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ESTABLISHMENT OF **TROLL**, A NEW STATION FACILITY FOR SUMMER OPERATIONS

INITIAL ENVIRONMENTAL EVALUATION

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PREPARED BY NORSK POLARINSTITUTT,

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Aerial photograph of Jutulsessen, taken 5 Jan. 1959 from 3 700 m elevation. Norsk Polarinstitutt Photo No. DML58-59 1301.

OMSLAGSFOTO: BJØRN LYTSKJOLD

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INTRODUCTION

The Antarctic environment is of singular value, both as a resource for science to obtain pristine conditions and for its unspoilt qualities of recreational value. Recognizing the importance of preserving this situation for future generations of scientists and other visitors, the Antarctic Treaty Consultative Meeting in 1987 adopted recommendation XIV-2: Man's impact on the Antarctic environment: Environmental impact assessment. This Initial Environmental Evaluation is prepared in accordance with that recommendation.

SITE DESCRIPTION

The Norwegian Antarctic Research Expedition (NARE) 1989/90 plans to establish a small research station, Troll, initially for summer operations in Jutulsessen (72^0 S, 2^0 40' E). This site is centrally placed in the region of Dronning Maud Land where NARE has conducted, and plans to conduct, research (Figs. 1 and 2).

Jutulsessen is located about 200 km from the ice front, and the overland route to Jutulsessen is about 230 km. The site is a north-facing amphitheatre-shaped ice free area covering approx. 15 x 20 km, enclosing an extensive blue-ice area. The ice-free area extends from 1100 to 2400 in elevation. (Fig. 3).

Jutulsessen has been briefly visited by previous Norwegian expeditions, most recently in January 1985. Extensive scientific research has not been conducted here.

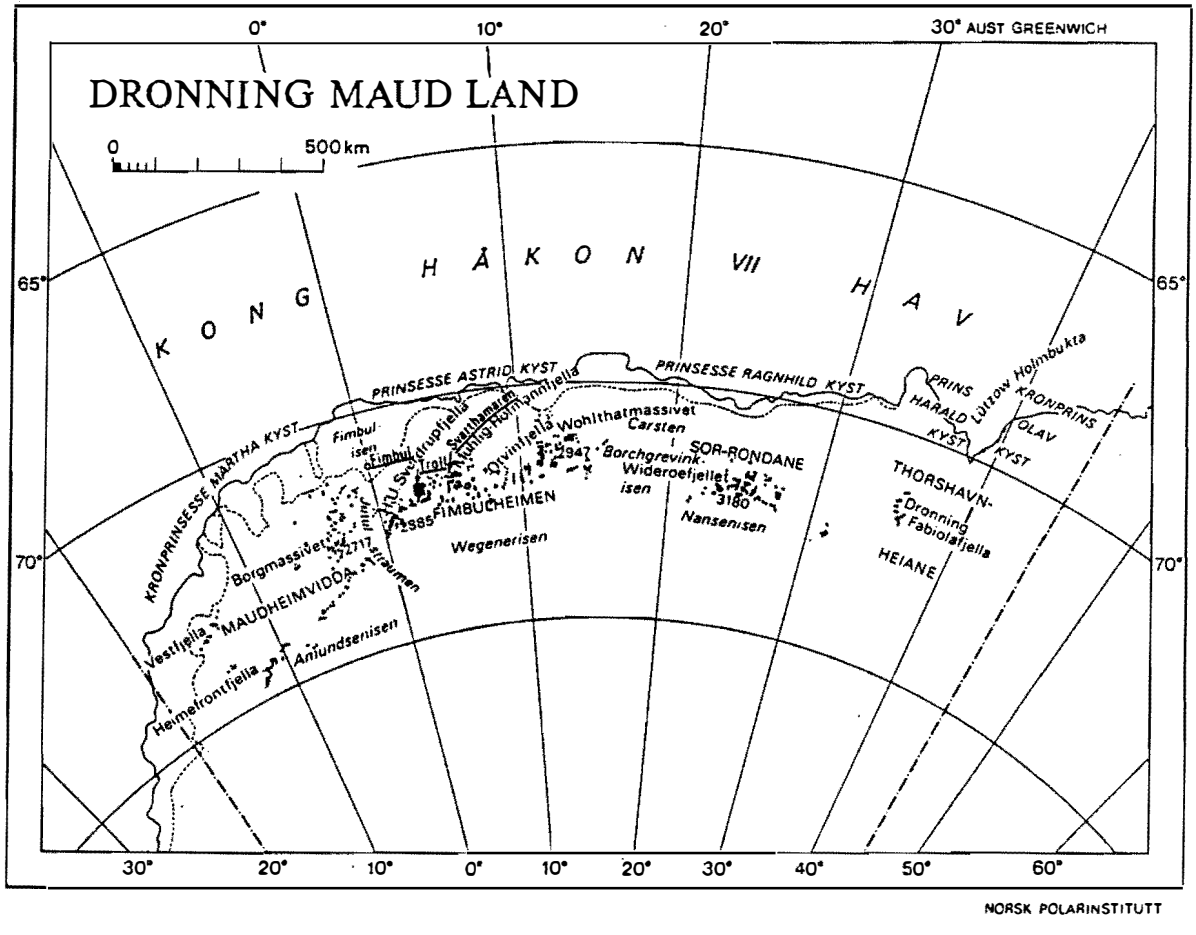

Fig. 1. Location of Troll (underlined) within Dronning Maud Land.

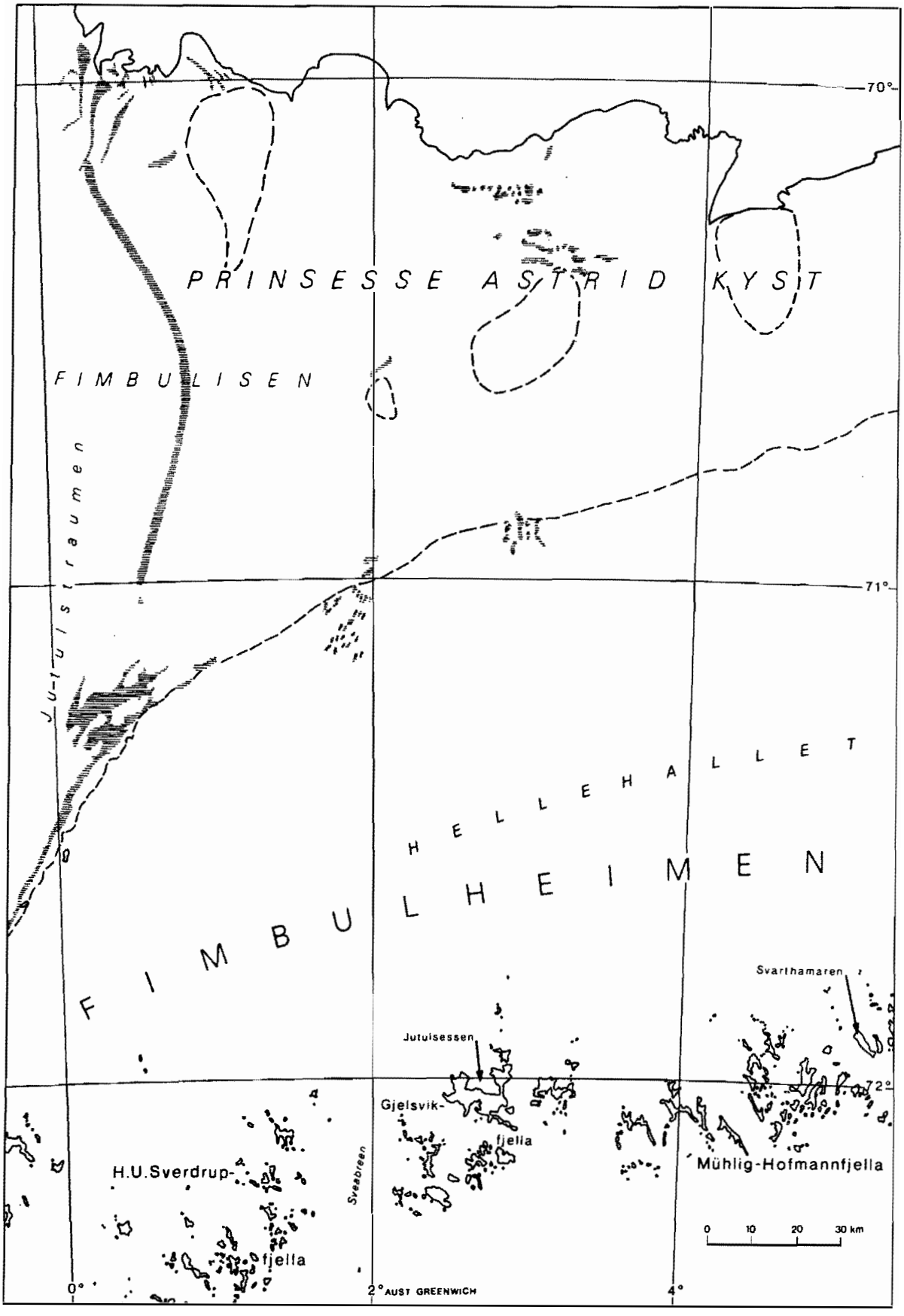

Fig. 2. Location of Jutulsessen and other areas of main research activity during NARE 1989/90.

Fig. 3. Jutulsessen with likely station locations: Grjotlia, Sætet, Armlenet.

PLANT AND ANIMAL LIFE

Animal and plant life in the Jutulsessen area have been scantily investigated. Botanical and ornithological registrations were undertaken in parts of the area during NARE 84/85. Generally, the flora in the area consists of algae, mosses and lichens (ANNEX II). The invertebrate fauna, which in part is closely connected to the flora, consists of protozoans, rotifers, nematodes, tardigrades, mites and insects (Annex II). The vertebrate fauna consists only of bird species. Of these, snow petrel (Pagodroma nivea), Antarctic petrel (Thalassoica antarctica) and south polar skua (Catharacta maccormicki)have been observed nesting in colonies in Jutulsessen. However, there does not seem to be any bird colonies within or near the proposed station sites, except for a relatively small snow petrel colony of unknown size near Grjotlia.

GROUND CONDITIONS

The mountains of Gjelsvikfjella are built of an Archean basement complex of gneiss and charnockite. The metamorphism ranges from amphibolite facies in the west to mainly granulite facies in the east. The lithology varies from granitic to gabbroid.

The texture and weathering of rocks vary in a way significant to vegetation. Charnockites yield a rugged surface of protruding feldspars, whereas the gneisses have smoother surfaces more suitable for lichen growth. Biotite-pyroxene rocks and dolerite dykes are dark coloured and effective in absorbing radiation.

The ground is permafrost consisting of scree blocks and frost weathering products. Some areas thaw during favourable weather conditions in summer, and melting pounds are characterized by growth of the green alga Prasiola crispa.

METEOROLOGY AND CLIMATE

Meteorological data from Gjelsvikfjella are sparse. However, data exist for the period 13 January to 15 February 1985 from the neighbouring, Mühlig-Hofmannfjella. Prevalent air temperature here ranged from -5^{0}C to -15^{0}C. A mean annual air temperature for this area is estimated to be -26^{0}C, using temperatures from snowdepths of 10 meters as an indicator. Gjelsvikfjella, which are of lower altitude, are expected to have a somewhat more benign climate.

At Gjelsvikfjella the sun is under the horizon for 2.5 months during mid winter, and above the horizon from 15 November to 27 January during the austral summer. Being so far inland, 200 km, the area is only slightly affected by the cyclones that buffet the coast. The climate is therefore little influenced by heat advected from the ocean, and radiation from the sun and the atmosphere is the main energy source.

The conditions at the nunataks in Gjelsvikfjella represent one of the limits for plant life on earth. The mean temperature for the warmest month is below 0^{0}C and winter temperatures may drop below -50^{0}C. Due to high intensity of solar radiation in summer, and low albedo, the surface temperature of the nunataks may be considerably higher than the air temperature, especially in small niches protected from the wind. The vegetation in these niches is very susceptible to desiccation.

REASONS FOR CHOOSING JUTULSESSEN

Establishment of an inland station facility was considered essential for continuation by Norway of modern scientific research in Antarctica.

Norwegian Antarctic research activity in the coming years is expected to include various research for which Jutulsessen is the best geographic position as support base. These studies include:

1) The Jutulstraumen/Fimbulisen ice stream/ice shelf system, the largest ice stream in Dronning Maud Land. The investigation will be concerned with understanding the ice shelf/ocean interaction and the response of the system to climatic change.

2) The interrelationship across the geologic boundary between East and West Antarctica, probably marked by a large geological break along the Jutulstraumen - Pencksøkket glacier system. This discontinuity is the most important key structure for the reconstruction of the Gondwana continent.

3) Studies of the colony of more than 200 000 breeding pairs of Antarctic petrels at Svarthamaren, and the energy flow and behavior of this population located 200 km from the ocean. Svarthamaren is a Site of Special Scientific Interest (SSSI) and it is located 90 km east of Jutulsessen. To establish Troll far from Svarthamaren is in accordance with requirement not to have large human logistic activities near to Svarthamaren.

A number of snow-free sites were considered for station location, and Jutulsessen was selected because:

a)It was centrally located in relation to Norwegian science priorities.

b)It appears to have relatively sparse biological activity
c)It has logistical advantages in terms of no difficult cravasse areas in the vicinity, and possibilities for creating a future airstrip. It has a 20 x 10 km blue-ice area suitable for future operations by wheeled aircraft. Next to this this is an area of level snow surfaces suitable for ski aircraft.
d)It appears to have a relatively benign climate

The combination of these four factors made Jutulsessen our primary choice amongst the examined sites.

ESTABLISHMENT OF STATION

The location of Troll fills a gap in the network of existing stations. The nearest, SANAE, lies 200 km to the northwest. More distant stations are Dakshin Gangotri, Novolazarevskaya and Georg Forster, all 300 km to the east-northeast, Georg von Neumayer, 400 km to the west, and the summer stations Wasa and Aboa, 500 km to the west-southwest.

1. LOCATION

Lack of detailed knowledge of Jutulsessen means that precise location of the station will be decided after further site survey during January 1990. For the time being, three possibilities within Jutulsessen have been selected in order of likelihood (see Fig. 3):

1. Grjotlia
2. Sætet
3. Armlenet

The location depends on where the most favourable conditions are found, both in regard to ground conditions and in order to minimise the influence on animal and plant life.

Requirements for station location include in priority:

1) No nearby bird colonies or vegetation of high conservation value,
2) Transport/traffic to the station must be able to avoid bird colonies and vegetation of high conservation value,
3) The ground must be reasonably level,
4) Easy access from nearby snow and ice areas, and
5) Reasonably protected from wind and drifting snow.

2. BUILDINGS

Two buildings will be erected, covering 95 m^2 and 20 m^2. The

station will be only one story. Walls, roof and floor for the main building and wing will be clad with 0.8 mm steel plates, covered with BSC Colorcoat Plastisol. The isolation is 18 cm high-pressure foamed polyurethan, strengthened by two horizontally running impregnated wooden beams. Roofing will be done with Napolar, and the floor covering is made of welded industrial-linoleum.

The station will be placed on a firm base (rock or permafrost). The foundation includes aluminium beams, which leave possibilities for vertical adjustment up to 1 m above ground level. If the station is placed on permafrost pebble, the foundation pillars will be dug about 0.5 m into the ground and the ground plates (0.5 x 0.5 m) will be bolted or concreted to the ground.

3. EMISSIONS FOLLOWING NORMAL ACTIVITY AT THE STATION

Emission into air

The station's electrical power source will be a multifuel operation aggregate (15 kW). Fuel will be diesel and jet-fuel (JP4, JP5, JP8), and consumption will be 50-70 litres per 24 hrs.

The Norwegian State Pollution Board has supplied the following values for emissions from combustion engines. Values are in Kg/ton except for lead (Pb) which is g/ton. No accurate values for kerosene are given, but this is considered to be similar to diesel, with the exception of the sulfer content which is similar to that of petrol.

	SO_2	NO_2	VOC	CO	CO_2	Pb	Particles
Petrol	0.1	26.6	26.0	250.0	3110	140	1
Diesel	5.8	40.4	6.7	16.9	3180	-	3.8
Kerosene	0.1	40.4	6.7	16.9	3180	-	3.8

The quantities of all above are expected to have only minimal local impact, but this will be investigated further by the monitoring programme (see below).

Alternative energy sources have also been evaluated and will be used as far as possible. We do not expect to be able to use wind power at Jutulsessen, because of its sheltered location. However, we have experience with wind generators from the Arctic, and should winds be heavier than anticipated such generators will be evaluated for future installation. The 1989/90 expedition carries nine solar cell panels, and these are used to provide energy for particular needs such as radios, repeaters and various scientific instruments. We expect to increase the use of solar power in the future, but not to the extent that it can cover the major energy requirements which will have to be filled by generators, as these provide electricity also in periods of no sunlight.

Liquid emissions

The mass of "domestic liquid wastes", i.e., from kitchen and human sanitation is calculated to approx. 50 litres per person every 24 hrs. It is estimated that NARE 1989/90 will spend 1000 man days in the area of the station. Kitchen waste water/sewage will be led approx. 100 m away from the station to an ice-covered sloping area. A heating cable will be used to avoid freezing.

No waste of chemical liquids related to research activities is planned.

Toilets

All septic waste will be contained in a closed circuit and transported out of the continent.

Refuse

The amount of solid refuse will be collected in covered containers. Solid refuse which does not release detrimental substances will be separated from the remaining refuse and burnt in an Ildolet incinerator. Owing to the incinerators draught system it provides practically complete combustion, and it can incinerate up to 50 kg solid waste per hour. Wall sheet thickness 3 mm and thickness of refractory 40 - 60 mm. Operation temperature is approx. 700^{0}C. The following materials will be combusted: Paper and paper products, in all cases only when not impregnated. The ashes will be returned to the expedition vessel and brought outside Antarctica. Refuse that is non-disposable, either because of its composition, waste gases (i.e. plastics) or other factors, will be transported out of Antarctica. Solid human sewage and plastic products will also be returned to the expedition vessel and disposed of in accordance with recommendations XV-3 and XV-4. The sandwich elements for the buildings are locked together mechanically and should not release polyurethan. If it is necessary to cut any panels the polyurethan fillings will be collected and transported out of Antarctica.

4. TRANSPORT

In connection with the construction of the station and the scientific work during the 89/90 expedition, 2 caterpillars (type BU 206 Hägglund), 8 snowscooters (type Bombardier Alpin/Tundra) and 2 helicopters (Bell 214 and AS 350 B1 Ecureuil) will be used. Necessary transport in the whole research area (approx. 150 km in extension, see Fig. 2) during the summer season is estimated to:

snowscooters: total 3 000 km (consumption 3 1/10 km)

caterpillars: total 5 000 km (mainly between the barrier and the station area, little or no driving within the station area. Consumption 15 1/10 km.

helicopter: The Bell 214 helicopter will be used for transporting heavy equipment in connection with establishment of the station. For the rest, flying will mostly be done with the Ecureuil 350 helicopter, mainly from the area around Jutulsessen towards Fimbulisen/-Jutulstraumen approx. 60-80 km NW. Estimated flight-times:
Ecureuil 350: 150 hours, with a consumption of 185 l jet fuel F-34 (JA1) per hour.
Bell 214B: 50 hours, 600 l/h.
The number of landings/take offs near the station in Jutulsessen is estimated at 20 and 100 for Bell 214 and Ecureuil 350, respectively.

Flexible tanks with approved military specifications will be brought for temporary fuel storage. Jerrycans will be utilized in limited numbers in connection with snowscooter driving.

It is anticipated storing approximately 5-10 cubic m of fuel at Troll. This will be stored in barrels and aluminium tanks. The amount to be stored depends upon transport- and scientific fuel consumption during the 1989/90 season.

ENVIRONMENTAL EVALUATION

This initial assessment is being presented before the actual site of the base has been chosen. It is therefore difficult to assess in detail the impact on the environment of establishing the station.

When choosing the site for the location of Troll Station, the Norwegian Antarctic Research Expedition will take all reasonable measures to minimize negative effects on the local environment.

In assessing the possible environmental impact of establishing a station in Gjelsvikfjella the constructional and operational periods are best devided into: Transportation Phase, Construction Phase, Present Operational Phase, Future Operational Phase.

Though no part of the construction of an Antarctic station or the land transport in Antarctica, we believe that the potential threat to the environment caused by vessels transporting expeditions to Antarctica should be included in an environmental evaluation. This because we in recent years have seen major oil spills in both Antarctic and Arctic waters.

TRANSPORTATION PHASE

Ship:
Barring any major accident K/V Andenes should not influence the terrestrial environment. When crossing into Antarctic waters the ship brought with it the following amounts of fuel:

Gass-oil = 750 m^3
Kerosene = 90 m^3
Petrol = 6 m^3

Transport Ship-Troll Station:
This transport will be undertaken by caterpillars, snowscooters and helicopter. A major part, if not all, of this transport will be conducted over ice and snow and should cause little or no lasting effect on the environment. The emissions by fuel combustion engines are, relatively speaking, so limited that they are negligible. Transport of goods to Troll should not pollute the route. However, 5-10 m^3 of fuel will we transported to Troll and should some damage occur to this transport, then a local hydrocarbon spill may take place. Since the transport is over ice and snow such a hydrocarbon spill will rapidly be concealed by drifting snow and melting through change in albedo, and will, but locally, not influence the environment.

Transport, especially around the station, may have to pass areas of bare ground. Locally this may damage the sparse flora and/or fauna, and leave tracks. This will as far as possible be avoided.

One condition for choice of station location is that there is no nearby bird colonies or vegetation of high conservation value. Transport and construction is therefore not expected to influence these.

CONSTRUCTION PHASE

The building of the station will, to a small degree, locally damage the construction site. This is unavoidable, but will be reduced to a absolute minimum.

During the transport and building phases emissions into air

will be at a higher level than during normal station operation due to helicopter traffic. This will be a part of a cumulative effect on the local environment at Troll.

During construction chances of fuel leakages are greater than under normal operating conditions. Should such a leakage occur the spill will mechanically be removed and incinerated.

PRESENT OPERATIONAL PHASE

The stations electrical generators, incinerator and helicopter will be the major causes of emissions to the air. The quantities in question are expected to have minimal local impact. This will, however, be part of a cumulative effect on the local environment. Such an effect will be monitored.

Kitchen waste water/sewage will be discarded on an ice area approximately 100 m from the station. This may lead to very local pollution, but is expected to be naturally covered by ice and therefore not influence the local environment.

Wastes that are nondisposable will be transported out of Antarctica and will therefore not influence the local environment.

FUTURE OPERATIONAL PHASE

The Troll Station is of permanent nature, and in future fixed-wing air-transport is planned. This will necessitate the using of near by blue-ice areas as airstrip. Emissions to air are expected to be negligible, but will have to be taken into consideration when considering the total cumulative effect on the area.

CONCLUSIONS

1) The initial environmental evaluation indicates that the establishment of the summer station, Troll, is likely to have only minor or transitory effect on the environment, and that a further Comprehensive Environmental Evaluation is not necessary.

2) A programme will be conducted to monitor the actual impact resulting from the establishment of Troll. This monitoring programme is described in Annex I. In addition the geology and biology of the site will be investigated by scientists from the expedition, including collection of environmental samples prior to, and after, station construction.

3) The advantages to scientific research and safety of operation gained by the construction of Troll justify the localized and overall relatively insignificant environmental impact caused by transport and building operations.

ANNEX I

MONITORING PROGRAMME

INTRODUCTION

A monitoring programme will be initiated in order to evaluate the potential environmental impact of activities associated with establishment of the research station. This programme will include monitoring of pollutants, seabird populations and vegetation.

Before the establishment of the station a reconnaissance group will select the most suitable place for the location based upon the requirements given in the IEE. The group's work will include photographic documentation, from helicopter and ground level, of the site. The group will also start the sampling programme for background pollution immediately after the selection of the location.

The station will disperse in the atmosphere heavy metals (V, Pb, Cd, Zn, etc.), sulphates, nitrates and organic pollutants due to combustion of fossil fuels used for electrical power production and transport purposes. This may contaminate the environment around the station to a distance of many kilometres, depending on the wind direction and speed. There will also be a contamination of the ground and ice surface due to spills from passing vehicles and other activity.

The region of the station is also influenced by:

a) the global transport of pollutants from distant sources
b) the local natural sources of contamination, i.e., eolian transport of material weathered from the nearby rock surfaces, not covered by ice and snow.
c) marine-origin pollutants due to wind transport and bird activity.

The primary interest of this study should be to find out how the activities at the station change the "base-line" pollutants' levels caused by these three other sources. This means that a set of environmental samples should be collected before or at the beginning of the activity at the station, and then another set of samples should be collected at the end of the expedition. Next expedition might continue this research.

Most reliable for observations of the pollution effects of the station are samples of the surface firn collected in the vicinity of the station. The highly developed surface of the snowfields is an excellent trap for aerosols, much better than the surface of the blue ice.

It is supposed that the polychlorinated hydrocarbons may pose a serious long-term hazard to some polar species, in which they accumulate in the tissue fat. The deposits of the solidified stomach oil regurgitated by petrels over a long time period (up to many thousands of years before present), occurring in the bird's colonies at Antarctica, offer a unique opportunity for establishing the "base-line" levels of organic pollutants in the biological material. The stratification of the deposits may be used for observation of temporal changes of these pollutants during the recent time and for comparison with the levels in the pre-industrial period.

SAMPLING PROGRAMME

A) COLLECTING OF FIRN OR ICE

The preferred material is firn. If its sampling is not possible near the station, ice may be collected instead.

Two collection sites will be located:

a) One site a few hundred metres from the station, in the direction of prevailing winds; and
b) A second reference site at a snowfield a few kilometres upwind from the station.

Both sites will be protected against passing by vehicles and by foot, and permanently marked, so that long-term observations could be carried out in the same places. This is done because distribution of pollutants at the surface of ice and snowfields is random and one order of magnitude differences in concentrations in close areas is common.

1) A total of 30 samples of snow/firn will be collected as follows:

   10 samples will be collected from a snowfield near the station, each at the beginning and at the end of the expedition, i.e., a total of 20 samples. Half the samples will be used for heavy metals determination and half for organic pollutants.

   Five samples will be collected at the reference site each at the beginning and end of the expedition, i.e. a total of 10 samples.

   The samples will be collected in 1-litre polyethylene wide-necked bottles. These are specially cleaned at the Institute of Chemistry, University of Oslo. Sampling procedure will be 1): Remove bottle from two polyethylene bags in which it is sealed. 2) Press open bottle horizontally several times against a 2 - 3 cm thick surface layer of snow, until a complete filling of the bottle. 3) Screw cap tightly and seal bottle in the same polyethylene bags. The samples will be collected about 2 metres apart.

2) Alternative procedure for collecting of surface ice.

Small chunks of ice are cut with a chisel from a 1 - 2 cm thick surface layer of ice, within a 0.2 x 0.5 m area. Chunks are collected in the 1 litre bottle as in 1), using the cap of the bottle.

B) COLLECTING OF SOLIDIFIED AVIAN OIL

Solidified avian oil in the form of waxy organic masses, of yellowish brown colour, and exuding a faintly resinous odour, are deposited in the colonies of snow petrels, near the nests.

Samples of the avian oil is planned to be collected at the inhabited colonies, as follows:

1) 5 samples from a site near the station, and
2) 10 samples at the reference site at Svarthameren.

The samples should be collected from 25 to 150 mm thick deposits, if possible from the parts without polygonal cracks at the surface. The typical size of the sample may be 50 x 100 x 150 mm, and larger samples are preferred.

The block of solidified avian oil is removed from the deposited layer using a chisel and knife, so that a total cross-section between the surface and the bottom is preserved.

C) BIRD CENSUS

Jutulessen will be completely surveyed to localize all bird colonies. Colonies will be mapped and the number of breeding pairs of the different species counted.

D) BOTANY

10 samples of plants will be collected as follows:

Five samples of lichens will be collected in 0.5 litre bottles, from a location close to the station, both at the beginning and at the end of the expedition.

Two additional collections will be done of the green alga Prasiola crispa from two localities:

a) One site a few hundred metres from the station, in the direction of prevailing wind.
b) A second reference site a few kilometres upwind from the station.

- o -

All sampling sites will be documented on maps/photos and protected against mechanical damage.

Collecting firn, ice and botanical samples is done using polyethylene gloves, "clean suit" and mask, and moving and staying downwind of sample site. Collection of solidified avian oil samples require only use of gloves.

Tools such as chisel, tube etc. are precleaned and sealed in plastic bags, and are not used for other purposes. Gloves are discarded after collecting each sample.

All samples (snow, ice, plants, avian oil) will be sealed in additional pre-cleaned polyethylene bags and brought frozen to the Institute of Chemistry, University of Oslo.

ANNEX II

GRJOTLIA, JUTULSESSEN: Note on vegetation and floristic content compared with other stations in Mühlig-Hofmannfjella and Gjelsvikfjella, Dronning Maud Land.

The flora of the proposed Norwegian base area was sampled by Engelskjøn during excursions 21 and 22 January 1985. The overall vegetational development and floristic content is scant when compared to other parts of Jutulsessen. This may be due to the prevailing unstable, cryoturbated or wind-eroded ground. Only part of the NW slope of the northern outlier of Grjotlia supports patches of richer algal vegetation. The adjacent SW cirque of Jutulsessen is richer as to areal extent of vegetation, but even here, mosses, foliose lichens and fructiose lichens are absent. Further collection of vegetation samples should especially be attempted in the southernmost cirque of Grjotlia, to the south of hill 1390 m a.s.l., where open water was observed from the distance.

In total, Mülig-Hofmannfjella and Gjelsvikfjella support two moss species (Grimmia lawiana and Sarconeurum glaciale), two species of fruticose lichens (Pseudephebe minuscula and Usnea sphacelata), three species of foliose lichens (Physcia caesia, Umbilicaria aprina and Umbilicaria decussata), none of which have been recorded from the Grjotlia area so far. Accordingly, there is only a very sparse plant material available for e.g. toxicological monitoring around the station area. Crustose lichens are scattered, but their biomass is small.

However, impact on the terrestrial, foliose green algae Prasiola, could be observed around the station area.

PRELIMINARY SPECIES LIST:

Grjotlia, northernmost outliers:

Acarospora sp. *Buellia* sp. *Candelariella hallettensis* *Lecanora expectans*	---(LICHENS)
Prasiola cf. *crispa* (scattered) "*Pleurococcus*" sp. *Ulothrix* sp.	---(GREEN ALGAE)
CYANOBACTERIA	---(BLUE GREEN ALGAE)

SW cirque of Jutulsessen to E of Grjotlia:

Acarospora sp. *Buellia frigida* *Candelariella hallettensis* *Lecanora* spp. *Xanthoria elegans*	---(LICHENS)
Prasiola cf. *crispa* (abundant)	---(GREEN ALGAE)
Oscillatoria *Phormidium*	---(BLUE GREEN ALGAE)
BACILLARIOPHYTA	---(DIATOMS)

INVERTEBRATE FAUNA

List of fauna observed in Gjelsvikfjella. Samples were taken from the SW and SE vallys of Sætet (altitude 1350m and 1150m respectively), from the eastern part of the mountainside below Brugda (1480m) and Stabben (1450m). Numbers of individuals and species compare with those from MÜhlig-Hofmannfjella, with the exception of one locality, Svarthammaren. This location has a much richer fauna, but this must be seen in light of the large (200 000 pairs) breeding colony of Antarctic petrels located nearby.

Protozoa
Rotifera
Nematoda
Tardigrada

--- known to be present,
but as of now undetermined.

Mites:

- prostigmatid: Eupodes angardi (Strandtmann & Sømme 1977)
  Tydeus erebus (Strandtmann 1967)
- cryptostigmatid: Maudheimia wilsoni (Dalenius 1958)
- oribatid: present, but undertermined

Insecta:

- collembola: Cryptopygus sverdrupi (Lawrence 1978)