmark with all the samples, while most of the equipment was left at Station Nord.

Personnel from Platinova A/S, Station Nord, the Danish Defence Command and the Sledge Patrol Sirius are thanked for their help and hospitality.

5. WEATHER

Platinova A/S in 1994 has measured different weather parameters at the Base Camp with a transportable weather station (refer to Appendix 4.1). Daily readings taken at approximately 8 a.m. and 6 p.m. (GMT) are available for the period 9 June to 13 August. Compared with 1993 the Base Camp in 1994 was moved downhill and further to the north, so that it in 1994 was approximately 40* meters above sea level (50 meters in 1993). In 1994 time was GMT as Station Nord, while in 1993 time was GMT-2.

*F.v.d.Stijl 13.9.95 Brew H RJG +35 mete

The parameters measured were:

- Pressure, in millibar at elevation 40 m above sea level, instantaneous value.
- Air temperature, in °C, instantaneous value.
- Wind speed, in knots (0.51 m per second), instantaneous value.
- Wind direction, in true north (magnetic deviation ca. 40°), instantaneous value.
- Relative humidity (the instrument probably need a calibration since the measurements never exceeded 55% even during rain)

The results of the temperature measurements are shown in figure 1.

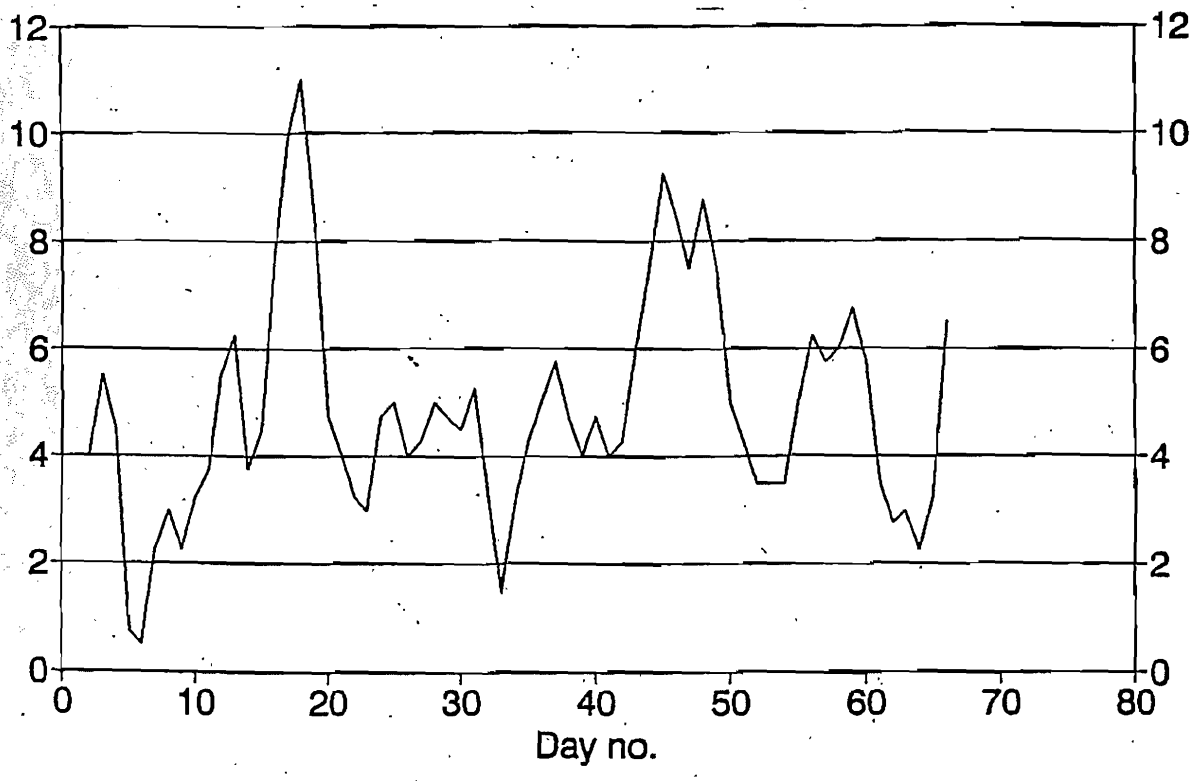

Figure 1. Mean temperature (°C) measured twice a day at the Citronen Fjord Base Camp from 9 June (day 0) to 13 August.

6. MARINE SAMPLES

In Citronen Fjord samples have been taken of sediment, fish, seaweed and sea water. On a total of 71 stations 208 samples were taken.

It had been planned to sample at four marine stations in Frederick E. Hyde Fjord, with two stations located a few kilometers to each side from the mouth of Citronen Fjord and two reference stations 30 to 50 km to each side of Citronen Fjord. It was however not possible to get to any of these stations with the rubber boat because of too much ice in F. E. Hyde Fjord. A narrow, ice free channel 2 to 5 meter wide, existed along the coast, but as no helicopter was in the area, we would not run the risk to get trapped should heavy winds rise from the north. Also, we were not able to be transported by helicopter to the reference stations.

6.1 Sediment

Sediment has been sampled at 26 stations, cf. Appendix 1.1, 2.1 and Fig. 2. At each station one sample of the upper 5 to 10 cm of sediment was taken with a Kayak bottom sampler. The samples were not sliced, but taken as a whole and put into a plastic bag and frozen the same day at the Base Camp.

The samples were taken with some difficulty, especially at greater depths. Also wind and waves made sampling difficult. Samples were taken on water depths ranging from 11 to 141 meters.

All sediment samples were brought to Denmark and stored in a GERI freezer. No samples have been analysed.

6.2 Fish

The only fish caught in Citronen Fjord was the Fourhorned sculpin (*Myoxycephalus quadricornis*), which is quite abundant along the coast of the fjord. A Polar cod (*Boreogadus saida*) or an Arctic cod (*Arctogadus glacialis*) was caught in the net at station F1 at the mouth of Esrum Elv, but managed to slip away.

Nets were set at 5 stations, cf. Appendix 1.1 and Fig. 4. A total of 111 fourhorned sculpins were caught, distributed as shown in Appendix 2.2. At each station a pound net was set along the shore at depths of approximately 1 meter. The length was 50 m and the mesh width 2.6 cm. Nets were set from 29 July to 2 August and tended every day for two to four days. The last net was taken 4 August.

From 1 to 4 August ice floes caused problems at four of the five nets. Ice moved the nets around and tore holes in them, but only one net was lost.

The length of the fish were measured and the fish were frozen whole. The average length of the fourhorned sculpins caught was 20.3 cm (SD=2.6, N=111), ranging from 14.0 to 26.4 cm.

All fish were transported to Denmark and stored in a GERI freezer.

According to the agreement with Platinova A/S 16 fish livers have been analysed at the GERI laboratory. Fourhorned sculpins from two stations, F2 and F3 (see Fig. 4) were weighed, the sex was determined and liver samples taken for analyses. The livers were cut out by a stainless steel scalpel, and approximately 0.5 g was dissolved in nitric acid in teflon pressure bombs.

After dissolution, the samples were diluted to 50 g by Milli Q water. Zinc was determined by flame AAS. Cadmium, lead and copper were determined by graphite furnace AAS. Mercury was determined by cold vapor AAS using sodiumborohydride as reductant and a Perkin Elmer flow injection system.

The results are shown in Table 1. They may be compared with reference values for shorthorn sculpin (*Myoxycephalus scorpius*) elsewhere in Greenland.

3,45 (R sd = 1,68)

For cadmium the geometric mean (G. mean) in Citronen Fjord is 3.8 µg/g dry weight (d.w), while in Uummannaq it is 1-2 µg/g d.w. Values of 4 to 8 µg/g d.w. are found in Maniitsoq, Nanortalik, Thule and Upernavik. Thus the cadmium level in liver of fourhorned sculpin from Citronen Fjord is within the range of values found in the liver of another sculpin species, the shorthorned sculpin, in other parts of Greenland.

Table 1. Metal concentrations (mg/kg dry weight) in fourhorned sculpin livers from two stations (F2 and F3). "Køn"=sex; M=male, F=female; "Lokalite"=station; "Tørstof"=dry weight.

IDNR	KØN	LOKALITE	TØRSTOF %	Cd	Pb	Zn	Cu	Hg
16697	M	F3	27,38	3,99	0,266	111	15,7	0,21
16660	M	F3	27,38	4,49	0,123	116	8,28	0,24
16700	M	F3	27,38	4,11	0,173	109	14,9	0,16
16678	M	F3	27,38	4,75	0,186	144	30,5	0,20
16730	M	F3	27,38	5,06	0,300	170	30,4	0,18
16674	M	F3	40,09	1,33	0,061	66,9	16,3	0,07
16661	M	F3	27,38	4,88	0,093	121	19,3	0,19
16698	M	F3	32,94	3,33	0,082	79,9	8,02	0,10
16695	M	F2	27,38	4,81	0,805	155	32,9	0,16
16688	M	F2	23,95	2,94	0,109	113	6,70	0,11
16696	F	F2	24,65	4,45	0,092	93,5	4,52	0,12
16689	M	F2	22,25	9,24	0,281	198	58,8	0,31
16690	F	F2	29,15	3,14	0,088	102	6,51	0,12
16690		F2	29,15	1,82	0,081	98,9	6,15	0,11
16652	F	F2	19,95	2,67	0,184	123	10,3	0,25
16652		F2	19,95	2,67	0,224	122	10,2	0,24
16611	M	F2	26,07	7,04	0,973	126	7,48	0,15
16693	F	F2	27,38	1,86	0,046	118	6,53	0,10
16693		F2	27,38	1,36	0,056	105	6,34	0,11
				x̄ 3,39	3,45	0,222	0,151	119,6	116	15,38	12,1	0,16
				SD 1,96	1,68	0,249	2,309	30,6	1,28	13,74	2,04	0,06
				N 19	19	19	19	19	19	19	19	19

2,48 2,67 1,61 0,15 (R.sd = 2,3) 116 (R.sd = 1,28) 12,1 (R.sd = 2,0) 0,15 (R.sd = 1,42)

G. mean values for lead in Citronen Fjord is 0.15 µg/g d.w., and at the reference station in Scoresby Sund less than 0.4 µg/g d.w. and in Uummannaq less than 0.04 µg/g d.w. As for Cd values are within the range of other parts of Greenland but in the high end if comparison is made with the newest data for shorthorn sculpin. or % = 1.23

G. mean for zinc in Citronen Fjord is 116 µg/g d.w., compared to a G. mean in Uummannaq of 100 (ranging from 85 to 129) as a 13 years average. The Citronen Fjord value is within this range.

For copper the G. mean in Citronen Fjord is 12.0. The reference G. mean from Uummannaq is 23 (ranging from 10 to 55) as a 10 years average. Here the Citronen Fjord values are in the lower end of the reference values for shorthorn sculpin..

In Citronen Fjord, the G. mean value for mercury is 0.15 µg/g d.w., and at the reference

stations in Maniitsoq, Thule and Kong Oscars Fjord (East Greenland) the median values are between 0.06 and 0.08 µg/g d.w. The Citronen Fjord value is about twice the value from other areas in Greenland.

All in all, metal concentrations in sculpin livers from Citronen Fjord were not significantly different from reference values from elsewhere in Greenland, expect for mercury which seems elevated in Citronen Fjord. It must be noted, that values are compared for two different sculpin species.

The two stations, F1 (east coast) and F2 (west coast) are not significantly different for any of the metals analyzed. Only sex shows a significant influence, giving higher lead concentrations for males than for females, and close to significant difference for cadmium and copper. The mechanism of this is not understood. The statistical method used is a covariance analyses.

6.3 Seaweed

Seaweed was sampled at 6 stations, cf. Appendix 1.1 and Fig. 4. At each station a sample was taken of sweet tangle (*Laminaria* sp - probably *saccharina*) and at three stations the seaweed species *Desmarestia* sp was sampled (cf. Appendix 2.3).

Samples were taken with a "seaweed rake" pulled behind the rubber boat moving at low speed. The rake was pulled over the bottom for 2 to 5 minutes at depths of 5 to 20 meters. A heavy rake looking like an intermediate between a hedgehog and a pinholder was brought to Citronen Fjord, but did not manage to catch much seaweed, because it dug itself down into the sediment. Instead, Platinova A/S´ handy man Louis Nielsen made a lightweight rake out of a field bed. With a lead placed a couple of meters in front of the rake, it became an easy job to collect enough seaweed on each station. The width of the rake was approximately 1 meter.

The seaweed samples were frozen the same day and the brought to Denmark where they were washed in milli Q water. The soft parts were cut free from the stem, freeze dried and crushed.

Included in the agreement with Platinova A/S was 3 analyses of seaweed and 3 of mussels zinc, cadmium, lead, copper and mercury. As only very few mussels were sampled, 1

sample of seaweed, i.e. *Laminaria* sp, from each of the 6 stations has been analysed. Approximately 0.2 to 0.5 g was dissolved and analysed in the same way as the fourhorned sculpins, cf. chapter 6.2.

The results are shown in Table 2. Below, values for *Laminaria* sp from Citronen Fjord is compared to reference values for other brown algae (*Fucus distichus* and *vesiculosus*) elsewhere in Greenland.

Table 2. Metal concentrations (mg/kg dry weight) in the seaweed *Laminaria* sp from six stations (T 1-6). "Lokalitet"=station.

IDNR	Lokalitet	Cd	Pb	Zn	Cu	Hg
16755	T 1	2,24	2,04	41,7	2,06	0,06
16757	T 2	1,61	2,60	33,8	1,92	0,06
16758	T 3	1,66	2,97	37,2	1,54	0,06
16759	T 4	1,99	3,58	53,6	4,37	0,10
16760	T 5	3,54	3,25	124	3,92	0,15
16761	T 6	2,41	7,21	91,9	7,23	0,12
16761	T 6	2,36	7,84	86,5	7,29	0,12

Whole *Laminaria* 's from Citronen Fjord were analysed, while growing tips from the Fucus species normally are analysed at reference stations. It has been found that concentrations are lower in growing tips than in whole plants.

The cadmium concentrations in *Laminaria* sp from Citronen Fjord is between 1.6 and 3.5 µg/g d.w., while aritmetric means in growing tips of fucus from reference stations range from 0.5 to approximately 2 µg/g d.w. For inner fjords values are found to be 1-2 µg/g d.w. lower than for outer fjords, giving rather low expected values in Citronen Fjord. On the other hand, whole algae gives 0.5 µg/g d.w. higher values than growing tips. Cadmium values in *Laminaria* sp seems to bee in the same order of magnitude as in Fucus in other parts of Greenland.

Lead concentrations in *Laminaria* sp from Citronen Fjord are on average 2.9 µg/g d.w. for five stations and 7.5 µg/g d.w. for one station (T6). Reference values for Fucus from Paamiut, Avernersuaq and Uummannaq are between 0.18 and 0.37 µg/g d.w. So, lead concentrations in *Laminaria* sp in Citronen Fjord is for most stations elevated

approximately 10 times and for one station close to the Eastern river appr. 25 times elevated.

The concentration of zinc in *Laminaria* sp in Citronen Fjord are for 4 stations in average 41.6 µg/g d.w. and 89.2 and 124 µg/g d.w. for two stations, T6 and T 5, respectively. Reference values from Paamiut, Nuuk and Avernarsuaq are between 6 and 13 µg/g d.w.. Thus zinc concentrations in *Laminaria* sp from Citronen Fjord are at most stations approximately 5 times higher than these reference values, while concentrations at the two stations are 7-20 times elevated.

In Citronen Fjord, the copper concentration in *Laminaria sp* are 2.8 µg/g d.w. at five stations and 7.3 µg/g d.w. at one station (T6). Reference values from Paamiut, Avernersuaq and Uummannaq range from 1.9 to 4.4 µg/g d.w. Most of the stations shows no elevated concentrations, while one seems elevated by a factor of appr.2.

In Citronen Fjord mercury concentration averages 0.1 µg/g d.w. No reference values are available.

In conclusion compared to Fucus, lead and zinc seems elevated 5-10 times in *Laminaria* in most of Citronen Fjord. If cadmium and copper are elevated it is only slightly. For the station closest to the Eastern River concentrations of lead, zinc and copper were elevated 25, 15 and 2 times, respectively, while station T5, also relatively close to the Eastern River has zinc concentrations elevated approximately 20 times.

In this connection it must be noted, that only one sample from each station has been analysed, which means the variations on each station is not known.

As GERI has no results for metal concentrations in *Laminaria* species from other areas of Greenland, it is important to sample and analyse *Laminaria sp* from the reference stations in Frederick E. Hyde Fjord.

6.4 Sea water, column

Sea water column samples were taken at 4 stations, cf. Appendix 1.1 and Fig. 4. Samples were taken from the following depths (in meters): 0, 2, 5, 10, 15, 20, 30, 50, 75 and 100, giving a total of 32 samples (refer to Appendix 2.4).

Temperature was measured with two reversible thermometers. The temperature is given as an adjusted average in °C (see Appendix 2.4).

The sea water samples were collected in 1 liter acid washed polyethylene bottles and shipped untreated to the GERI laboratory. An uncontrolled part of the dissolved metals will precipitate on the walls of the bottle and on the particles in the water sample. These precipitated metals were dissolved again in the laboratory by addition of 1 ml suprapure nitric acid. After a week or more the samples were analysed by anodic stripping voltammetry. The method was checked by analysing the reference sea water sample NASS-4. pH was measured with a glass electrode, and salinity with a Guildline Portasal conductivity salinity meter (see Appendix 2.4). All samples were analysed for zinc, and most were analysed for cadmium, lead and copper.

The surface temperatures differs some 2°C, between +1.8 and +4.0, but already at a depth of 10 m the four stations are almost identical. Here the temperature is approximately -1.0°C. Minimum temperature of -1.6°C is found in 50 m´s depth; at 100 m it has risen to -0.2°C. The same trend is found in Miki Fjord near Kangerlussuaq in Southeast Greenland (Glahder 1990).

Salinity in the surface was not measurable and therefor comparable to fresh water. At the inner stations, H1 and H2, the salinity was quite low at 2 m´s depth (2-4 $^0/_{00}$), while salinity at 2 m´s depth at the stations in the middle and the mouth of Citronen Fjord was 28-30 $^0/_{00}$, similar to the bottom water (see Fig. 5). Below 10 meter sea water at all stations exceeded 31 $^0/_{00}$. Highest salinity, 34.4 $^0/_{00}$, was reached at 100 m´s depth in the mouth of the fjord. The salinity in Citronen Fjord at depths below 10 m is approximately 1 $^0/_{00}$ higher than salinity found in the Kangerlussuaq area (Glahder 1990).

Both temperature and salinity found in Citronen Fjord deeper than 5 to 10 m correspond well to those in the Polar Water fraction (upper 150 meters) of the East Greenland Current, flowing south from the Greenland Sea along the east coast of Greenland. In this fraction, temperatures are between 0°C and -2°C and salinity between 30 and 34.5 $^0/_{00}$ (Buch 1990).

Concentrations of zinc, cadmium, lead and copper in sea water at different depths of Citronen Fjord are shown in Appendix 5.1.

The zinc concentrations in the sea water samples below 2 meters can be compared to sea water samples from uncontaminated areas in Uummannaq Fjord, where similar sampling and analytical methods have been used. Fig. 6 shows zinc concentrations in the four sea water columns. In Citronen Fjord sea water samples below 2 meters have an average zinc concentration of 2.03 µg/kg (SD=1.86, N=24); at Maarmorilik reference stations the average zinc concentration was 1.17 µg/kg (SD=1.31, N=25). So, zinc concentrations in the sea water samples from Citronen Fjord were higher than the concentrations at the reference stations. However, the difference is not significant, but close to the 95 % confidence level.

If the same calculations are performed for cadmium and lead, cadmium concentrations in the Citronen Fjord surface is on average 25,89 µg/kg (SD=10,76, N=20), compared to a reference station in Uummannaq Fjord, where the average concentration was 25,42 µg/kg (SD=10.83, N=25). For lead the figures in Citronen Fjord are 0.2186 µg/kg (SD=0.2675, N=21), and Uummannaq 0.144 (SD=0.141, N=25).

The cadmium concentrations in the sea water below 2 m is obviously the same in Citronen Fjord and in Uummannaq Fjord. Lead concentrations are slightly higher in Citronen Fjord, but the determination was not significant.

The average value for copper in Citronen Fjord below 2 m was 0.42 µg/kg (SD=0.14, N=20). This value is higher than reported for open ocean water, approximately 0.1 µg/kg, but probably typical for fiord water.

6.5 Sea water, surface

A total of 30 surface sea water samples were taken in one day, the 29 July. Only one sample was taken at each position (refer to Appendix 1.1, 2.5 and Fig. 3).

Sea water from the surface was sampled in three transect with one in the middle of the fjord and two along the two north-south going coasts. Approximately 10 samples were taken in each transect (cf. Fig.3). One liter of sea water was sampled in a plastic bottle while the rubber boat was moving at slow speed in order to avoid contamination from the exhaust of the engine.

The samples were transported to Denmark and analysed in the GERI laboratory. All

samples were analysed for zinc, and only two were analysed for other metals, i.e. cadmium, lead and copper (see Appendix 5.2). Preparation and analyses of the samples were identical to the sea water column samples, see chapter 6.4. Conductivity of the surface samples was measured by a simple conductivity meter that was calibrated with 1 g/kg NaCl (=1700 µS/cm).

The approximate area of Citronen Fjord is 11.25 km^2. The fresh water layer seems to be confined to the upper 2 meters, which then has a volume of 22.5 x $10^6 m^3$. In the week prior to the sampling date, 29 July, the flow in the Eastern river was approximately 2 x 10^6 m^3/day. The flow in Esrum Elv is estimated to be significantly higher (Glahder & Langager 1993). So, the residence time of the fresh water in Citronen Fjord is only a few days, e.g. if the water flow is twice as high in Esrum Elv than in the Eastern River, the residence time is 22.5 : (2+4) = 3.75 days.

The surface water samples taken the 29 July therefore must depict the different concentrations in the two fresh water sources. The zinc concentration in the Eastern River from 24 to 29 July averages 5.3 µg/kg (SD=1.8, variation: 3.3 - 7.5) while Esrum Elv in only one sample had a zinc concentration of 0.18 µg/kg. The Citronen Fjord surface zinc concentration was on average 2.42 µg/kg (SD=1.4, variation: 0.38 - 7.3). It must be expected, that the zinc concentration in the beginning of June is higher in the Citronen Fjord surface water because of a higher zinc concentration in the Eastern River. From Fig. 7 it appears, that concentrations above 2 µg/kg zinc has a more eastern distribution in the fjord than concentrations below 2 µg/kg. This could be due both to the outlet on the eastern part of the head of the fjord and to a north-northwestern wind blowing the 28 and 29 July. Also, Esrum Elv flowing out into the fjord in the western part containing low zinc concentrations contribute to this picture.

7. LIMNOLOGICAL SAMPLES

In the Citronen Fjord area samples of sediment and fresh water have been collected from the Eastern River and Esrum Elv. On a total of 21 stations 97 samples have been taken. Below, the sediment samples and the fresh water samples are described in detail.

7.1 Sediment

Sediment was sampled at 10 stations in the Eastern River and at 2 stations in Esrum Elv, cf. Appendix 1.1, 3.1 and Fig. 4. Only one sample was taken at each station. Samples were collected in plastic bags, frozen the same day and transported to Denmark, where they were freeze dried. No samples have been analysed.

7.2 Fresh water

Fresh water was sampled in the Eastern River at one station with a total of 76 samples, and at 6 stations with a total of 7 samples, and in Esrum Elv cf. Appendix 1.1, 3.4 and Fig. 4.

At the stations, a fresh water sample was taken with a one liter plastic bottle, stored at the Base Camp and transported to Denmark for analyses. Preparation and analyses of the samples were equal to the sea water column samples except for the salinity measurement, see chapter 6.4.

At the one station, V1, in the Eastern River close to the Base Camp, one daily sample was collected in the evening. At the same time the water level, in inches, was read from a folding ruler taped on a staff anchored in the river. The set up was done by Frank van der Stijl, Platinova A/S 8 June. He also made the readings until 28 July and from 13 to 22 August. Samples in the intermediate period were taken by GERI. The staff was left so that readings might continue next year. The 12 August the Greenland Field Investigations (GFU) and GERI marked two points on the cliffs nearby. This will make it possible to continue readings with comparable results should the staff disappear in the course of the winter. Also, a cross section of the river bed was measured in order to calculate the water flow from water level measured.

The other fresh water stations, apart from V1, and a sample from a brooklet flowing from the showing to the Eastern River, were analysed for zinc, cadmium, copper and lead. The sample from the brooklet shows very high metal concentrations and a very low pH. Obviously, pyrite is oxidized to sulphuric acid which dissolves the heavy metals from the mineralization. The fresh water samples from Esrum Elv and from upstream the showings had much lower metal concentrations than samples from the Eastern River downstream the showings.

All 76 samples from station V1 has been analysed for zinc, and 22 of these also for cadmium, lead and copper. Most of the 22 samples analysed for all metals are from the first third part of the period.

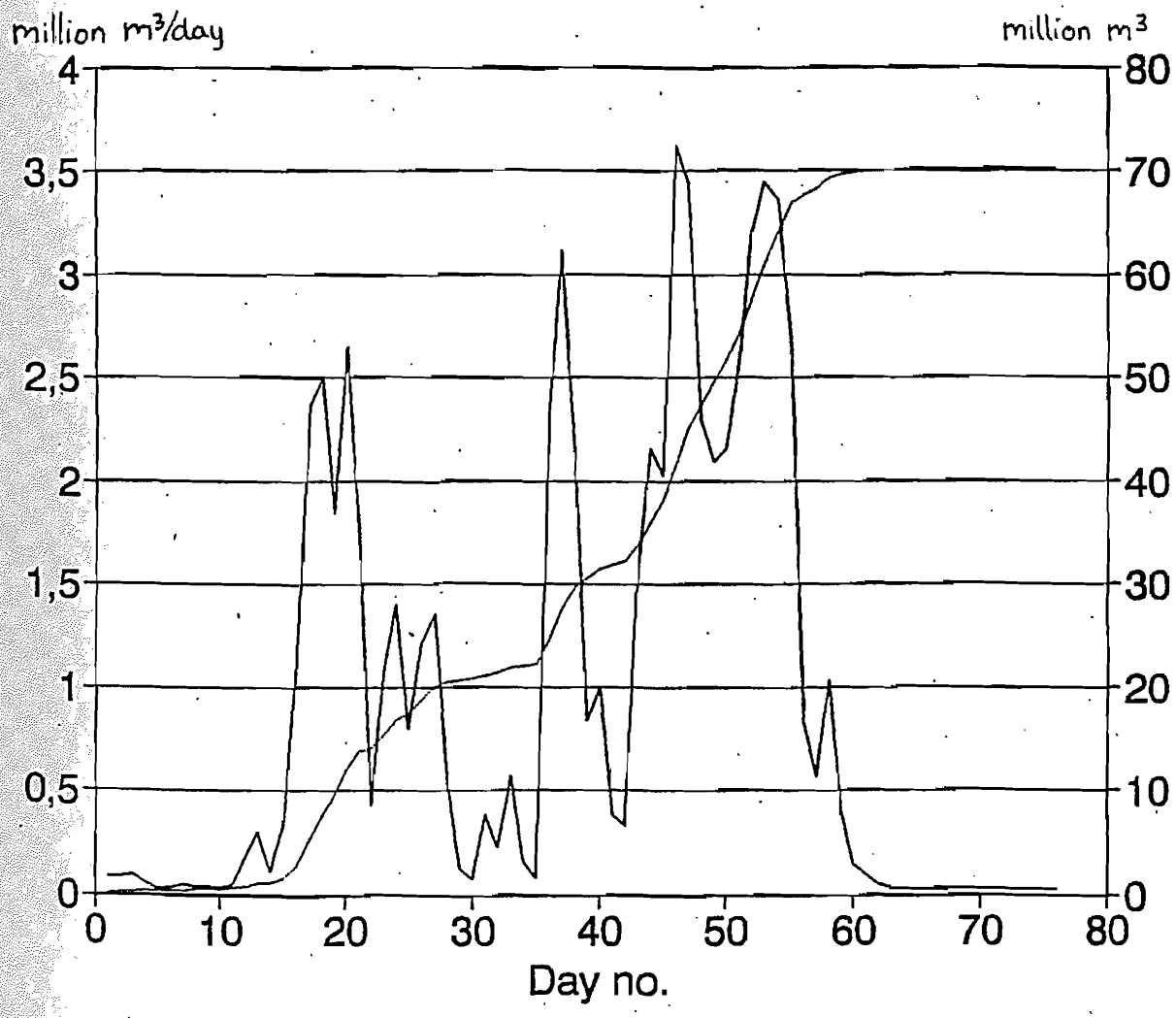

Figure 8. Water flow in Eastern River at station V1 from 8 June (day 0) to 22 August. Solid line: Daily flow in 10^6 m³/day; dotted line: Daily sum of flow in 10^6 m³.

The total amount of zinc transported out through the Eastern River to Citronen Fjord has been calculated to a little less than 1,500 kg (refer to Appendix 6.1). The daily water flow, Q, is calculated from the equation, $Q=2.3\ l/s \times (L + 4.7)^{2.5}$, where L is the read water level in inches (see Appendix 6.2). It must be stressed, that this equation gives only a rough estimate on the water flow; a much better estimate can be made with water flow measurements at different water levels. Water flow during the period is seen from Fig. 8. More than 2/3 of the total amount of zinc was transported to Citronen Fjord during the first 20 days.

A rough estimate is done with the three other metals. The period where water is running in the Eastern River is separated into two periods, i.e. from day 1 to 20 and from day 21 to 76.

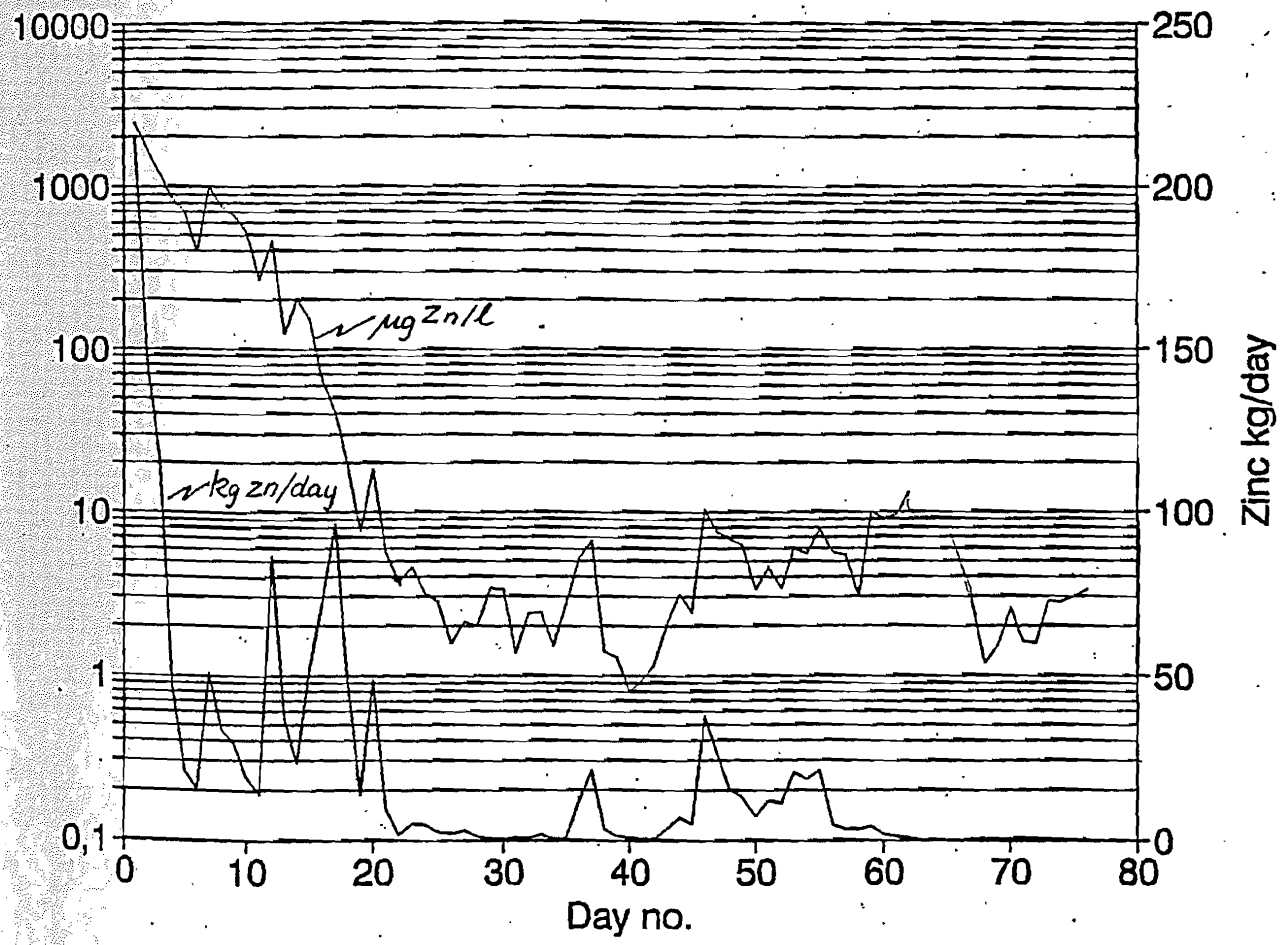

Figure 9. Zinc concentrations in Eastern River at station V1 from 8 June (day 0) to 22 August. Solid line: Calculated amount in kg/day; dotted line: Zinc concentration in µg/l.

During the first period 12 million m^3 was discharged. The concentrations of the metals were 0.86 µg/kg for cadmium (SD=0.96, N=12); 3.13 µg/kg for lead (SD=1.71, N=12); and 1.19 µg/kg for copper (SD=0.44, N=13). The amount for this period then may be calculated as 10 kg Cd, 38 kg Pb and 14 kg Cu.

During the second period 58 million m^3 was running, and the metal concentrations were <0.01 µg/kg for cadmium, (N=10); 0.09 µg/kg for lead (SD=0.08, N=10); and 0.18 µg/kg for copper (SD=0.11, N=9). The amount for this period then is calculated to <0.5 kg Cd, 5 kg Pb and 10 kg copper.

In the two periods together, the total amounts transported are estimated as 10 kg cadmium, 43 kg lead and 24 kg copper.

8. TERRESTRIAL SAMPLES

In the Citronen Fjord area samples were taken of soil, plants and faeces. On a total of 21 stations 97 samples have been collected.

It was the intention also to sample plants and faeces at approximately 5 reference stations some 30 to 50 km from Citronen Fjord and at the two marine stations situated a few kilometers to each side from the mouth of Citronen Fjord. But, as no helicopter was in the Citronen Fjord area while GERI was there, it was not possible to reach these stations in 1994.

8.1 Soil

Only two soil samples at two stations were collected near the showings at the Eastern River, cf. Appendix 1.1, 3.2 and Fig. 4. One sample was composed of sand and one by a yellow crust on the sulphide deposit.

8.2 Plants

Higher plants were sampled at 19 stations in the Citronen Fjord area with a total of 54 samples, cf. Appendix 1.1 and Fig. 4.

Three species of higher plants were sampled at the stations, in order be able to chose the best indicator species and to study differences in metal concentrations between species. In Greenland lichens have been used to monitor heavy metal atmospheric deposition, but no lichen species suitable for that purpose has been found in the Citronen Fjord area. The three species chosen were Arctic willow (*Salix arctica*), entired-leafed mountain avens (*Dryas intergrifolia*) and a meadow-grass species, possibly low speargrass *Poa abbreviata*, see Appendix 3.3.

Whole plants were sampled, dried as much as possible in open paper bags and transported to Denmark. Here they were dried at 60°C and stored in paper bags. No plant species have been analysed.

8.3 Faeces

In order to be able to establish baseline levels of metal burdens in terrestrial animals, faeces from three mammal species were collected at 16 stations in the Citronen Fjord area with a total of 41 samples, cf. Appendix 1.1 and Fig. 4.

The three species were Collared lemming (*Discrostonyx torquatus*), Arctic hare (*Lepus arcticus*) and Muskox (*Ovibos moschatus*) (refer to Appendix 3.3). The idea is to sample the rather easily accessible faeces from mammals difficult to catch or unacceptable to kill. The collared lemming is the species best suitable for monitoring, as it is stationary, Muskoxen are moving over large areas. The Arctic hare is considered rather stationary mostly like the lemmings. When using faeces as an indicator, it is important to collect faeces as fresh as possible.

The faeces samples were transported to Denmark, dried at 60°, and stored. No samples have been analysed.

9. OBSERVATIONS OF FLORA AND FAUNA

In this chapter all observations made in 1994 on flora and fauna are described. Observations include both those from the baseline study in the Citronen Fjord area, 28 July to 13 August, and observations made by Frank van der Stijl, Platinova A/S, in the Citronen Fjord area and elsewhere in Peary Land, from 30 April to 13 August.

For observations made in 1993 and earlier in Citronen Fjord and in Peary Land, reference is made to Glahder & Langager (1993).

9.1 Seaweed

Three species of seaweed were found in 1994.

Sweet tangle (*Laminaria* sp - probably *saccharina*) was numerous at all six seaweed stations, and it was this species that was analysed - see chapter 6.3.

Another brown algae - *Desmarestia* sp - was rather numerous at three stations, but were lacking at the other three. This algae was also found in 1993.

The third species was a red algae species, not yet identified, found at two stations (T1 and T2).

9.2 Mussels

A few live mussels were sampled during the seaweed sampling. Most of the mussels were sitting between the *Laminaria* "roots". The species is not yet identified.

9.3 Vegetation

Survey of higher plants were performed more extensively in 1993. However in 1994 at least one new species for the Citronen Fjord area was found, the White Arctic Bell-heather

(*Cassiope tetragone*). It was found sporadic in Frigg Fjord and Brainard Sund (Aastrup 1986).

9.4 Fish

Three species of fish were observed in 1994.

The Fourhorned sculpin (*Myoxycephalus quadricornis*) was caught at all five stations in Citronen Fjord with a total of more than 100 (see chapter 6.2).

One individual of either polar cod (*Boregadus saida*) or Arctic cod (*Arctogadus glacialis*) was caught in the pound net in the mouth of Esrum Elv but escaped(F1).

Some Arctic char (*Salvelinus alpinus*) fry were observed in the shallow waters of the fresh water supply lake near the camp.

9.5 Birds

Compared to observations in 1993 one new species, the Knot, was seen in 1994.

Red-throated diver (*Gavia stellata*). One pair at the fresh water lake, seen at least from 11 June until 13 August.

Goose sp (*Anser* sp). Two were seen 14 June, and approximately 30 flew SW in the Citronen Fjord area. Three dropping and some prints (length 8 cm - indicating snow goose (*Anser caerulescens*)) were seen the 4 August on the eastern shore of Citronen Fjord.

Glaucous gull (*Larus hyperboreus*). Two adult in Citronen Fjord.

Long-tailed skua (*Stercorarius longicaudus*). One adult was chasing the two glaucous gulls and one pair was seen at the station P9 upstream the Eastern River.

Ringed plover (*Charadrius hiaticula*). One was seen at the head of Citronen Fjord 28 July.

Knot (*Calidris canutus*). One was seen 15 June by Frank van der Stijl.

Sanderling (*Calidris alba*). One adult with two chicks were seen around the 8 August at the fresh water lake by Frank van der Stijl. Three adults were seen at the head of Citronen Fjord.

Turnstone (*Arenaria interpres*). One in August.

Snow bunting (*Plectrophenax nivalis*). One was singing 9 May. In August two females or young birds were seen.

9.6 Mammals

Polar bear (*Ursus maritimus*). One female with a young bear of 2 years were seen 17 June near Freja Fjord opposite Frigg Fjord inside F. E. Hyde Fjord.

Ringed seal (*Phoca hispida*). At least two were seen in Citronen Fjord in August while we were taking sea water samples; they showed no fear.

Hooded seal (*Cystophora cristata*) or bearded seal (*Erignatus barbatus*). Two were seen 4 July in the mouth of Citronen Fjord.

Muskox (*Ovibos moschatus*). Two adults and one calf (second calendar year) were seen 12 June at the northwest coast of Citronen Fjord. Two oxen were observed 26 June in Esrum Elv valley near Børglum Elv and three to four in Esrum Elv valley, probably in July.

Polar wolf (*Canis lupus*). Two wolves stayed approximately two weeks in the Citronen Fjord area from 30 April where they were heard howling. They were also heard 4 May. Fresh prints were seen 14 and 15 May along F. E. Hyde Fjord and in the Citronen Fjord area. The 26 June one was observed at Kap Molkte and 4 July one in the Citronen Fjord delta. The 16 July one was seen at the airstrip close to the Base Camp and prints were seen in the area.

Arctic fox (*Alopex lagopus*). At least 3, maybe 5, often visited the Base camp, especially the kitchen tent.

Arctic hare (*Lepus arcticus*). During May and June 3-4 were seen. None were seen in July and August at the baseline study.

Collared lemming (*Discrotonyx torquatus*). Young lemmings were seen mid May, but according to Frank van der Stijl lemmings were not so numerous in 1994 as in 1993. Some lemmings were living below some of the Base Camp tents in July and August.

10. DISCUSSION AND CONCLUSION

Due to the uncertainties of impact from a future mining operation we have collected a variety of samples and stored these carefully for possible future use. In this report we describe the collection of three plant species, the most abundant plants of the area and three types of samples, faeces, that represents the three most abundant land mammals. These samples were dried and are now stored at the Greenland Environmental Research Institute. Of the plants only Arctic willow is an obvious choice as an indicator of atmospheric deposition of metals as this plant was very abundant, and clean dustfree samples could easily be obtained. From land mammals (hare, muskox and lemming) collecting of faeces samples probably is the only, and certainly the most practical way to get an impression of the metal burden of lemming, hare and muskox.

A visitor to the zinc mineralization notes readily the red and yellow colours of the rocks and the river banks. There can be no doubt that an active weathering of sulphides is going on. This was confirmed by the water samples from Eastern River, that cuts its way through the zinc containing sulphide deposit. When the river starts to flow, the weathering products are washed into the river, and very high concentrations of zinc, cadmium, lead and copper are found. The concentration rapidly (2-3 weeks) falls to values 200-1000 times lower. This event will also affect metal levels in the marine environment of Citronen Fjord. The seawater of the fiord was, as one could expect, mainly affected by metals in the upper 2 meters, where the influence of the Eastern River could be seen. At lower depths an influence was doubtful.

The seaweed and the fish (fourhorned sculpin) collected from Citronen Fjord has been partly analysed. There is a possible influence in seaweed (elevated zinc- and lead levels) from the metals of Eastern River, but a reliable reference level for comparison has not been established. Sediment samples of the fiord was collected, freeze dried and stored.

It is recommended to repeate the sampling at least once more, with exception of the marine sediments to get a knowledge of year to year variations. Also it is recommended to collect reference samples in Frederich Hyde Fjord.

11. REFERENCES

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PENDICES

ppendix 1.1 Station positions

Station	Place	Latitude (N)	Longitude (W)	Depth (m)/sample
S1	Citronen Fjord	83°0660	28°1712	22/sediment
S2	"	83°0679	28°1729	25/sediment
S3	"	83°0710	28°1740	11/sediment
S4	"	83°0731	28°1652	32/sediment
S5	"	83°0759	28°1619	45/sediment
S6	"	83°0784	28°1545	45/sediment
S7	"	83°0810	28°1470	49/sediment
S8	"	83°0831	28°1357	57/sediment
S9	"	83°0641	28°2017	42/sediment
S10	"	83°0634	28°2236	36/sediment
S11	"	83°0645	28°2263	40/sediment
S12	"	83°0656	28°2268	55/sediment
S13	"	83°0680	28°2422	33/sediment
S14	"	83°0701	28°2418	32/sediment
S15	"	83°0726	28°2429	20/sediment
S16	"	83°0749	28°2412	48/sediment
S17	"	83°0778	28°2428	42/sediment
S18	"	83°0799	28°2396	48/sediment
S19	"	83°0826	28°2404	95/sediment
S20	"	83°0798	28°2199	141/sediment
S21	"	83°0775	28°2212	128/sediment
S22	"	83°0746	28°2210	117/sediment
S23	"	83°0724	28°2216	100/sediment
S24	"	83°0688	28°2148	80/sediment
S25	"	83°0672	28°2123	71/sediment
S26	"	83°0656	28°2067 ?	60/sediment

Appendix 1.1 Station positions (cont.)

Station	Place	Latitude (N)	Longitude (W)	Depth (m)/sample
F1	Citronen Fjord	83°0622	28°2325	fish
F2	"	83°0701	28°1661	"
F3	"	83°0685	28°2509	"
F4	"	83°0790	28°2465	"
F5	"	83°0778	28°1339	"
T1	Citronen Fjord	83°0748	28°2474	seaweed
T2	"	83°0790	28°2396	"
T3	"	83°0685	28°2509	"
T4	"	83°0780	28°1369	"
T5	"	83°0705	28°1710	"
T6	"	83°0659	28°1640	"
H1	Citronen Fjord	83°0650	28°1860	0-30/seawater
H2	"	83°0650	28°2210	0-30/seawater
H3	"	83°0739	28°1868	0-50/seawater
H4	"	83°0815	28°1931	0-100/seawater
O1	Citronen Fjord	83°0634	28°2005	0/seawater
O2	"	83°0643	28°2000	"
O3	"	83°0669	28°2000	"
O4	"	83°0694	28°2004	"
O5	"	83°0722	28°2005	"
O6	"	83°0752	28°2005	"
O7	"	83°0779	28°2005	"
O8	"	83°0800	28°2005	"
O9	"	83°0818	28°2005	"
O10	"	83°0797	28°1612	"
O11	"	83°0785	28°1504	"

Appendix 1.1 Station positions (cont.)

Station	Place	Latitude (N)	Longitude (W)	Depth (m)/sample
O12	Citronen Fjord	83°0760	28°1580	0/seawater
O13	"	83°0734	28°1695	"
O14	"	83°0711	28°1796	"
O15	"	83°0685	28°1781	"
O16	"	83°0660	28°1717	"
O17	"	83°0635	28°1785	"
O18	"	83°0636	28°2291	"
O19	"	83°0662	28°2310	"
O20	"	83°0685	28°2368	"
O21	"	83°0708	28°2411	"
O22	"	83°0734	28°2400	"
O23	"	83°0759	28°2401	"
O24	"	83°0784	28°2376	"
O25	"	83°0725	28°2472	"
O26	"	83°0646	28°2370	"
O27	"	83°0703	28°1685	"
O28	"	83°0679	28°1874	"
O29	"	83°0651	28°1963	"
O30	"	83°0631	28°2041	"
E1	Eastern River	83°0597	28°1973	sediment
E2	"	83°0570	28°1911	"
E3	"	83°0549	28°1738	"
E4	"	83°0519	28°1652	"
E5	"	83°0458	28°1375	"
E6	"	83°0416	28°1134	"
E7	"	83°0377	28°0720	"

Appendix 1.1 Station positions (cont.)

Station	Place	Latitude (N)	Longitude (W)	Depth (m)/sample
E8	Eastern River	83°0493	28°1658	sediment
E9	"	83°0319	27°5912	"
E10	"	83°0227	27°4500	"
E11	"	83°0418	28°3035	"
E12	"	83°0506	28°2197	"
J1	Eastern River	83°0458	28°1375	soil
J2	"	83°0458	28°1375	"
P1	Citronen Fjord	83°0685	28°2509	plants, faeces
P2	"	83°0790	28°2465	"
P3	"	83°0778	28°1339	"
P4	"	83°0701	28°1661	"
P5	Eastern River	83°0458	28°1375	"
P6	"	83°0416	28°1134	"
P7	"	83°0377 (384)	28°0720 (776)	" V4 E7
P8	"	83°0493	28°1658	"
P9	"	83°0319 (318)	27°5912 (5968)	" V6 E9
P10	"	83°0227 (223)	27°4500 (46.55)	" V7 E10
P11	Esrum Elv	83°0359	28°3536	" V10 E13
P12	"	83°0418	28°3035	" V8 E11
P13	Eastern River	83°0536	28°1803	"
P14	Esrum Elv	83°0506	28°2197	" V9 E12
P15	Citronen Fjord	83°0632	28°1639	"
P16	Eastern River	83°0470	28°1310	plants
P17	"	83°0460	28°1230	"
P18	"	83°0450	28°1115	"
P19	"	83°0456	28°1229	plants, faeces

P20 Esrum Elv V11 E14

Appendix 1.1 Station positions (cont.)

Station	Place	Latitude (N)	Longitude (W)	Depth (m)/sample
E8	Eastern River	83°0493	28°1658	sediment
E9	"	83°0319	27°5912	"
E10	"	83°0227	27°4500	"
E11	"	83°0418	28°3035	"
E12	"	83°0506	28°2197	"
J1	Eastern River	83°0458	28°1375	soil
J2	"	83°0458	28°1375	"
P1	Citronen Fjord	83°0685	28°2509	plants, faeces
P2	"	83°0790	28°2465	"
P3	"	83°0778	28°1339	"
P4	"	83°0701	28°1661	"
P5	Eastern River	83°0458	28°1375	"
P6	"	83°0416	28°1134	"
P7	"	83°0377 (384)	28°0720 (376)	" V4 E7
P8	"	83°0493	28°1658	"
P9	"	83°0319 (3,18)	27°5912 (5968)	" V6 E9
P10	"	83°0227 (2.23)	27°4500 (46.55)	" V7 E10
P11	Esrum Elv	83°0359	28°3536	" V10 E13
P12	"	83°0418	28°3035	" V8 E11
P13	Eastern River	83°0536	28°1803	"
P14	Esrum Elv	83°0506	28°2197	" V9 E12
P15	Citronen Fjord	83°0632	28°1639	"
P16	Eastern River	83°0470	28°1310	plants
P17	"	83°0460	28°1230	"
P18	"	83°0450	28°1115	"
P19	"	83°0456	28°1229	plants, faeces

P20 Esrum Elv V11 E14

Appendix 1.1 Station positions (cont.)

Station	Place	Latitude (N)	Longitude (W)	Depth (m)/sample
V1	Eastern River	83°0511	28°1629	freshwater
V2	"	83°0458	28°1375	"
V3	"	83°0416	28°1134	"
V4	"	83°0377	28°0720	"
V5	"	83°0493	28°1658	"
V6	"	83°0319	28°5912	"
V7	"	83°0227	28°4500	"
V8	Esrum Elv	83°0418	28°3035	"
V9	"	83°0506	28°2197	"

Appendix 2.1 Sea sediment samples

Station	ID.no.	Project	Date	Ini.
S1	16701	Citronen Fjord	2.8.94	GAS
S2	16702	"	"	"
S3	16703	"	"	"
S4	16704	"	"	"
S5	16705	"	"	"
S6	16706	"	"	"
S7	16707	"	"	"
S8	16708	"	"	"
S9	16709	"	"	"
S10	16710	"	3.8.94	"
S11	16711	"	"	"
S12	16712	"	"	"
S13	16713	"	"	"
S14	16714	"	"	"
S15	16715	"	"	"
S16	16716	"	"	"
S17	16717	"	"	"
S18	16718	"	"	"
S19	16719	"	"	"
S20	16720	"	"	"
S21	16721	"	"	"
S22	16722	"	"	"
S23	16723	"	"	"
S24	16724	"	"	"
S25	16725	"	"	"
S26	16765	"	2.8.94	CMG

Appendix 2.2 Fish samples (Fourhorned sculpin *Myoxycephalus quadricornis*) (cont.)

Station	ID.no.	Project	Date	Ini.	Length (cm)
F1	16601	Citronen Fjord	30.7.94	GAS	21.2
F1	16602	"	"	"	19.3
F1	16603	"	"	"	19.3
F1	16604	"	"	"	24.1
F1	16605	"	"	"	19.5
F1	16606	"	"	"	14.9
F1	16607	"	"	"	22.0
F1	16608	"	"	"	22.7
F1	16609	"	"	"	18.3
F1	16610	"	"	"	16.6
F1	16613	"	31.7.94	"	18.1
F1	16614	"	"	"	14.8
F1	16615	"	"	"	23.0
F1	16616	"	"	"	20.7
F1	16617	"	"	"	21.9
F1	16618	"	"	"	24.7
F1	16619	"	"	"	22.4
F1	16620	"	"	"	18.7
F1	16621	"	"	"	17.0
F1	16622	"	"	"	18.0
F1	16623	"	"	"	19.9
F1	16624	"	"	CMG	18.8
F1	16625	"	"	"	19.7
F1	16626	"	"	"	21.9
F1	16627	"	"	"	21.7
F1	16628	"	"	"	23.0

Appendix 2.2 Fish samples (Fourhorned sculpin *Myoxycephalus quadricornis*) (cont.)

Station	ID.no.	Project	Date	Ini.	Length (cm)
F1	16629	Citronen Fjord	31.7.94	CMG	18.1
F1	16630	"	"	"	14.9
F1	16631	"	"	GAS	16.3
F1	16632	"	"	"	18.0
F1	16633	"	"	"	15.9
F1	16634	"	"	"	20.3
F1	16635	"	"	"	22.1
F1	16636	"	"	"	16.8
F1	16637	"	"	"	19.5
F1	16638	"	"	"	18.6
F1	16639	"	"	"	23.4
F1	16640	"	"	"	21.5
F1	16641	"	"	"	19.4
F1	16642	"	"	"	26.4
F1	16643	"	"	"	22.1
F1	16644	"	"	"	23.0
F1	16645	"	"	"	16.4
F1	16646	"	"	"	19.9
F2	16611	Citronen Fjord	31.7.94	GAS	20.2
F2	16612	"	"	"	25.0
F2	16651	"	1.8.94	"	19.5
F2	16652	"	"	"	22.6
F2	16653	"	"	"	14.0
F2	16654	"	"	"	17.0
F2	16688	"	2.8.94	GAS	20.6
F2	16689	"	"	"	22.0

Appendix 2.2 Fish samples (Fourhorned sculpin *Myoxycephalus quadricornis*) (cont.)

Station	ID.no.	Project	Date	Ini.	Length (cm)
F2	16690	Citronen Fjord	2.8.94	GAS	21.5
F2	16691	"	"	"	19.9
F2	16692	"	"	"	23.7
F2	16693	"	"	"	21.1
F2	16694	"	"	"	25.2
F2	16695	"	"	"	20.6
F2	16696	"	"	"	20.4
F2	16737	"	3.8.94	"	19.4
F3	16655	Citronen Fjord	1.8.94	GAS	19.4
F3	16656	"	"	"	19.8
F3	16657	"	"	"	20.6
F3	16658	"	"	"	16.2
F3	16659	"	"	"	20.8
F3	16660	"	"	"	21.5
F3	16661	"	"	"	21.4
F3	16673	"	2.8.94	"	20.4
F3	16674	"	"	"	21.9
F3	16675	"	"	"	18.7
F3	16676	"	"	"	23.1
F3	16677	"	"	"	18.3
F3	16678	"	"	"	21.1
F3	16697	"	3.8.94	"	21.0
F3	16698	"	"	"	21.1
F3	16700	"	"	"	21.3
F3	16726	"	"	"	20.4
F3	16727	"	"	"	24.0

Appendix 2.2 Fish samples (Fourhorned sculpin *Myoxycephalus quadricornis*) (cont.)

Station	ID.no.	Project	Date	Ini.	Length (cm)
F3	16728	Citronen Fjord	3.8.94	GAS	24.4
F3	16729	"	"	"	23.1
F3	16730	"	"	"	21.6
F3	16731	"	"	"	23.9
F3	16732	"	"	"	24.2
F4	16663	Citronen Fjord	1.8.94	GAS	21.6
F4	16664	"	"	"	20.3
F4	16665	"	"	"	19.6
F4	16666	"	"	"	23.7
F4	16667	"	"	"	17.5
F4	16668	"	"	"	24.4
F4	16669	"	"	"	19.7
F4	16670	"	"	"	22.9
F4	16671	"	"	"	19.8
F4	16672	"	"	"	18.1
F4	16679	"	2.8.94	"	24.1
F4	16680	"	"	"	21.6
F4	16681	"	"	"	20.5
F4	16682	"	"	"	22.6
F4	16683	"	"	"	20.6
F4	16684	"	"	"	19.8
F4	16685	"	"	"	19.2
F4	16686	"	"	"	20.8
F4	16687	"	"	"	17.0

Appendix 2.2 Fish samples (Fourhorned sculpin *Myoxycephalus quadricornis*) (cont.)

Station	ID.no.	Project	Date	Ini.	Length (cm)
F5	16733	Citronen Fjord	3.8.94	GAS	18.0
F5	16734	"	"	"	19.7
F5	16735	"	"	"	23.3
F5	16736	"	"	"	19.7
F5	16738	"	4.8.94	"	17.2
F5	16739	"	"	"	16.5
F5	16740	"	"	"	19.1
F5	16741	"	"	"	15.3
F5	16742	"	"	"	18.0

Appendix 2.3 Seaweed (Sweet tangle *Laminaria* sp and *Desmarestia* sp)

Station	ID.no.	Species	Project	Date	Ini.	Comments
T1	16755	*Laminaria* sp	Citronen Fjord	9.8.94	GAS	2 parts (leaf, "root"), rinsed
T2	16757	"	"	"	"	"
T3	16758	"	"	"	"	"
T4	16759	"	"	"	"	"
T5	16743	"	"	4.8.94	"	"
T5	16760	"	"	9.8.94	"	"
T6	16761	"	"	"	"	"
T1	16762	*Desmarestia* sp	Citronen Fjord	9.8.94	GAS	parted, rinsed
T2	16763	"	"	"	"	rinsed
T3	16764	"	"	"	"	"

Appendix 2.4 Seawater columm samples

Station	Bottle no.	Project	Date	Depth (m)	Temp (°C)	Salinity (°/oo)	pH
H1	107	Citronen Fjord	31.7.94	0	3.58	-	7.52
H1	180	"	"	2	3.37	4.374	7.58
H1	182	"	"	5	-0.53	30.745	7.57
H1	181	"	"	10	-0.94	31.030	7.72
H1	137	"	"	15	-1.07	31.283	7.92
H1	130	"	"	20	-1.19	31.457	7.73
H1	171	"	"	30	-1.38	31.569	7.36
H2	122	Citronen Fjord	1.8.94	0	3.48	-	7.70
H2	164	"	"	2	3.04	2.381	7.65
H2	129	"	"	5	-0.62	30.796	7.35
H2	156	"	"	10	-1.07	31.257	7.68
H2	172	"	"	15	-1.16	31.382	7.60
H2	138	"	"	20	-1.27	31.512	7.82
H2	136	"	"	30	-1.47	31.591	7.74
H3	111	Citronen Fjord	30.7.94	0	3.68	-	7.60
H3	149	"	"	2	1.16	28.304	7.75
H3	146	"	"	5	-0.18	30.526	7.65
H3	148	"	"	10	-0.99	31.173	7.84
H3	165	"	"	15	-1.27	31.366	7.62
H3	160	"	"	20	-1.21	31.482	7.80
H3	158	"	"	30	-1.41	31.595	7.58
H3	197	"	"	50	-1.66	31.750	7.59

Appendix 2.4 Seawater columm samples (cont.)

Station	Bottle no.	Project	Date	Depth (m)	Temp (oC)	Salinity (°/oo)	pH
H4	166	Citronen Fjord	30.7.94	0	1.77	-	7.77
H4	116	"	"	2	-0.11	30.287	7.55
H4	191	"	"	5	-0.81	30.875	7.77
H4	194	"	"	10	-1.04	31.230	7.72
H4	150	"	"	15	-1.21	31.363	7.68
H4	199	"	"	20	-1.22	31.519	7.72
H4	115	"	"	30	-1.43	31.579	7.53
H4	153	"	"	50	-1.58	31.766	7.63
H4	157	"	"	75	-0.61	33.800	7.75
H4	174	"	"	100	-0.23	34.366	7.75

Appendix 2.5 Seawater surface samples

Station	Bottle no.	Project	Date	Depth (m)
O1	177	Citronen Fjord	29.7.94	0
O2	134	"	"	"
O3	199	"	"	"
O4	123	"	"	"
O5	195	"	"	"
O6	124	"	"	"
O7	128	"	"	"
O8	198	"	"	"
O9	105	"	"	"
O10	196	"	"	"
O11	104	"	"	"
O12	103	"	"	"
O13	106	"	"	"
O14	120	"	"	"
O15	121	"	"	"
O16	113	"	"	"
O17	119	"	"	"
O18	193	"	"	"
O19	140	"	"	"
O20	112	"	"	"
O21	110	"	"	"
O22	118	"	"	"
O23	178	"	"	"
O24	100	"	"	"
O25	189	"	"	"
O26	108	"	"	"
O27	117	"	"	"
O28	109	"	"	"
O29	102	"	"	"
O30	101	"	"	"

Appendix 3.1 River sediment samples

Station	ID.no.	Project	Locality	Date	Ini.
E1	16647	Citronen Fjord	Eastern River	1.8.94	GAS
E2	16648	"	"	"	"
E3	16649	"	"	"	"
E4	16650	"	"	"	"
E5	16744	"	"	5.8.94	"
E6	16745	"	"	"	"
E7	16746	"	"	"	"
E8	16747	"	"	?	?
E9	16751	"	"	6.8.94	"
E10	16750	"	"	"	"
E11	16748	"	Esrum Elv	"	"
E11	16749	"	"	"	"
E12	16752	"	"	7.8.94	"

Appendix 3.2 Soil samples

Station	ID.no.	Project	Locality	Date	Ini.	Comments
J1	16753	Citronen Fjord	Lower Showing	8.8.94	GAS	Sand
J2	16754	"	"	"	"	Yellow surface

Appendix 3.3 Plant and faeces samples

Plants: Meadow-grass species *Poa abbreviata*, Arctic Willow *salix arctica* and Entired-leafed mountain avens *Dryas integrifolia*.

Faeces from: Collared lemming *Discrostonyx torquatus*, Arctic hare *Lepus arcticus* and Musk ox *Ovibos moschatus*.

Station	ID.no.	Species	Project	Date	Ini.
P1	17301	*Salix arctica*	Citronen Fjord	9.8.94	GAS
P1	17302	"	"	"	GAS
P2	17303	"	"	"	GAS/CMG
P3	17304	"	"	4.8.94	GAS/CMG
P3	17305	"	"	"	GAS/CMG
P4	17306	"	"	"	GAS/CMG
P4	17307	"	"	"	GAS/CMG
P5	17308	"	"	5.8.94	GAS/CMG
P5	17309	"	"	"	GAS/CMG
P6	17310	"	"	"	GAS/CMG
P7	17311	"	"	"	GAS/CMG
P8	17312	"	"	"	GAS/CMG
P9	17313	"	"	6.8.94	CMG
P10	17314	"	"	"	CMG
P11	17315	"	"	"	GAS/CMG
P12	17316	"	"	"	GAS
P13	17317	"	"	7.8.94	GAS/CMG
P14	17318	"	"	"	GAS/CMG
P15	17321	"	"	"	GAS/CMG
P16	17319	"	"	8.8.94	GAS
P18	17320	"	"	"	GAS
P19	17322	"	"	"	GAS

Appendix 3.3 Plant and faeces samples (cont.)

Plants: Meadow-grass species *Poa abbreviata*, Arctic Willow *salix arctica* and Entired-leafed mountain avens *Dryas integrifolia*.

Faeces from: Collared lemming *Discrostonyx torquatus*, Arctic hare *Lepus arcticus* and Musk ox *Ovibos moschatus*.

Station	ID.no.	Species	Project	Date	Ini.
P1	17394	*Poa abbreviata*	Citronen Fjord	9.8.94	GAS/CMG
P2	17323	"	"	9.8.94	GAS/CMG
P3	17324	"	"	4.8.94	GAS/CMG
P4	17325	"	"	4.8.94	GAS/CMG
P5	17326	"	"	5.8.94	GAS/CMG
P6	17327	"	"	5.8.94	GAS/CMG
P7	17328	"	"	5.8.94	GAS/CMG
P8	17329	"	"	5.8.94	GAS/CMG
P9	17330	"	"	6.8.94	GAS/CMG
P10	17331	"	"	6.8.94	GAS
P11	17332	"	"	6.8.94	GAS/CMG
P11	17333	"	"	6.8.94	GAS/CMG
P12	17334	"	"	6.8.94	GAS/CMG
P13	17335	"	"	7.8.94	GAS
P14	17336	"	"	7.8.94	GAS/CMG
P15	17338	"	"	7.8.94	GAS/CMG
P18	17337	"	"	8.8.94	GAS
P1	17339	*Dryas integrifolia*	Citronen Fjord	9.8.94	GAS/CMG
P2	17340	"	"	9.8.94	GAS/CMG
P3	17341	"	"	4.8.94	GAS/CMG
P4	17342	"	"	4.8.94	GAS/CMG
P5	17343	"	"	5.8.94	GAS/CMG
P6	17344	"	"	5.8.94	GAS/CMG
P7	17345	"	"	5.8.94	GAS/CMG

Appendix 3.3 Plant and faeces samples (cont.)

Plants: Meadow-grass species *Poa abbreviata*, Arctic Willow *salix arctica* and Entired-leafed mountain avens *Dryas integrifolia*.

Faeces from: Collared lemming *Discrostonyx torquatus*, Arctic hare *Lepus arcticus* and Musk ox *Ovibos moschatus*.

Station	ID.no.	Species	Project	Date	Ini.
P8	17346	*Dryas integrifolia*	Citronen Fjord	5.8.94	GAS/CMG
P9	17347	"	"	6.8.94	CMG
P10	17348	"	"	6.8.94	CMG
P11	17349	"	"	6.8.94	GAS
P12	17350	"	"	6.8.94	GAS
P13	17351	"	"	7.8.94	GAS/CMG
P14	17352	"	"	7.8.94	GAS/CMG
P17	17353	"	"	7.8.94	GAS
P4	17354	*Discrostonyx torquatus*	Citronen Fjord	-	GAS/CMG
P5	17355	"	"	5.8.94	GAS/CMG
P6	17356	"	"	5.8.94	GAS/CMG
P7	17357	"	"	5.8.94	GAS/CMG
P8	17358	"	"	6.8.94	CMG
P9	17359	"	"	6.8.94	CMG
P11	17360	"	"	6.8.94	GAS
P13	17361	"	"	7.8.94	GAS
P14	17362	"	"	7.8.94	GAS/CMG
P15	17363	"	"	7.8.94	GAS/CMG
P1	17364	*Lepus arcticus*	Citronen Fjord	9.8.94	GAS/CMG
P2	17365	"	"	9.8.94	GAS/CMG
P3	17366	"	"	4.8.94	GAS/CMG
P4	17367	"	"	4.8.94	GAS/CMG
P5	17368	"	"	5.8.94	GAS/CMG

Appendix 3.3 Plant and faeces samples (cont.)

Plants: Meadow-grass species *Poa abbreviata*, Arctic Willow *salix arctica* and Entired-leafed mountain avens *Dryas integrifolia*.

Faeces from: Collared lemming *Discrostonyx torquatus*, Arctic hare *Lepus arcticus* and Musk ox *Ovibos moschatus*.

Station	ID.no.	Species	Project	Date	Ini.
P6	17369	*Lepus arcticus*	Citronen Fjord	5.8.94	GAS/CMG
P7	17370	"	"	5.8.94	GAS/CMG
P8	17371	"	"	5.8.94	GAS/CMG
P9	17372	"	"	6.8.94	GAS/CMG
P10	17373	"	"	6.8.94	CMG
P11	17374	"	"	6.8.94	GAS
P12	17375	"	"	6.8.94	GAS
P13	17376	"	"	7.8.94	GAS/CMG
P14	17377	"	"	7.8.94	GAS/CMG
P15	17378	"	"	7.8.94	GAS/CMG
P19	17395	"	"	8.8.94	GAS
P1	17379	*Ovibos moschatus*	Citronen Fjord	9.8.94	GAS/CMG
P2	17380	"	"	9.8.94	GAS/CMG
P3	17381	"	"	4.8.94	GAS/CMG
P4	17382	"	"	4.8.94	GAS/CMG
P5	17383	"	"	5.8.94	GAS/CMG
P6	17384	"	"	5.8.94	GAS/CMG
P7	17385	"	"	5.8.94	GAS/CMG
P8	17386	"	"	5.8.94	GAS/CMG
P9	17387	"	"	6.8.94	CMG
P10	17388	"	"	6.8.94	CMG
P11	17389	"	"	6.8.94	GAS
P12	17390	"	"	6.8.94	GAS
P13	17391	"	"	7.8.94	GAS/CMG
P14	17392	"	"	7.8.94	GAS/CMG
P15	17393	"	"	7.8.94	GAS/CMG

Appendix 3.4 Freshwater samples

Station	Bottle no.	Project	Locality	Date	Hour (GMT)	Waterlevel (inch)
V1	1	Citronen Fjord	Eastern River	8.6.94	18.00	6.75
V1	2	"	"	9.6.94	18.20	6.75
V1	3	"	"	10.6.94	18.05	7.25
V1	4	"	"	11.6.94	18.30	4.75
V1	5	"	"	12.6.94	18.10	2.75
V1	6	"	"	13.6.94	18.10	3.50
V1	7	"	"	14.6.94	10.30	4.50
V1	8	"	"	15.6.94	18.30	4.00
V1	9	"	"	16.6.94	18.20	4.00
V1	10	"	"	17.6.94	18.30	3.25
V1	11	"	"	18.6.94	18.30	4.50
V1	12	"	"	19.6.94	18.30	10.75
V1	13	"	"	20.6.94	18.10	14.00
V1	14	"	"	21.6.94	18.10	8.00
V1	15	"	"	22.6.94	18.15	15.00
V1	16	"	"	23.6.94	18.10	27.00
V1	17	"	"	24.6.94	18.20	38.00
V1	18	"	"	25.6.94	18.15	39.00
V1	19	"	"	26.6.94	18.30	34.00
V1	20	"	"	27.6.94	18.15	40.00
V1	21	"	"	28.6.94	10.30	33.00
V1	22	"	"	29.6.94	18.50	17.00
V1	23	"	"	30.6.94	19.30	26.50
V1	24	"	"	1.7.94	18.50	30.00
V1	25	"	"	2.7.94	20.30	23.00
V1	26	"	"	3.7.94	19.40	28.00
V1	27	"	"	4.7.94	18.45	29.50

ppendix 3.4 Freshwater samples (cont.)

Station	Bottle no.	Project	Locality	Date	Hour (GMT)	Waterlevel (inch)
V1	28	Citronen Fjord	Eastern River	5.7.94	19.00	18.75
V1	29	"	"	6.7.94	17.45	8.50
V1	30	"	"	7.7.94	20.00	6.00
V1	31	"	"	8.7.94	20.30	16.00
V1	32	"	"	9.7.94	19.30	12.00
V1	33	"	"	10.7.94	21.30	19.50
V1	34	"	"	11.7.94	20.30	10.00
V1	35	"	"	12.7.94	18.30	6.50
V1	36	"	"	13.7.94	23.30	37.50
V1	37	"	"	14.7.94	18.30	43.00
V1	38	"	"	15.7.94	20.30	36.50
V1	39	"	"	16.7.94	20.45	23.50
V1	40	"	"	17.7.94	22.00	25.50
V1	41	"	"	18.7.94	23.45	16.00
V1	42	"	"	19.7.94	21.00	14.75
V1	43	"	"	20.7.94	20.15	31.50
V1	44	"	"	21.7.94	23.00	36.50
V1	45	"	"	22.7.94	19.00	35.50
V1	46	"	"	23.7.94	22.30	46.00
V1	47	"	"	24.7.94	21.45	45.00
V1	48	"	"	25.7.94	22.00	37.50
V1	49	"	"	26.7.94	20.45	36.00
V1	50	"	"	27.7.94	23.15	36.50
V1	51	"	"	28.7.94	22.05	39.50
V1	52	"	"	29.7.94	21.00	43.50
V1	53	"	"	30.7.94	23.30	45.00
V1	54	"	"	31.7.94	23.05	44.50

Appendix 3.4 Freshwater samples (cont.)

Station	Bottle no.	Project	Locality	Date	Hour (GMT)	Waterlevel (inch)
V1	55	Citronen Fjord	Eastern River	1.8.94	18.35	40.00
V1	56	"	"	2.8.94	22.40	23.50
V1	57	"	"	3.8.94	23.40	19.50
V1	58	"	"	4.8.94	23.59	26.00
V1	59	"	"	5.8.94	22.10	16.50
V1	60	"	"	6.8.94	21.50	9.50
V1	61	"	"	7.8.94	19.30	7.00
V1	62	"	"	8.8.94	23.59	4.50
V1	63	"	"	9.8.94	23.59	3.00
V1	64	"	"	10.8.94	22.30	2.50
V1	65	"	"	11.8.94	21.45	2.00
V1	66	"	"	12.8.94	16.00	/
V1	67	"	"	13.8.94	-	/
V1	68	"	"	14.8.94	-	/
V1	69	"	"	15.8.94	-	/
V1	70	"	"	16.8.94	-	/
V1	71	"	"	17.8.94	-	/
V1	72	"	"	18.8.94	-	/
V1	73	"	"	19.8.94	-	/
V1	74	"	"	20.8.94	-	/
V1	75	"	"	21.8.94	-	/
V1	76	"	"	22.8.94	-	/
V2	141	"	"	5.8.94		
V2	169	"	Tributary to Eastern River	5.8.94		
V3	167	"	Eastern River	5.8.94		
V4	192	"	"	5.8.94		
V5	135	"	"	5.8.94		

/ = waterlevel not readable

ppendix 3.4 Freshwater samples (cont.)

Station	Bottle no.	Project	Locality	Date	Hour (GMT)	Waterlevel (inch)
V6	151	Citronen Fjord	Eastern River	6.8.94		
V7	132	"	"	6.8.94		
V8	176	"	Esrum Elv	6.8.94		
V9	155	"	"	7.8.94		

Appendix 4.1 Weather data from Citronen Fjord Base Camp.

	time	temp C	wind dr	wind sp knots	qnh mbar	hum %	time	temp C	wind dr	wind sp knots	qnh mbar	hum %
8.juni												
9.juni	8,30	3	e	2,5	1008,3	37	18,30	3	ene	7,5	1007,4	32
10.juni	8,15	7	s	6,5	1001,6	17	18,10	9	s	12,5	1001,4	7
11.juni	8,15	1	ne	10,0	1006,7	33	18,40	1	ne	10,0	1010,8	30
12.juni	8,20	0	ene	7,5	1014,0	25	18,50	1	ne	5,0	1012,8	26
13.juni	8,50	0	ne	5,0	1011,6	30	18,20	1	ne	7,5	1010,6	23
14.juni	8,15	3	ne - se	7,5	1008,2	27	18,15	5	nnw	17,5	1008,7	22
15.juni	8,00	2	ne	12,5	1010,2	40	18,30	2	nne	10,0	1009,1	32
16.juni	8,15	2	n	2,5	1004,0	33	18,30	3	nne	7,5	1004,2	33
17.juni	8,30	6	ne	5,0	1004,4	26	18,30	2	nnw	2,5	1000,3	40
18.juni	8,15	3	s	17,5	1004,8	37	18,30	4	se	17,5	1004,3	28
19.juni	8,10	6	se	12,5	1005,8	20	19,00	9	ssw	12,5	1006,3	14
20.juni	8,00	8	ne	2,5	1007,6	15	18,15	2	ne	10,0	1007,0	37
21.juni	9,15	2	nne	5,0	1004,6	48	18,15	3	ne	5,0	1003,7	50
22.juni	8,00	4	ne	2,0	1001,9	41	18,15	9	ne	1,5	1005,1	28
23.juni	8,15	9	ne	1,5	1011,2	28	18,15	9	ne	1,5	1012,1	25
24.juni	8,15	12	sw	10,0	1013,4	12	18,30	10	nne	3,0	1011,1	18
25.juni	8,15	13	s	7,5	1008,0	10	18,20	9	n	5,0	1009,2	21
26.juni	8,00	5		0,0	1009,2	31	18,00	6		0,0	1012,2	31
27.juni	8,15	5	ne	3,0	1010,4	33	17,15	3	ene	3,0	1007,3	47
28.juni	8,30	4	nne	5,0	1000,0	48	18,30	4	nne	5	999,7	40
29.juni	8,15	2	ene	5,0	1000,2	46	18,45	3	nne	5,0	1000,1	47
30.juni	8,00	3	ne	3,0	1002,5	49	18,45	4	ne	5,0	1005,5	44
1.juli	8,00	4		0,0	1010,9	45	18,30	8	ne	7,5	1011,5	32
2.juli	8,20	3	ne	1,5	1009,1	45	18,30	5	ne	1,5	1006,9	37
3.juli	8,00	4	ne	7,5	1010,9	37	19,30	4	e	5,0	1013,4	37
4.juli	8,15	5		0,0	1011,1	37	18,00	4	ne	1,5	1006,6	38
5.juli	8,15	6	nne	17,5	1008,5	29	18,00	5	ne	10,0	1014,5	23
6.juli	8,45	4	wnw	17,5	1014,5	27	18,00	4	nw	15,0	1015,0	24
7.juli	8,15	4	n	17,5	1021,3	30	18,30	6	n-w	7,5	1021,3	23
8.juli	8,00	7	ne	17,5	1018,0	21	18,30	4	ene	10,0	1019,0	51
9.juli	10,30	2	e	2,5	1017,7	55	18,10	0		0,0	1014,5	65
10.juli	8,00	1	ne	12,5	1009,5	49	18,30	3	nne	7,5	1006,4	41
11.juli	8,00	4	nw	12,5	994,5	26	18,00	5	nw	12,5	993,2	20
12.juli	8,00	4	ne	5,0	999,4	33	18,30	4	ne	10,0	999,8	34
13.juli	8,15	4	ne	2,5	1000,3	35	23,00	8		0,0	1000,4	30
14.juli	8,00	6		0,0	1002,4	33	17,00	5	ne	10,0	1002,0	37
15.juli	10,00	3		0,0	1000,7	42	17,45	5	ne	7,5	998,5	39
16.juli	8,45	2	ne	7,5	999,5	46	18,00	6	e	12,5	999,3	30
17.juli	8,00	6	e	8,0	998,2	25	18,00	5	nne	7,5	997,1	34
18.juli	7,00	2	ne	2,5	1000,3	43	18,00	3	n	5,0	1003,5	37
19.juli	8,30	5	n	2,5	1005,6	33	18,15	7	ne	5,0	1004,5	28
20.juli	8,00	5		0,0	1007,9	34	18,00	7	ne	5,0	1007,2	30
21.juli	8,00	7		0,0	1006,2	26	20,00	11	ne	5,0	1002,5	15
22.juli	8,00	9	ne	3,0	1005,8	22	18,30	10		0,0	1005,1	22
23.juli	9,00	8	ne	3,0	1006,0	22	18,30	7	nne	3,0	1005,5	28
24.juli	8,00	4		0,0	1007,9	35	20,00	11	ne	3,0	1007,9	18
25.juli	7,30	12	nnw	7,5	1005,3	16	18,00	8		0,0	1005,0	28
26.juli	8,30	6		0,0	1004,8	31	18,15	4		0,0	1003,1	46
27.juli	8,00	5		0,0	1003,5	49	18,00	5	ne	5,0	1000,3	40
28.juli	9,00	3		0,0	999,7	45	18,00	4	nne	2,5	1000,8	38
29.juli	8,30	4	nne	2,5	1003,3	36	18,30	3	ne	2,5	1004,5	40
30.juli	8,45	1	ne	2,5	1009,4	41	18,30	6	ne	1,5	1009,4	29
31.juli	8,00	2		0,0	1005,3	43	19,00	5	n	2,5	1006,1	33
1.aug	9,30	8		0,0	1003,6	28	19,00	5	ne	10,0	1001,9	30
2.aug	9,30	5		0,0	1007,5	32	18,45	7	ne	12,5	1009,5	23
3.aug	8,00	5	n	5,0	1010,7	31	18,30	6		0,0	1006,3	28
4.aug	8,00	6		0,0	999,2	31	18,30	7	ne	7,5	999,7	28
5.aug	8,30	6	n	17,5	1003,5	28	18,30	8	nw	15,0	1003,1	20
6.aug	8,00	4	nw	12,5	1001,4	21	20,00	5	nw	7,5	997,5	17
7.aug	8,30	2	ne	10,0	992,9	43	20,00	3	nw	20,0	999,0	21
8.aug	10,00	3	nw	22,5	989,8	28	18,30	3	ne	27,5	991,2	23
9.aug	9,00	2	e	17,5	1005,0	21	19,45	4	nnw	12,5	1006,8	21
10.aug	8,00	1	ene	12,5	1010,4	45	18,30	2	ene	10,0	1018,2	25
11.aug	9,00	4	ene	12,5	1019,4	28	19,00	6	e	2,5	1017,0	28
12.aug	8,30	7		0,0	1013,7	24	19,00	9	nne	2,5	1010,0	23
13.aug	8,00	8		0,0	1006,6	24						

Appendix 5.1 Hydrographic stations (H 1-4)
Metal concentrations (µg/kg), salinity and pH.

Bottle no.	Cond. uS/cm	St. Depth	pH	Salinity 0/00	Zn	Cd ug/kg	Pb	Cu
107	2580	st1 0m	7,52		2,27	0,0054	0,080	0,84
180		st1 2m	7,58	4,374	2,44	0,0079	0,015	0,38
182		st1 5m	7,57	30,745	1,41	0,0250	0,230	0,69
181		st1 10m	7,72	31,030	0,26	0,0233	1,145	1,11
137		st1 15m	7,92	31,283	2,31	0,0236	0,036	0,48
130		st1 20m	7,73	31,457	1,87	0,0349	0,080	0,98
171		st1 30m	7,36	31,569	0,92	0,0211	0,181	0,77
122	1940	st2 0m	7,70		2,44	0,0103	0,476	0,35
164		st2 2m	7,65	2,381	2,46	0,0104	0,088	0,30
129		st2 5m	7,35	30,796	0,37	0,0103	0,140	0,86
156		st2 10m	7,68	31,257	0,56	0,0116	0,074	0,47
172		st2 15m	7,60	31,382	0,27	0,0406	0,648	0,83
138		st2 20m	7,82	31,512	0,71	0,0140	0,020	0,28
136		st2 30m	7,74	31,591	1,79	0,0315	0,125	0,47
111	3800	st 3 0m	7,60		2,80			
149		st3 2m	7,75	28,304	0,99			
146		st3 5m	7,65	30,526	3,27			
148		st3 10m	7,84	31,173	0,68	0,0135	0,109	0,43
165		st3 15m	7,62	31,366	0,43	0,0228	0,046	0,62
160		st3 20m	7,80	31,482	0,94	0,0193	0,021	0,55
158		st3 30m	7,58	31,595	0,64	0,0295	0,059	0,31
197		st3 50m	7,59	31,750	1,29			
166	5480	st4 0m	7,77		9,24			
116		st4 2m	7,55	30,287	3,66			
191		st4 5m	7,77	30,875	5,58	0,0132	0,427	0,68
194		st4 10m	7,72	31,230	2,79	0,0459	0,289	1,09
150		st4 15m	7,68	31,363	8,17			
199		st4 20m	7,72	31,519	5,43			
115		st4 30m	7,53	31,579	2,01	0,0242	0,363	0,72
153		st4 50m	7,64	31,766	3,23	0,0330	0,120	0,81
157		st4 75m	7,75	33,800	2,85	0,0411	0,292	0,45
174		st4 100m	7,75	34,366	3,20	0,0394	0,049	0,34

Appendix 6.1 Fresh water samples from V1 in the eastern river.
Metal concentrations (µg/kg), total zinc in kg and kg/day, and water flow (m^3/day).

Date	Bottle	Zn	Cd	Pb	Cu	Water level inches	Kg Zn/day	Kg Zn	m+3/day	m+3
8.juni	1	2445	2,75	2,86	1,15	6,75	214,72	214,72	87837	87837
9.juni	2	1671	2,58	3,98	1,55	6,75	146,78	361,49	87837	175675
10.juni	3	1192	1,43	7,49	1,73	7,25	116,46	477,95	97743	273417
11.juni	4	858	0,98	3,64	1,21	4,75	46,62	524,58	54356	327773
12.juni	5	693				2,75	20,78	545,36	29995	357769
13.juni	6	396			1,54	3,5	15,11	560,47	38124	395893
14.juni	7	1000				4,5	50,83	611,30	50832	446724
15.juni	8	754	0,84	3,42	0,96	4	33,34	644,65	44204	490929
16.juni	9	660	0,79	3,98	1,04	4	29,16	673,80	44204	535133
17.juni	10	537	0,69	2,76	0,97	3,25	18,93	692,73	35284	570417
18.juni	11	268				4,5	13,62	706,36	50832	621249
19.juni	12	465				10,75	86,47	792,82	185775	807024
20.juni	13	124				14	37,06	829,88	299412	1106436
21.juni	14	203	0,19	1,32	0,78	8	23,12	853,00	113808	1220244
22.juni	15	153				15	52,16	905,16	341060	1561304
23.juni	16	65,0	0,06	3,12	1,19	27	72,86	978,02	1120246	2681550
24.juni	17	40,8	0,02	2,69	2,09	38	96,31	1074,33	2359038	5040587
25.juni	18	19,2	0,01	1,23		39	48,00	1122,33	2499590	7540177
26.juni	19	7,5			0,88	34	13,82	1136,15	1844772	9384949
27.juni	20	18,6	0,01	1,11	0,42	40	49,09	1185,24	2645051	12030000
28.juni	21	5,7				33	9,80	1195,04	1727900	13757900
29.juni	22	3,7				17	1,60	1196,64	434325	14192224
30.juni	23	4,6	-0,01	0,20		26,5	4,91	1201,55	1076593	15268818
1.juli	24	3,2				30	4,46	1206,01	1404394	16673211
2.juli	25	2,8	-0,01	0,08	0,39	23	2,22	1208,23	799585	17472796
3.juli	26	1,8				28	1,91	1210,14	1210695	18683491
4.juli	27	2,1	-0,01	0,11	0,28	29,5	2,85	1212,98	1354348	20037839
5.juli	28	2,0				18,75	1,06	1214,04	527257	20565096
6.juli	29	3,4				8,5	0,43	1214,47	125343	20690439
7.juli	30	3,3				6	0,25	1214,72	74152	20764592
8.juli	31	1,4				16	0,52	1215,24	386003	21150595
9.juli	32	2,4				12	0,54	1215,78	225661	21376256
10.juli	33	2,4				19,5	1,37	1217,15	570432	21946687
11.juli	34	1,5	0,00	0,03		10	0,25	1217,40	164043	22110731
12.juli	35	2,8				6,5	0,23	1217,63	83121	22193852
13.juli	36	5,1				37,5	11,79	1229,42	2290585	24484436
14.juli	37	6,7				43	20,85	1250,27	3111438	27595874
15.juli	38	1,4				36,5	3,03	1253,30	2157289	29753163
16.juli	39	1,3	-0,01	0,06	0,22	23,5	1,08	1254,38	836157	30589320
17.juli	40	0,8				25,5	0,79	1255,17	992390	31581710
18.juli	41	0,9				16	0,36	1255,53	386003	31967714
19.juli	42	1,1				14,75	0,38	1255,91	330342	32298056
20.juli	43	2,0				31,5	3,18	1259,09	1561121	33859177
21.juli	44	3,1	-0,01	0,25	0,18	36,5	6,74	1265,83	2157289	36016466
22.juli	45	2,4				35,5	4,89	1270,72	2028758	38045224
23.juli	46	10,5				46	37,89	1308,62	3623974	41669198
24.juli	47	7,5				45	26,02	1334,63	3447912	45117110
25.juli	48	6,8				37,5	15,53	1350,16	2290585	47407694
26.juli	49	6,2				36	12,95	1363,11	2092431	49500126
27.juli	50	3,3				36,5	7,18	1370,29	2157289	51657414
28.juli	51	4,6				39,5	11,92	1382,21	2571703	54229118
29.juli	52	3,4				43,5	10,87	1393,08	3193617	57422734
30.juli	53	5,9				45	20,43	1413,52	3447912	60870646
31.juli	54	5,5				44,5	18,52	1432,04	3361847	64232493
1.aug	55	7,9				40	20,91	1452,96	2645051	66877544
2.aug	56	5,6				23,5	4,68	1457,63	836157	67713701
3.aug	57	5,3				19,5	3,05	1460,68	570432	68284133
4.aug	58	3,0				28	3,14	1463,82	1033978	69318110
5.aug	59	10,0				16,5	4,09	1467,91	409737	69727847
6.aug	60	9,0				9,5	1,35	1469,26	150448	69878295
7.aug	61	9,7				7	0,89	1470,15	92711	69971006
8.aug	62	13,2				4,5	0,67	1470,82	50832	70021837
9.aug	63	0,0				3	0,00	1470,82	32576	70054413
10.aug	64	9,6				2,5	0,26	1471,09	27542	70081955
11.aug	65	0,0				2	0,00	1471,09	23007	70104962
12.aug	66	0,0			0,17	2	0,00	1471,09	23007	70127968
13.aug	67	2,7	-0,01	0,05	0,17	2	0,06	1471,15	23007	70150975
14.aug	68	1,2	-0,01	0,01	0,06	2	0,03	1471,17	23007	70173981
15.aug	69	1,5	-0,01	0,02	0,06	2	0,04	1471,21	23007	70196988
16. aug	70	2,6				2	0,06	1471,27	23007	70219995
17.aug	71	1,6				2	0,04	1471,31	23007	70243001
18.aug	72	1,6				2	0,04	1471,34	23007	70266008
19.aug	73	2,9	-0,01	0,04	0,09	2	0,07	1471,41	23007	70289014
20. aug	74	2,8				2	0,06	1471,47	23007	70312021
21. aug	75	3,0				2	0,07	1471,54	23007	70335027
[illegible]	76	3,3				2	0,08	1471,62	23007	70358034

Appendix 6.2 Water flow calculations in Eastern river (V1).
Paper in Danish prepared by Hans Christian Langager, GFU.

19. januar 1995

tat om afstrømning m.m. i Østre Elv/Citronen Fjord.

grundlag af kortstudier, observationsmateriale fra St. Nord og gistreringer i felten er der i det følgende givet et første bud vandføringsforholdene samt størrelseordenen af årsafstrøm-ngen for Østre Elv i Platinova A/S' tilladelses område ved tronen Fjord i Peary Land, Nordgrønland.

t skal understreges at endskønt de fundne resultater har en god dre sammenhæng er der tale om en kvalificeret indledende rdering, der skal eftervises og tilpasses ved nødvendige senere linger for at give et pålideligt billede af de faktiske rhold.

Vandføring i Østre Elv.

vedlagte kort er vist position for vandførings profil B, hvor r i 1993 er udført 1 vandførings måling med vinge udstyr samt kvalificeret skøn over vandføringen. I 1994 er der udført 1 køn samt en kvalificeret vurdering af vandføringen. Endvidere er værprofilet opmålt i 1994, hvor også 2 reference punkter til temtidig vandstandsaflæsning er oprettet.

forbindelse med et prøveudtagnings program er der i et punkt dstrøms for profilet foretaget daglige vandstandsaflæsninger i mmeren 1994.

lgende observationer har dannet grundlag for opstilling af en H relation:

2. august 1994: kl. 15-17 GMT	vandstand	=	0 m
	Ho	=	- 0,15 m
	Punkt I	=	+ 2,20 m
	Punkt II	=	+ 1,61 m
	LM-stok	=	+ 1¼ inch
	Q	~	200 l/s, på grundlag af tværsnits areal og overflade strømhastighed.

Opmåling af tværsnit

6. august 1994: kl. 22 GMT	LM-stok	=	+ 9½ inch
	Vandstand	~	"få cm højere" end 20. august 1993.
	Q	~	"lidt større" end 20. august 1993.
20. august 1993: kl. 14 GMT	Vandstand	~	+ 0,18 m på grundlag af geometri i tværsnit og bredde af profil ved måling.
	Q	=	1,4 m^3/s
18. august 1993: kl. 22 GMT	Q	~	6,3 m^3/s

Følgende Q/H relation er fundet geometrisk ved indplotning på log-log papir:

$$Q = A \times (H-Ho)^n$$
$$n \sim 2,5$$
$$A \sim 22$$

$$Q \sim 22 \times (H-Ho)^{2,5}$$

Ved anvendelse af punkt I:

$Q\ (m^3/s) \sim 22 \times (2,35\ m - H)^{2,5}$, hvor H er den lodrette afstand mellem punkt I og vandspejlet, angivet i meter.

Ved anvendelse af punkt II:

$Q\ (m^3/s) \sim 22 \times (1,76\ m - H)^{2,5}$, hvor H er den lodrette afstand mellem punkt II og vandspejlet, angivet i meter.

Det skal bemærkes at ovenstående formel skal verificeres gennem målinger i felten. Da tværprofil B ikke nødvendigvis kan anses for stabilt ved større strømningshastigheder, skal formlen

videre checkes med mellemrum - alternativt kan der bygges et erfald eller lokaliseres et andet tværsnit.

Vandføring ved udtagningspositionen for vandprøver i 1994.

fremt der gøres den grove antagelse at vandstandsændringerne ed prøvestedet (LM-stok) og ved tværprofil B er ens kan følgende lation opstilles:

$$Q = A_1 \times (H-Ho,_1)^{n1}$$
$$n_1 \sim 2,5$$
$$A_1 \sim 2,3 \text{ l/s}$$
$$Ho,_1 \sim -4,7 \text{ inch}$$

$$Q \text{ (l/s)} \sim 2,3 \times (\text{Aflæsning (inch)} + 4,7)^{2,5}$$

ntagelsen om vandstandsændringerne er grov fordi der ved røvetagnings stedet vil optræde strygende strømning - men i angel af bedre må formlen anbefales til beregning af indledende verslag.

3. Årsvandmængde gennem Østre Elv.

På kortgrundlag 1:100.000 (orthofoto kort med 100 m kurveækvidistance) er skitseret oplandet der afvandes gennem Østre Elv. Grænsen er indlagt udfra overfladevandskel og usikkerheder optræder på lokale gletscherdækker samt elvdalens afgrænsning mod sydøst. Disse forhold kan kun afklares ved rekognoscering i felten.

Oplandet afgrænset af måleprofil B er planimetreret til 510,8 km^2.

Lokal gletschere er forudsat i balance, hvilket betyder at netto ablationen er sat til 0 mm/år.

Nedbøren er skønnet ud fra middel af 22 års måling på station Nord (målt i kote 35) fratrukket et bidrag til fordampning/sublimation (20%), fratrukket et bidrag s.f.a. forskellen i kystafstand ved Station Nord og ved Østre Elv (30%) samt tillagt

et bidrag for den højere middelkote omkring Østre Elv (30%).

Den skønnede middel årsnedbør omkring Østre Elv bliver herefter:

N ~ 201 mm x 70% x 1/70% x 80% = 160 mm,
der skønnes at have en standardafvigelse på 30-40%.

Den skønnede årsafstrømning gennem måletværsnit B bliver herefter:

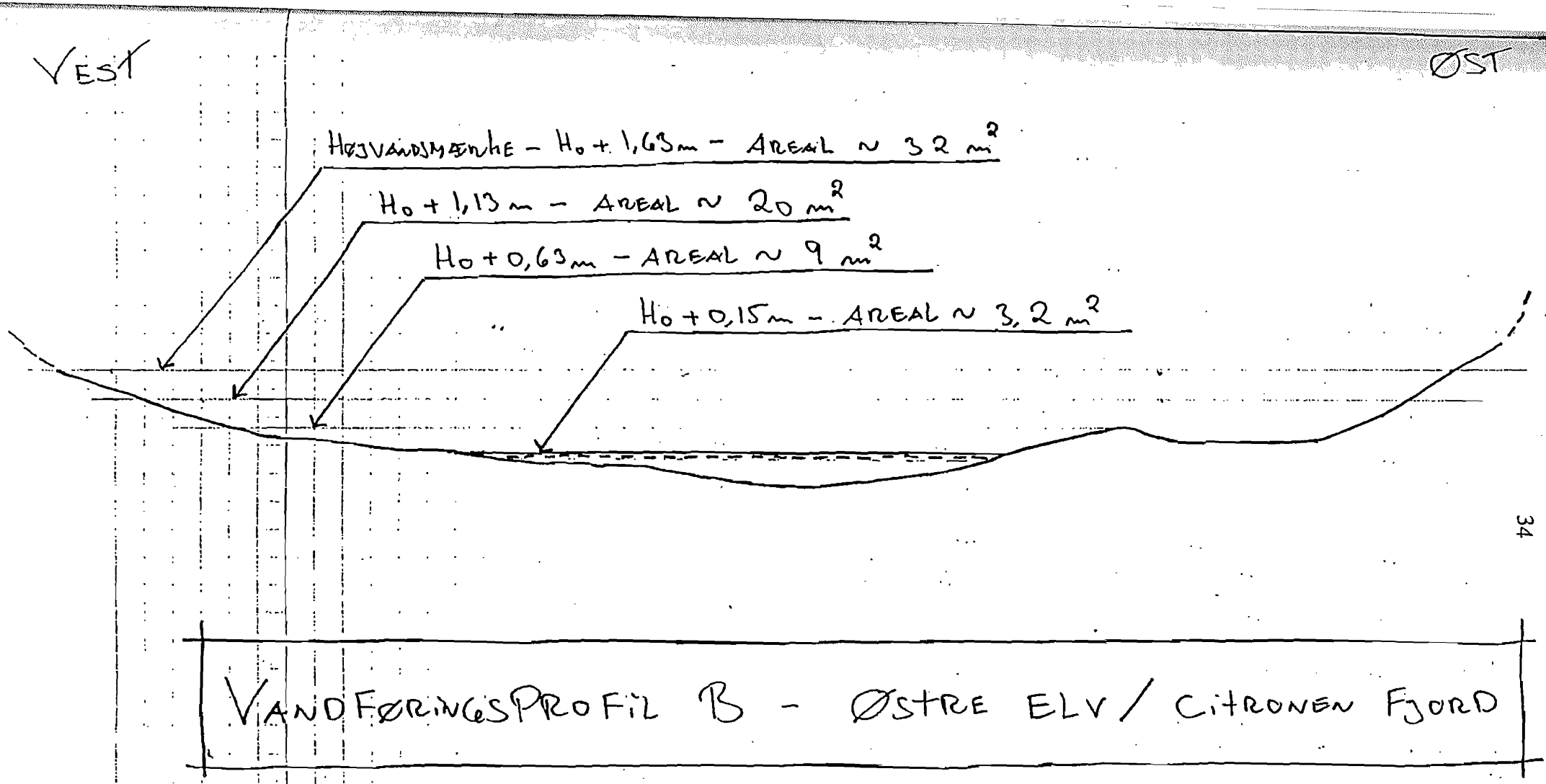
Q År ~ 510 x 10^6 x 0,16 ~ 80 x 10^6 m^3,
der skønnes at optræde over en 5 måneders periode (maj - september).

En mere pålidelig bestemmelse af årsafstrømningen kan kun opnåes gennem kontinuert måling i felten. Som kontrol og for at bestemme eventuelt bidrag fra lokal ablation bør sideløbende foretages fastlæggelse af oplandsgrænsen og kontinuert registrering af nedbør.

Hans Chr. Langager

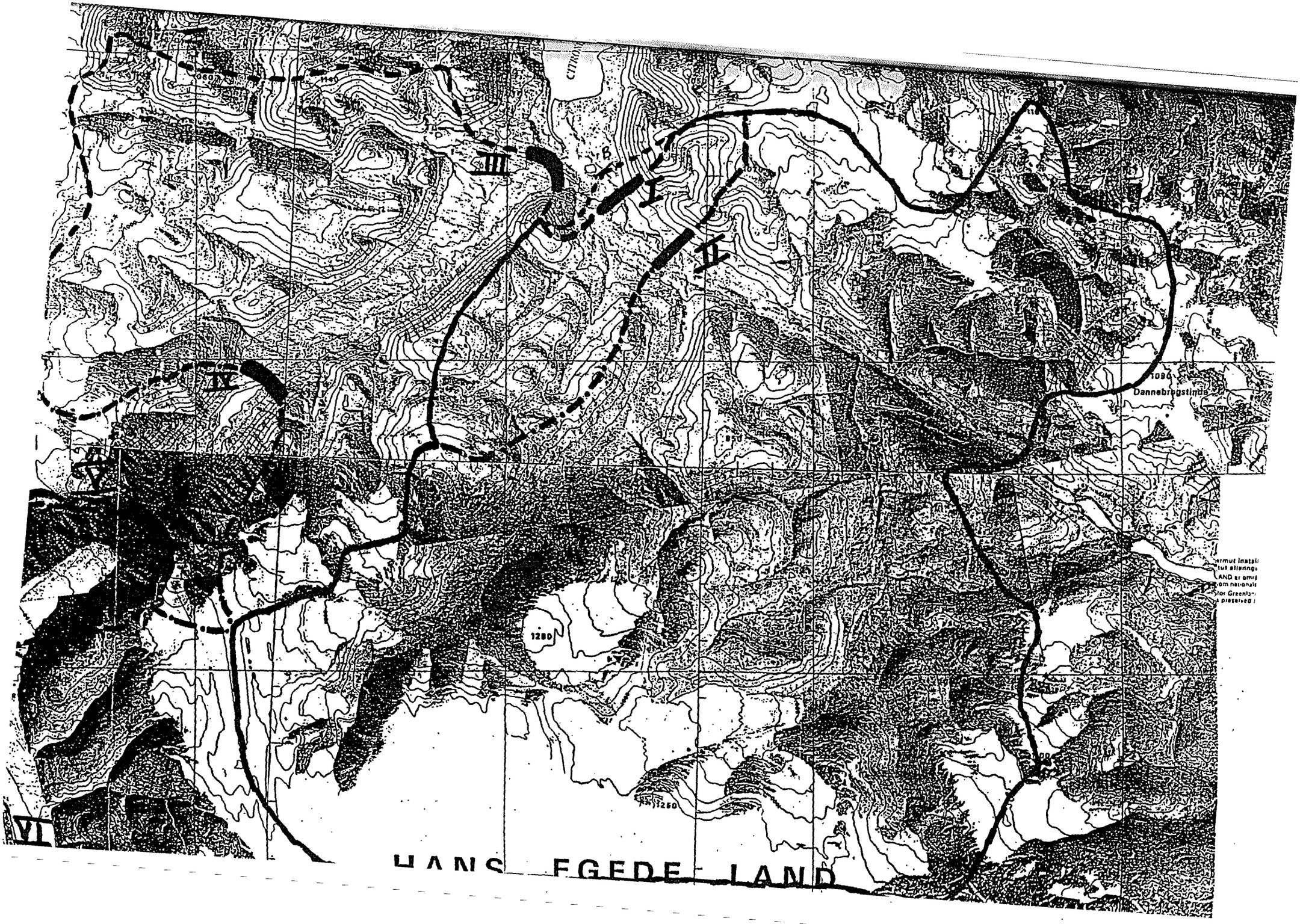
Bilag: Kort med tværprofil B og opland - 1:100.000/100 m.

Tværprofil B, 12. august 1994.



VANDFØRINGSPROFIL B – ØSTRE ELV / CITRONEN FJORD

1:100 / 12 AUGUST '94 /


I
II
III
IV
V
VI
1250
Dannebrogstinde
HANS FGEDE LAND

Appendix 6.3 Fresh water samples from other stations (V2-4,6,7,9) and a brooklet at the showings.
Metal concentrations (µg/kg).

Analyses of other fresh water samples

Station	No.	pH	Zn	Cd	Pb	Cu
V7	132	8.00	0.07	0.00	0.020	0.15
V2 a)	141	7.82	2.90	0.02	0.050	0.14
V6	151	7.89	<0.1	<0.01	0.035	0.10
V9	155	7.91	0.30	<0.01	0.270	0.40
*	161	2.42	155000	354	525	6.40
V3	167	7.90	<0.1	<0.01	0.025	<0.2
V2 b)	169	8.20	<0.2	<0.01	0.025	0.16
V4	192	7.98	<0.3		<0.01	0.20

* a brooklet from the showings, mercury concentration was 0.47

V2 : der er sandsynligvis taget en prøve i Østre Elv (a) hvor sideelven løber ud, samt en prøve i sideelven (b).

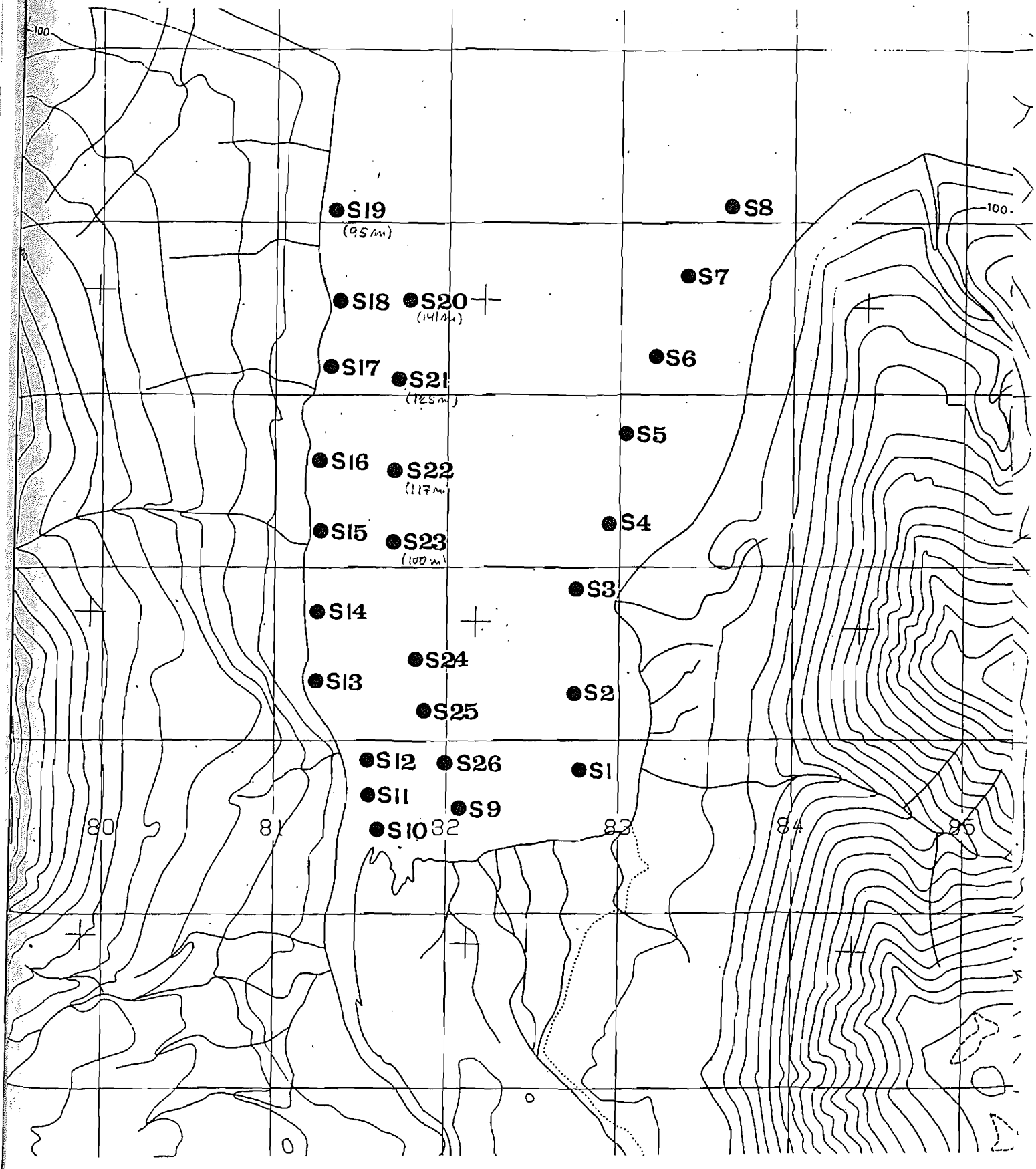


Figure 2. Sediment stations (S) in Citronen Fjord.

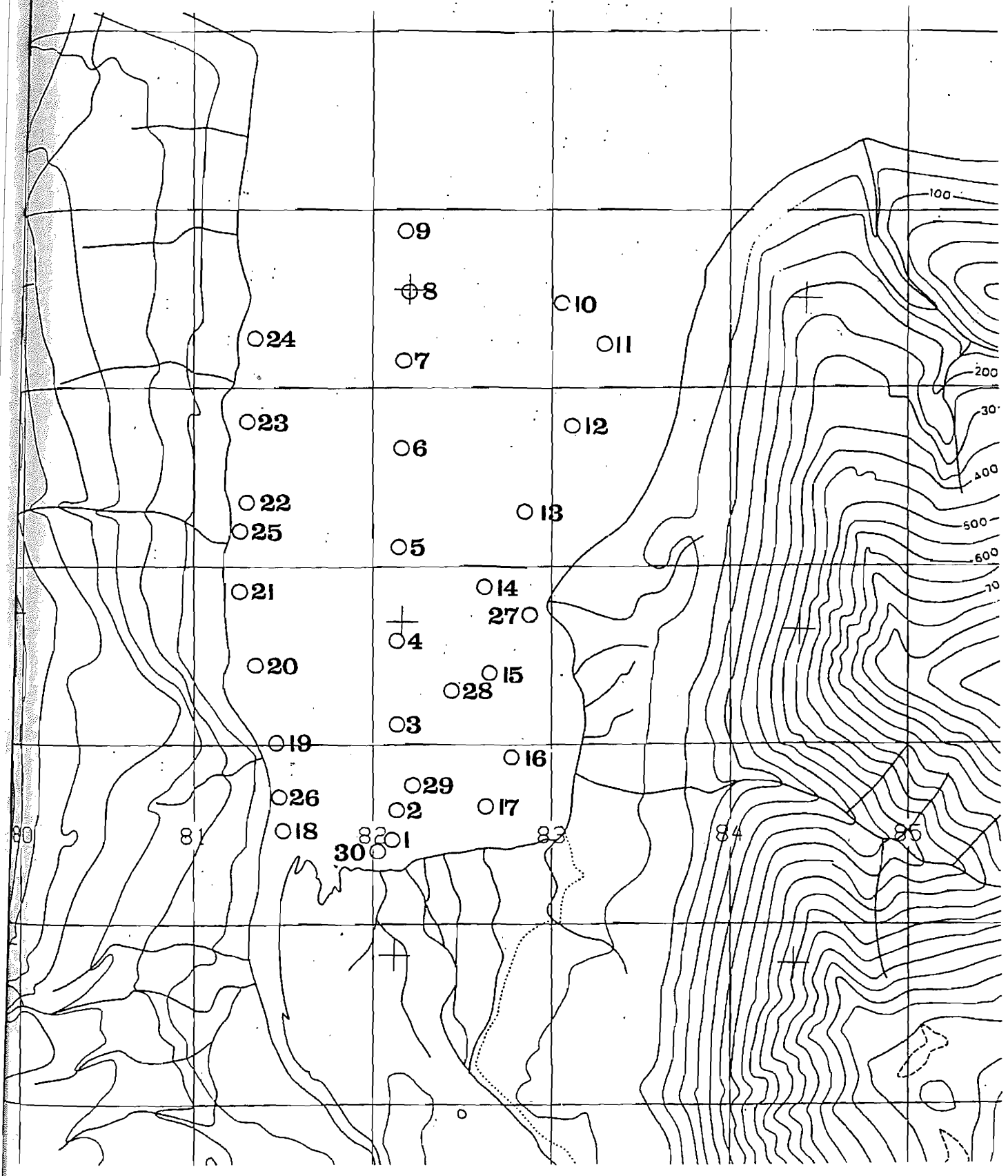


Figure 3. Sea water surface stations (O) in Citronen Fjord.

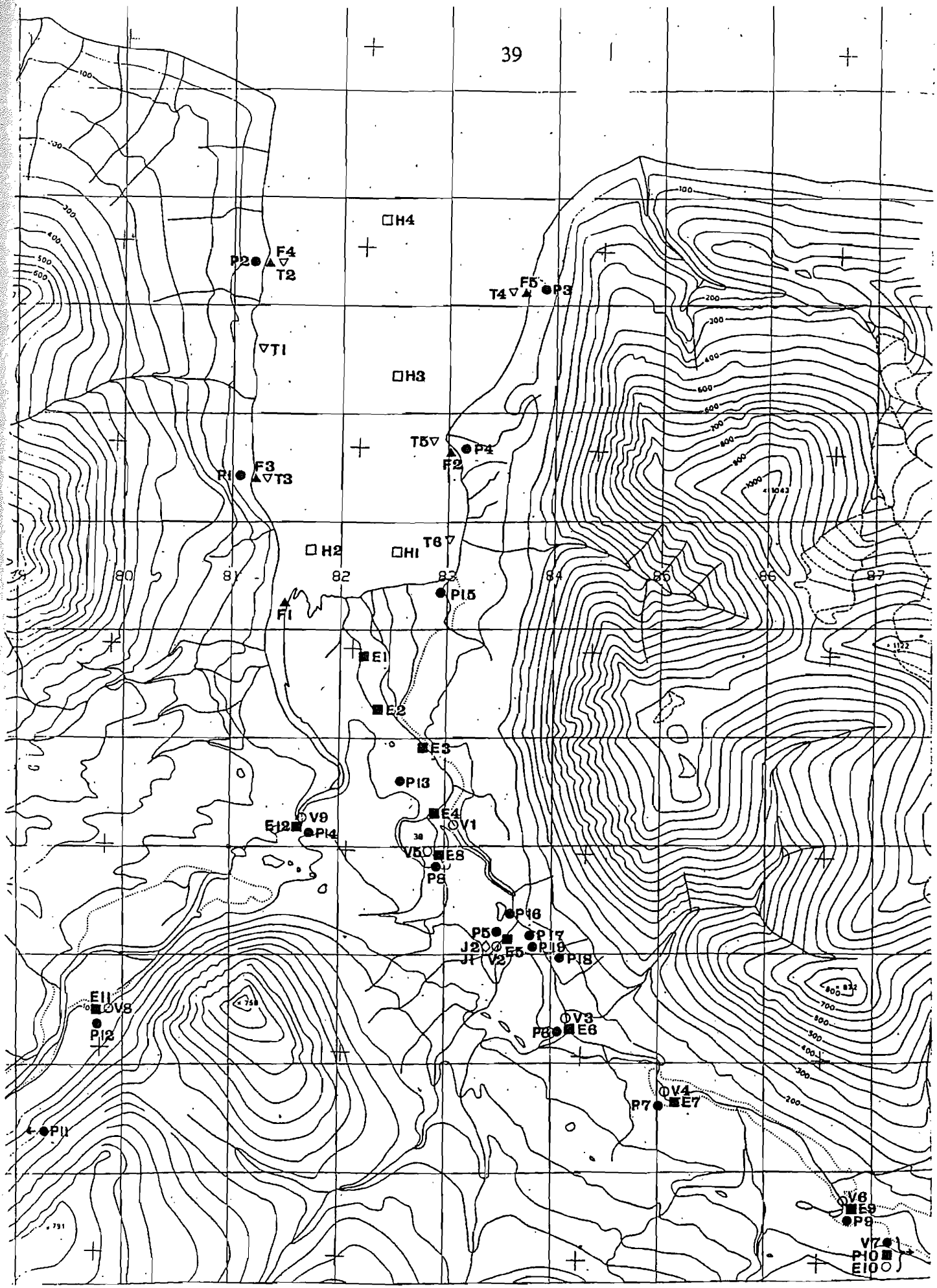


Figure 4. Stations in Citronen Fjord: Fish (▲ F), Seaweed (▽ T), Sea water column (□ H), River sediment (■ E), Soil (◇ J); Plant and faeces (● P) and Fresh water (○ V).

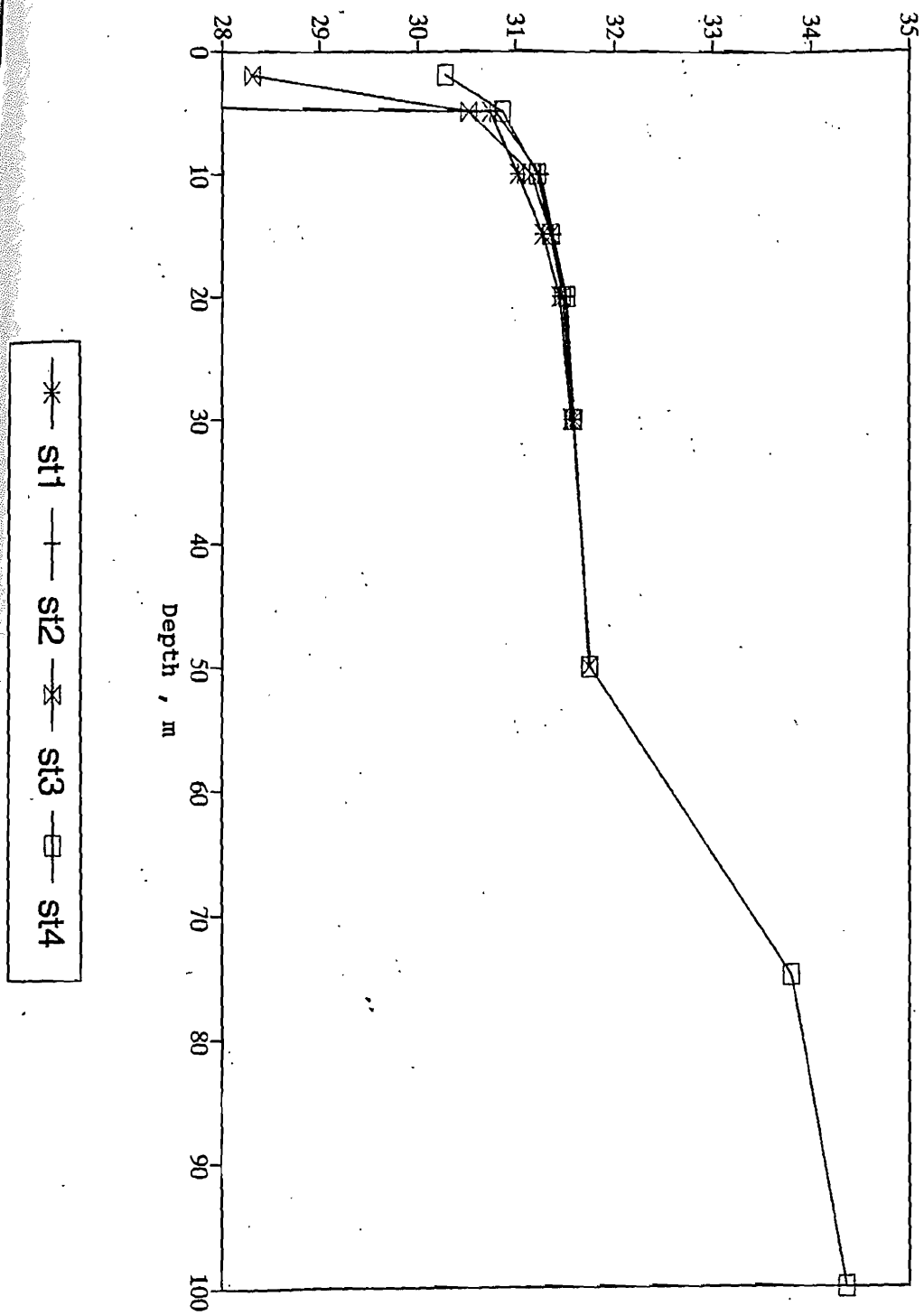


Figure 5 Salinity (0/00) at four sea water column stations (H 1-4).

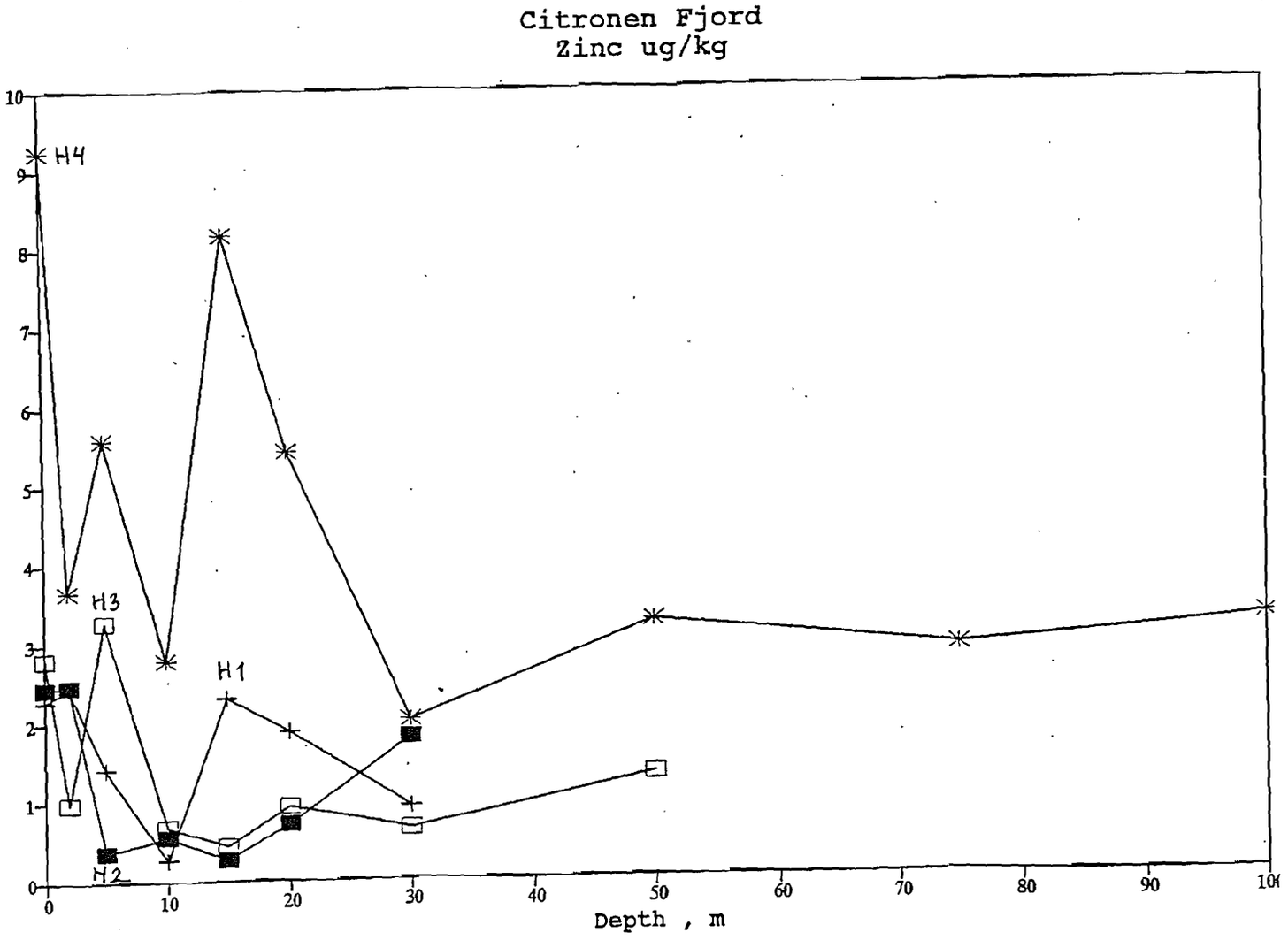


Figure 6. Zinc concentrations (µg/kg) at four sea water column stations (H 1-4)