NGU-RAPPORT 88.153

M I D - N O R D E N P R O J E C T

PROPOSAL FOR PARTICIPATION BY NGU

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RAPPORT

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Tittel:

MID-NORDEN PROJECT: PROPOSAL FOR PARTICIPATION BY NGU

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Oppdragsgiver: NGU / NORDISK RÅD

Fylke: Nordland, Nord-Trøndelag, Sør-Trøndelag, Møre og Romsdal

Kommune:

Kartbladnavn (M. 1:250 000) Vega, Mosjøen, Namsos, Grong, Kristiansund, Trondheim, Østersund, Ulstein, Ålesund, Røros, Sveg

Kartbladnr. og -navn (M. 1:50 000)

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Sammendrag:

The project aims to produce a modern geoscientific atlas and databank to be used in prospecting for mineral resources and in the evaluation of environmental and geochemical issues within a belt extending from W of Norway to the E border of Finland. The N and S limits of the project area meet the coast at Syv Søstrene and Stad respectively.

The proposal includes nine subprojects: 1) Data, 2) Bedrock geology, 3) Quaternary geology, 4) Marine geology, 5) Geophysics, 6) Geochemistry, 7) Metallogeny, 8) Industrial Minerals and 9) Environmental geology.

Total costs are estimated to be of the order of NOK 53.000.000.

The proposal assumes a time-frame of 1988-1993 but the dependence of subprojects 7) and 9) on the conclusions of the other subprojects several of which are also interdependent would make extension to 1994 or 1995 desirable. The proposal will be made available in both English and Norwegian.

Emneord		
GEOFYSIKK	GEOKJEMI	MARIN GEOLOGI
MALM	MINERALER	MILJØGEOLOGI
BERGGRUNNSGEOLOGI	LØSMASSEGEOLOGI	

CONTENTS

1. INTRODUCTION

The general aims for the Mid-Norden project were formulated in a proposal submitted to the Nordic Council of Ministers by the directors of the geological surveys of Denmark, Finland, Greenland, Norway and Sweden in September, 1986 (Appendix 1). An allocation of NOK 500.000 for 1987 was made by the Council on February 9th, 1987.

The project has as its main aim the production of modern geoscientific data to be used as a better starting point for prospecting for ores and industrial minerals and to enable the evaluation of various aspects of environmental geology and geomedicine within a belt extending from off the W coast of Norway to the E border of Finland and from tangents to 66°N and 62°45'N on longitude 18°E in Sweden (Fig. 1). The project area has western limits of 65°15' in the north to 62°10' in the south (Fig. 1). Its limits meet the coast at Syv Søstrene in the north (S limit of Nordkalott area) and at Stad in the southwest.

The proposal has been compiled by R. Boyd, national coordinator for NGU's participation on the basis of contributions from the national subproject leaders. (The contribution on geophysics was written by O.Olesen, who has been succeeded by J.R. Skilbrei). The administrative structure of the project and the manning of the roles it involves are shown in Fig. 2. The proposal is being issued in English, the language used internationally in the project. It will be available in Norwegian when it reaches its final form early in 1989.

NGU has one major integrated geological program in progress within the Mid-Norden area, in the county of N-Trøndelag and in the part of S-Trøndelag N of Trondheimsfjord, an area corresponding to c. 40 % of the land part of the Mid-Norden transect in Norway. Most of the effort being put into regional mapping within this program can be regarded as a direct contribution to the Mid-Norden project.

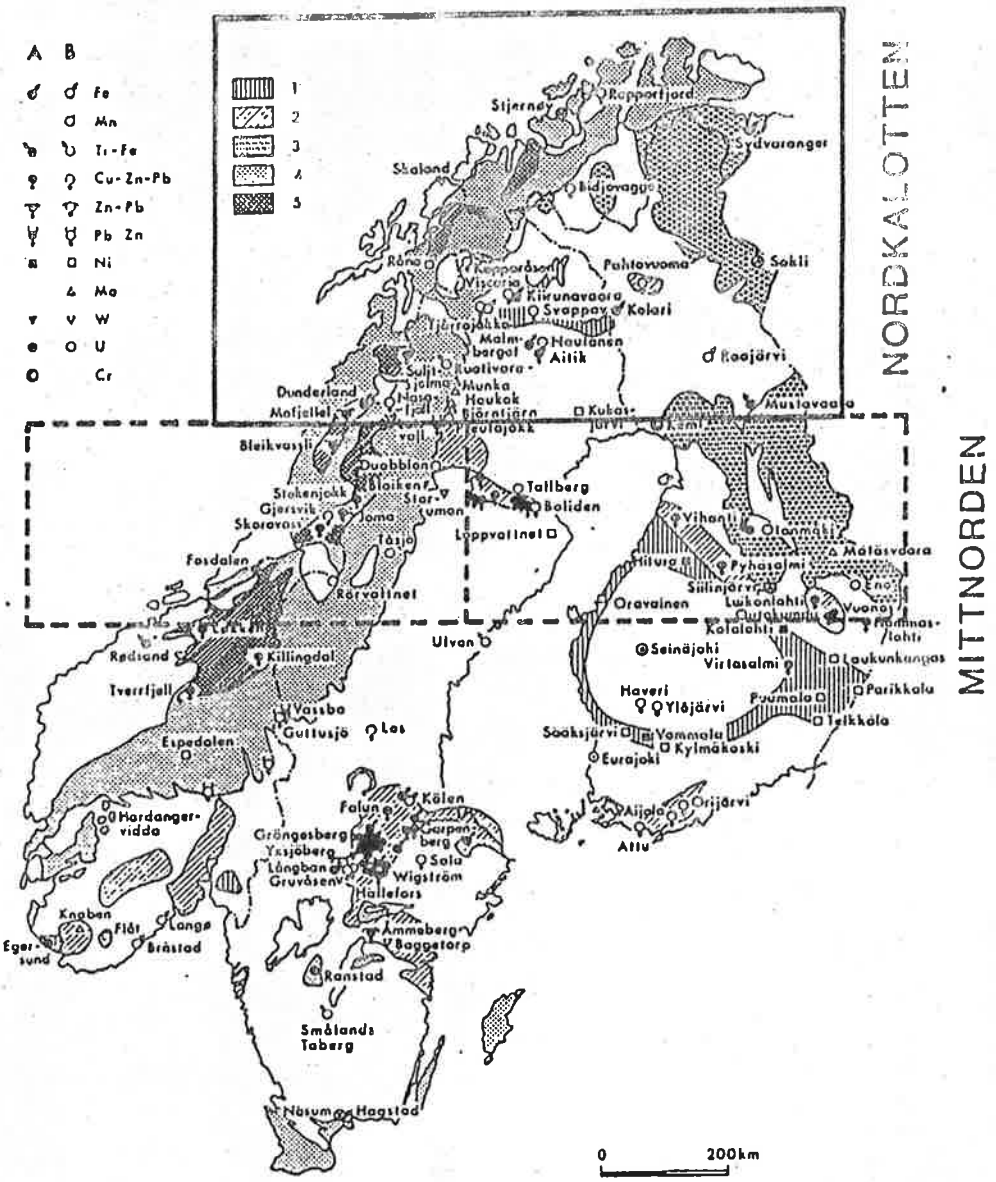

Fig. 1: Extent of Mid-Norden project area.

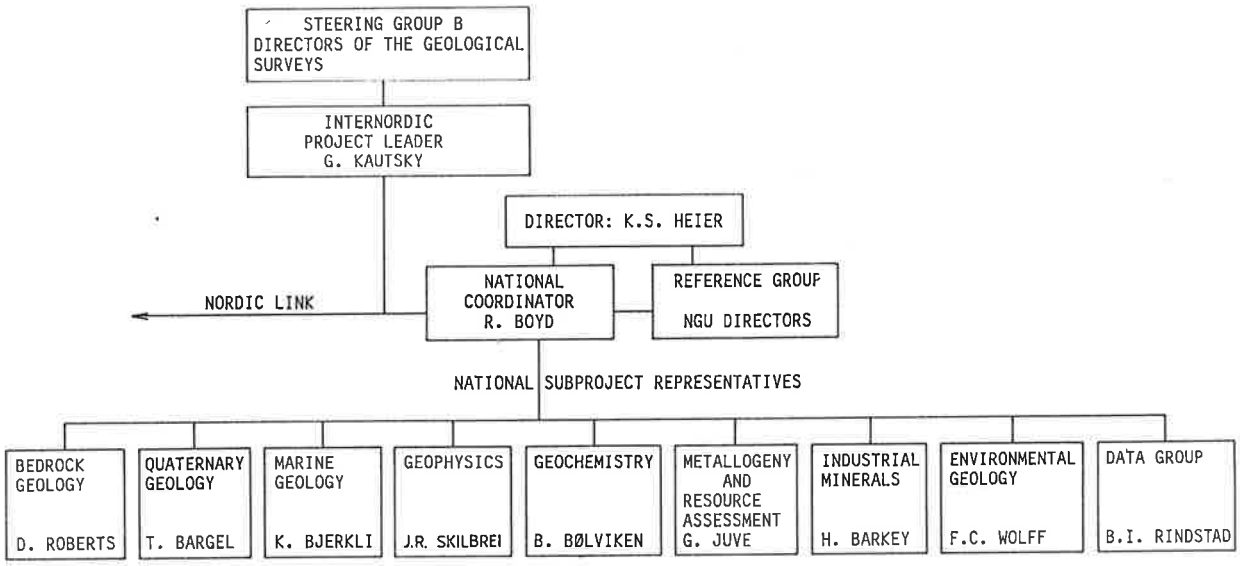

Fig. 2: Administrative structure of the Norwegian part of the Mid-Norden project.

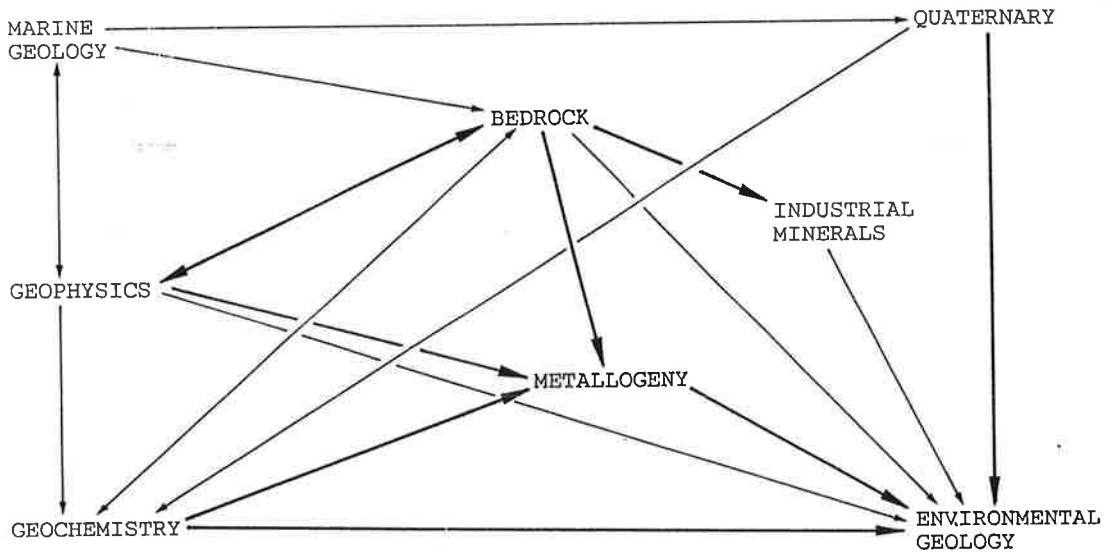

Fig. 3: Mid-Norden Project: Interdependence of and data flow between the subprojects. (All have ties to the data subproject).

Other projects which are recently completed / in progress which involve major contributions to the Mid-Norden project are the regional bedrock and Quaternary mapping programs and the geochemical mapping of Nordland county.

Participation in the Mid-Norden project offers a number of exciting challenges:

- integration and interpretation of a wide variety of data types across national boundaries
- integration of onshore and offshore data
- assessment of the potential for resources which will be in demand into the next century
- evaluation of environmental issues which will influence the quality of life of the inhabitants of this part of Norden.

The interdependence of the subprojects (Fig. 3) and in particular the dependence of the Environmental Geology and Metallogeny subprojects on conclusions from the other subprojects makes an extension of the original time frame, 1988-93 to 1994 or 1995 desirable if not imperative.

2. SUBPROJECT: DATA

PERSONNEL

Bjørn Ivar Rindstad: subproject leader
Ronald Nystad, Morten Reitan, Geir Strand

OBJECTIVES

- Coordination of ADP in the Norwegian subprojects and on a Nordic basis
- The use of standard tools.
- Storage of a maximum amount of data in databases.
- Dissemination of information on data sources via NGUs Information system.
- Production of maps by digital methods.

PRODUCTS

- Digital base map at 1:1.000.000 in the correct projection.
- X-Y database for all Norwegian Mid-Norden data (equivalent to the Finnish index-database).
- Databases for some of the other subprojects.
- An information system for data from the project.

METHODS

- The x-y-database should be implemented using the ORACLE database management system.
- Graphic work stations and CAD systems should be used for map production from databases which do not have production systems already.

TASKS

The project is dependent on development of the x-y-database which must therefor be given priority in 1989.

- Implementation of the xy-database (specifications are complete).
- Entry of data into the xy-database (each subproject responsible for its own data).

- Adaption of existing databases, possibly conversion of them to the ORACLE system.
- Development of new databases using ORACLE.
- Couple all databases to NGUs Information system in accordance with an agreed plan.
- Establish a digital base map.
- Establish digital map production.

RESOURCES

Implementation of the xy-database will be done by NGU-personnel (and by a consultant. Implementation of new subject databases and modification of existing ones will be done by the ADP section. New disc capacity will be required from 1989: funds must be allocated for this. Digital map production will require a graphic work station.

The project will require disc capacity; funding for a new disc should be allocated in 1989. Graphic work stations and map production systems should be assessed, purchased and put into use. A high resolution colour plotter will be required in connection with digital map production.

Months	1988	1989	1990	1991	1992	1993	SUM
Planning	0.5	0.5					1
Implementation of xy-database		10					10
Entry of data into xy-database		0.5	1	1	1	0.5	4
Development of subject databases		0.5	1	1	1		3.5
Production system, thematic maps		0.5	2				2.5
Reporting		0.5	0.5	0.5	0.5	0.5	2.5
Total	0.5	12.5	4.5	2.5	2.5	1	23.5

Costs (in 1000 kr)	1988	1989	1990	1991	1992	1993	SUM
Salaries	20	500	180	100	100	40	940
Consultant		220					220
Production system, thematic maps		200	200				400
Disc		80					80
Colour plotter			600				600
Travel	10	30	30	30	30	30	160
Total	30	1030	1010	130	130	70	2400

Table 1: Resource estimate for data subproject.

3. SUBPROJECT: BEDROCK GEOLOGY

PERSONNEL

David Roberts: subproject leader
Rognvald Boyd, Magne Gustavson, Ole Lutro, August Nissen, Øystein Nordgulen, Ellen M.O. Sigmond, Arne Solli, Brian Sturt, Terje Thorsnes, Einar Tveten, Fredrik Wolff

OBJECTIVES

(1) To produce
- a lithostratigraphic map
- a structural-metamorphic map

These maps will form part of the basis data for the subprojects on metallogeny and industrial minerals.

(2) To investigate more fully proposed correlations between Proterozoic rocks occurring in Norway, Sweden and Finland; in Norway, such rocks are largely allochthonous as a result of extensive, Caledonian thrust deformation.

(3) To aim at establishing improved correlations within the Caledonian fold belt between the various rock successions in the allochthonous complexes extending from Norway into Sweden.

DATA BASE AND METHODS

Published bedrock geological maps pertinent to the above objectives exist at 1:1 million, 1:250,000, 1:100,000 and 1:50,000 scales. An overview of the map coverage is shown in Fig. 4 (excluding 1:100,000 scale). These include colour-printed maps and maps at 1:250,000 and 1:50,000 scale in black & white 'preliminary' map-series. Several of the 'preliminary' map-sheets are currently being assessed and revised for colour production.

NGU has had a major programme of 1:50,000 scale mapping in Trøndelag since 1985, aiming at complete coverage of N-Trøndelag and the part of S-Trøndelag

N of Trondheimsfjord. Work is also in progress on compiling the 1:250,000 sheets, Grong and Namsos, both of which will be available in 'preliminary' form in 1988/89. The only 1:250 000 sheet within the project area which will not be available in black-white or colour by the end of 1989 is the Ålesund sheet.

Very few of the colour-printed maps have published descriptions. Those available are indicated in Fig. 4.

Other maps which will be of value include: -

- published two-tone aeromagnetic maps at 1:250,000 scale.
- Applicon-printed colour maps of magnetics and gravity at 1:250,000 scales. Limited availability.
- a tectonostratigraphic map of the Scandinavian Caledonides, 1:2 million scale (IGCP project 27 - The Caledonide Orogen, 1985).

Needless to say the subproject will also derive considerable benefit from experience gained in the Nordkalott Project.

Fieldwork i.e. bedrock mapping at 1:50,000 scale, will be needed in many areas but particularly in the Proterozoic gneisses of the 1:250,000 'Ålesund' sheet. Follow-up work on map-sheets hitherto produced as 'preliminary' editions will also be necessary and not least excursions in order to establish regional correlations.

Chemical analyses of rocks, as an aid towards classification, map interpretation and correlation, will represent an important part of the work. These should also include certain metasediments, including metalliferous black shales and phyllites, as well as plutonic and volcanic rocks. For the period 1989-1992, a rough estimate would call for 1000 whole-rock and c. 150 REE analyses.

Isotopic age determinations will form a significant part of the overall work - essential to legend preparation and map interpretation, and ultimately for correlation. Several methods may be employed, depending on the lithologies and the problem on hand, but the U-Pb method is likely to be particularly important. It would be very valuable if some of the

geochronological work needed could be done within the framework of the Mid-Norden collaboration.

TASKS

It would seem natural that persons already responsible for the bedrock geology on the 1:250,000 maps-sheets should continue up-dating these map-areas. These are:

- Vega: M. Gustavson
- Mosjøen: M. Gustavson
- Namsos: A. Solli
- Grong: D. Roberts
- Kristiansund: E.M.O. Sigmond
- Trondheim: F.C. Wolff/D. Roberts
- Østersund: F.C. Wolff/D. Roberts
- Ulstein: O. Lutro/E. Tveten
- Ålesund: O. Lutro/E. Tveten
- Røros: F.C. Wolff
- Sveg: F.C. Wolff

Descisions regarding compilers for the lithostratigraphic and structural-metamorphic maps will be taken later. With so much variation in the geology, a 3-man 'team' per map (one of whom would act as coordinator) would seem a reasonable solution.

SCHEDULE AND RESOURCE REQUIREMENTS

1988 -	Planning stage, including planning of 1989 excursion.
1989 -	Fieldwork, sample collection, initiation of analytical work, initial stage of map compliation. Field excursion in early September, Trøndelag (Lierne, Sanddøla, Grong, Høylandet, Leka).
1990 -	Continuation of fieldwork, analytical work and compilation, initial stage of inter-Nordic compilations, and map digitalisation.
1991 - 92	Advanced stages of compilation and correlations, and map digitalisation. Maps provided for subprojects on metallogeny and industrial minerals.
1993 -	Final stage, compilation of final reports, etc.

Months	1988	1989	1990	1991	1992	1993	SUM
Planning	3	3	1	2	2		9
Mapping		22	22	15	5		64
Map compilation		36	36	36	18	6	132
Map production		12	12	12	18	6	60
Correlation		2	2	4	4	2	14
ADP		-	-	1	2	-	3
Reporting		2	2	2	4	12	14
Sum	3	77	75	72	53	26	306

Costs (in 1000 kr)	1988	1989	1990	1991	1992	1993	SUM
Salaries	110	2890	2810	2700	1990	980	11480
Field work	20	650	650	400	130	-	1850
Travel	70	20	60	60	50	50	300
Analyses	-	100	100	100	100	-	400
Map production	-	-	-	-	-	150	150
Sum	200	3660	3620	3260	2270	1180	14190

Table 2: Resource estimate for the bedrock subproject.

4. SUBPROJECT: QUATERNARY GEOLOGY

PERSONNEL

Terje H. Bargel: subproject leader
Arne J. Reite
Harald Sveian

OBJECTIVES

To produce and present data on the Quaternary deposits for use in:
- regional/local planning
- planned exploitation of resources
- regional geological studies.

PRODUCTS

It would be logical to adopt the same range of products as the Nordkalott Project, as far as is feasible. We propose four maps (1:1,000,000) in the following order of priority:

1) Quaternary geology
2) Glacial geomorphology and palaeohydrography
3) Ice flow directions and indicators
4) Quaternary stratigraphy.

A map of potential raw materials in the superficial deposits (sand and gravel) as suggested in the Finnish proposal, can be included as a fifth map. It is felt though that this topic should be part of the Environmental Geology subproject.

METHODS AND EXISTING MATERIAL

1) Quaternary geology, 1:1,000,000
   The following are available:

- A Quaternary geological map, 1:1,000,000 (National Atlas map of superficial deposits) was completed in 1988. A limited effort would suffice to adapt this map to the appropriate standard.
- Quaternary geological maps, 1:250,000
  - Sør-Trøndelag (will be printed in 1988/89).
  - Nord-Trøndelag (will be compiled within the lifetime of the Mid-Norden Project).
- Quaternary geological map, Røros, 1:100,000 (1956). This map is based on a different philosophy from that in use at present.
- Quaternary geological maps, 1:50,000.
  29 maps have been compiled (Fig. 5). The area will continue to have a high priority in the 1:50,000 mapping program.
- Quaternary geological maps, 1:20,000. 19 sheets have been mapped in whole or in part, on this scale (Fig. 5).

2) Glacial geomorphology and palaeohydrography. Data exist in the form of unpublished interpretations for much of the area (both 1:50,000 and 1:250,000). Aerial photograph interpretations of some areas should be checked.

3) Ice flow directions and indicators. Scour-mark observations are available in the areas which have been mapped at 1:50,000 and 1:20,000 (Fig. 5) and more sporadically elsewhere.

4) Quaternary stratigraphy.
   Information on the Quaternary stratigraphy of this area is very limited. Some data is available from areas mapped at 1:50,000 and 1:20,000 (Fig. 5). Much trenching will be needed to obtain good coverage along the border with Sweden, especially around Lierne.

TASKS, SCHEDULE AND RESOURCE REQUIREMENTS

- Compilation of existing data for production of maps 1, 2 and 3. This would be most rational if done in parallel by the same person or group.
- Trenching for stratigraphical studies.

Coordination between the Finnish, Swedish and Norwegian groups is a Orerequisite: we approve, provisionally, of the schedule proposed by GTK.

Months	1988	1989	1990	1991	1992	1993	TOTAL
Planning	0,5	2					2
Quat. geol. map		27	25	30			82
Glacial geomorphology		2	1				3
Ice flow		2	2	2	2	2	10
Quat. stratigraphy		12	12	12	12	12	60
Map production						12	12
Total	0,5	45	40	44	14	26	169

Costs (in 1000 kr)	1988	1989	1990	1991	1992	1993	TOTAL
Salary, etc.	20	1750	1560	1725	525	975	6555
Fieldwork		350	350	450	100		1250
Travel	20	50	50	50	50	50	250
Map production					100	100	200
Total	40	2150	1960	2225	775	1125	8275

Table 3: Resource estimate for Quaternary subproject.

5. SUBPROJECT: MARINE GEOLOGY

PERSONNEL

Kristian Bjerkli: subproject leader
Reidulf Bøe, Ellen M.O. Sigmond, Jan Reidar Skilbrei

OBJECTIVES

Compilation and interpretation of all available bedrock geological and geophysical data from the part of the Norwegian continental shelf within the Mid-Norden area and integration of this with the maps of onshore areas.
As far as possible, completion of the same operation for Quaternary deposits.

PRODUCTS

- 1:1,000,000 map of bedrock geology, covering onshore and offshore areas with profiles.

- 1:1,000,000 map of Quaternary geology, onshore and offshore.

DATA BASE

NGU is in the process of compiling a 1:3,000,000 map of the bedrock geology of mainland Norway, Svalbard and the continental shelf on the basis of published data and unpublished information made available by the Norwegian Polar Institute, The Petroleum Directorate, the Institute for Continental Shelf Studies, the Seismological Observatory, the University of Oslo, the University of Tromsø, Statoil and Norsk Hydro.

Maps, both bedrock and Quaternary, covering parts of the shelf at a scale of 1:500,000 have been published by the Institute for Continental Shelf Studies (IKU) (Fig. 6). NGU has made detailed studies of the Quaternary and near-surface geology in several off-shore and inshore areas (Fig. 6). Numerous scientific publications and reports on aspects of the geology of the area are also available.

NGU has recently been given responsibility for mapping the uppermost layers of the continental shelf (down to the base of the Pliocene) under the leadership of a steering group on which NGU and other institutions are represented. Until this group has completed planning for this task it is not possible to say what resources will be committed to new work off the coast of Central Norway in the period to 1993.

Months	1988	1989	1990	1991	1992	1993	SUM
Planning	0,5	0,5	0,5				1,5
Map compilation		3	3	3	3		12
Map production					3	3	6
Reporting					3	3	6
	0,5	3,5	3,5	3	9	6	25,5

Costs (in 1000 kr)	1988	1989	1990	1991	1992	1993	SUM
Salaries	20	140	140	120	360	240	1020
Travel	5	10	10	10	10	10	45
Sum	25	150	150	130	370	250	1065

Table 4: Resource estimate for Marine Geology subproject.

6. SUBPROJECT: GEOPHYSICS

PERSONNEL

Jan Reidar Skilbrei: subproject leader
Jomar Gellein, Ola Kihle, Odleiv Olesen, Trond Torsvik

OBJECTIVES/PRODUCTS

- Aeromagnetic and gravimetric maps (1:1,000,000) for both on- and offshore areas in the Norwegian part of the Mid-Norden area.
- Smaller scale plates (e.g. 1:4,000,000) showing derived and thematic maps, e.g. gravity residual map, relief map, petrophysical maps, map of magnetic fabric and palaeomagnetic and petrophysical diagrams.
- Interpretative map with profiles (1:1,000,000). The interpretation will include results from helicopter measurements, palaeomagnetic studies and from deep seismic profiles on land (Stjørdal-Storlien) and offshore (Mobil Search, Haakon Mosby).

EXISTING MATERIAL

- Digital aeromagnetic data on a 500 x 500 m. grid. The original flight lines and altitudes are shown in Fig. 7.
- Gravity measurements from 5400 points, registered in a database. The point density is uneven (se Fig. 8). Data from Statens Kartverk have a point separation of 10 km, and cover the whole onshore area. Further measurements have been made by NGU in Trøndelag, giving point separations down to 1 km. in certain areas. Measurements in offshore areas have resulted from collaboration between Statens Kartverk, Norges Teknisk-Vitenskapelige Forskningsråd and the U.S. Defence Mapping Agency. Data from offshore areas in the southern part of the Midt-Norden area will be entered into the database as soon as they are available from Statens Kartverk.
- Values for density, susceptibility and Q-value for 1200 samples, mainly from Trøndelag, in NGUs database (Fig. 9).
- 1000 measurements of remanence and magnetic fabric are stored on a PC. These come mainly from the Møre-Trøndelag Fault Zone.
- Helicopter measurements (Fig. 10) including EM-slingram, EM-VLF, magnetic and radiometric measurements.

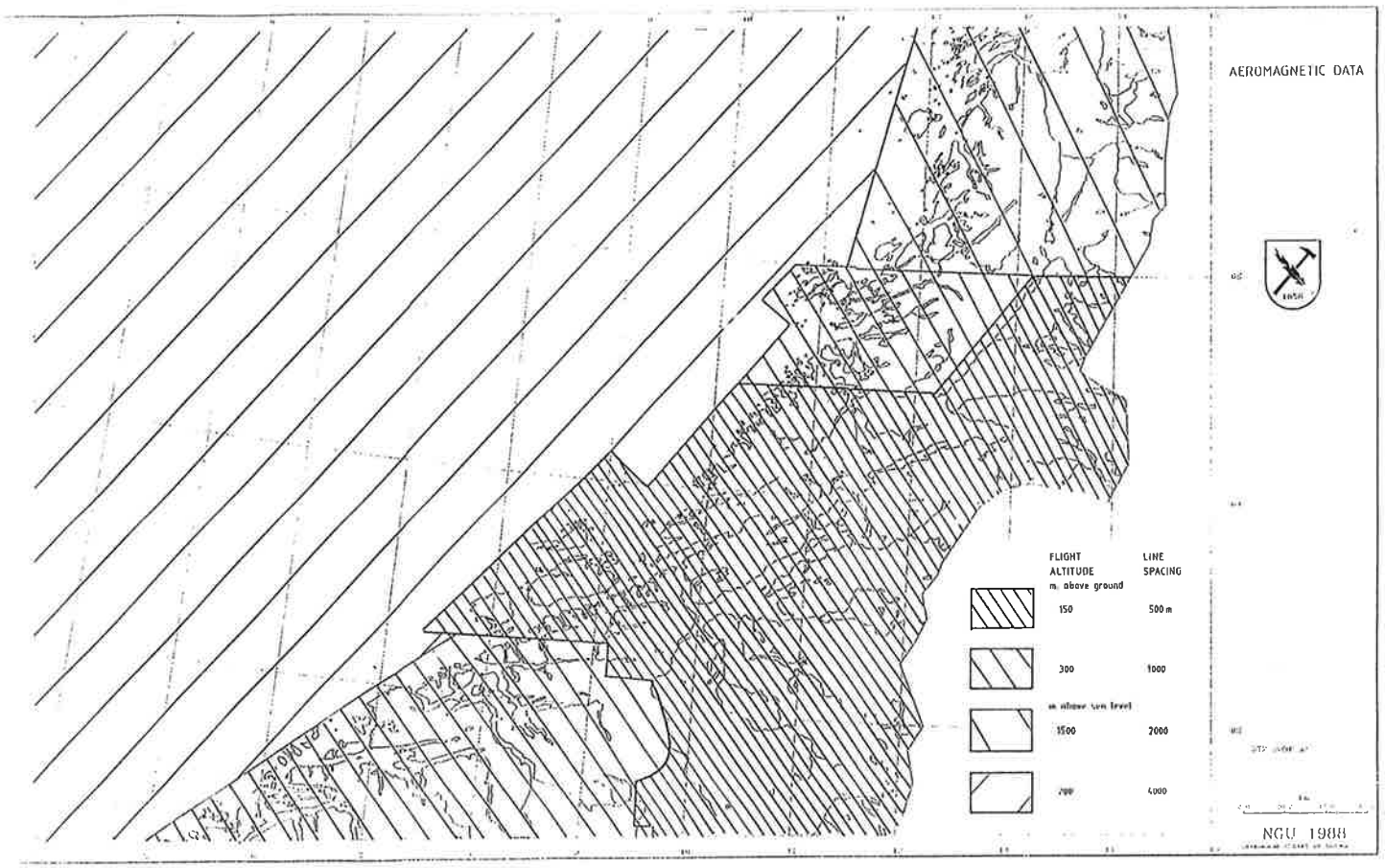

Fig. 7: Coverage of aeromagnetic data.

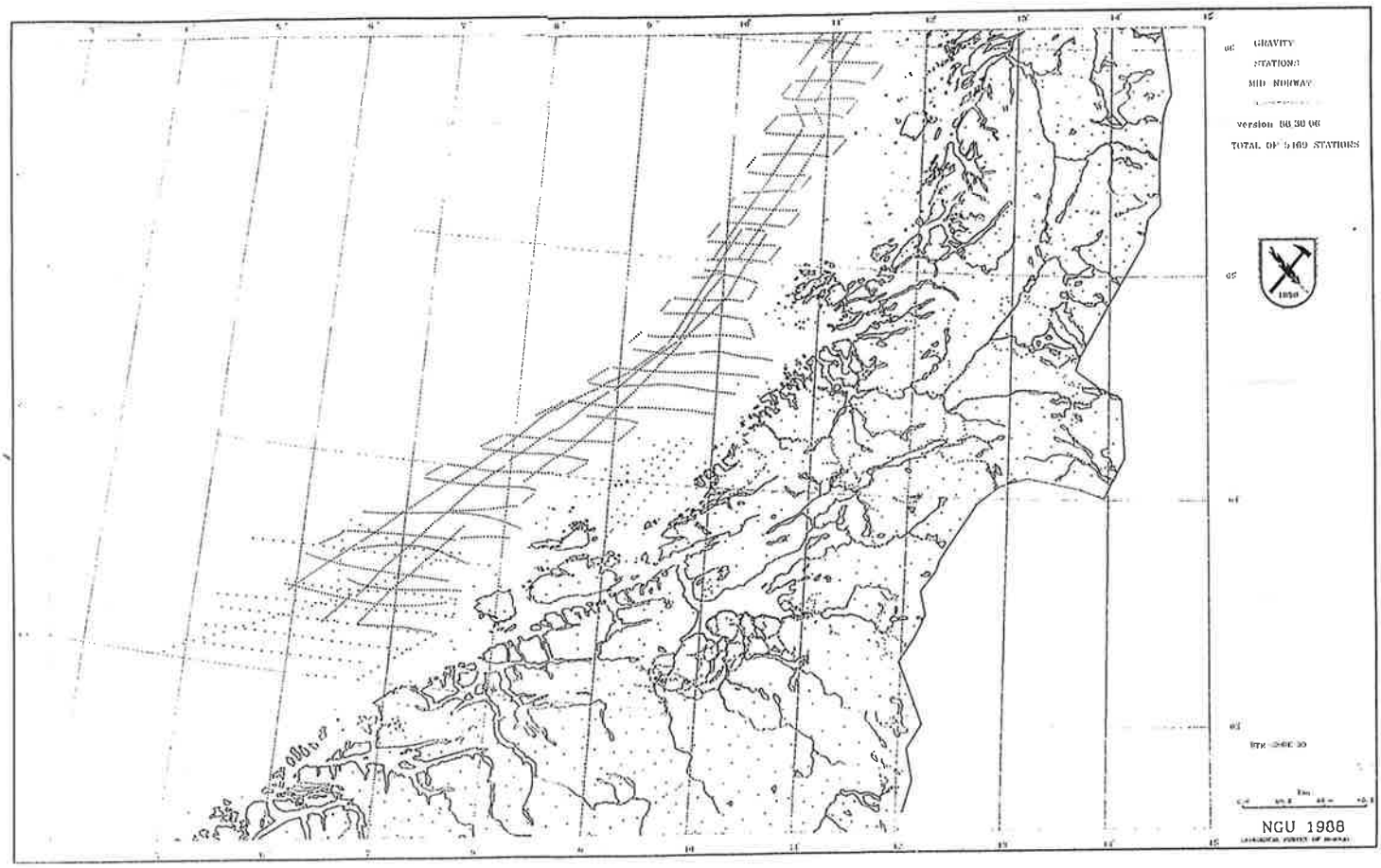

Fig. 8: Location of gravity stations.

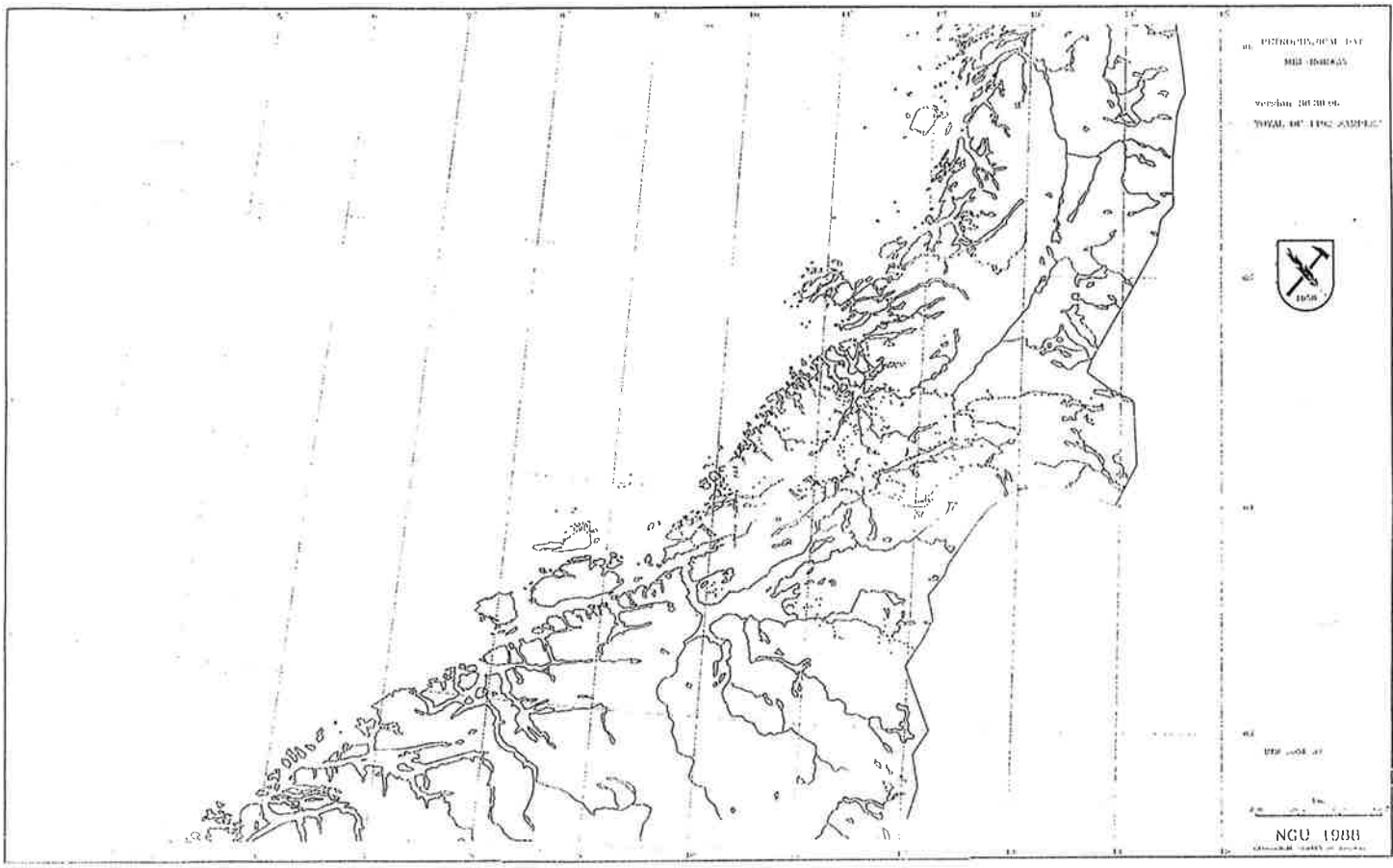

Fig. 9: Location of points sampled for petrophysical studies.

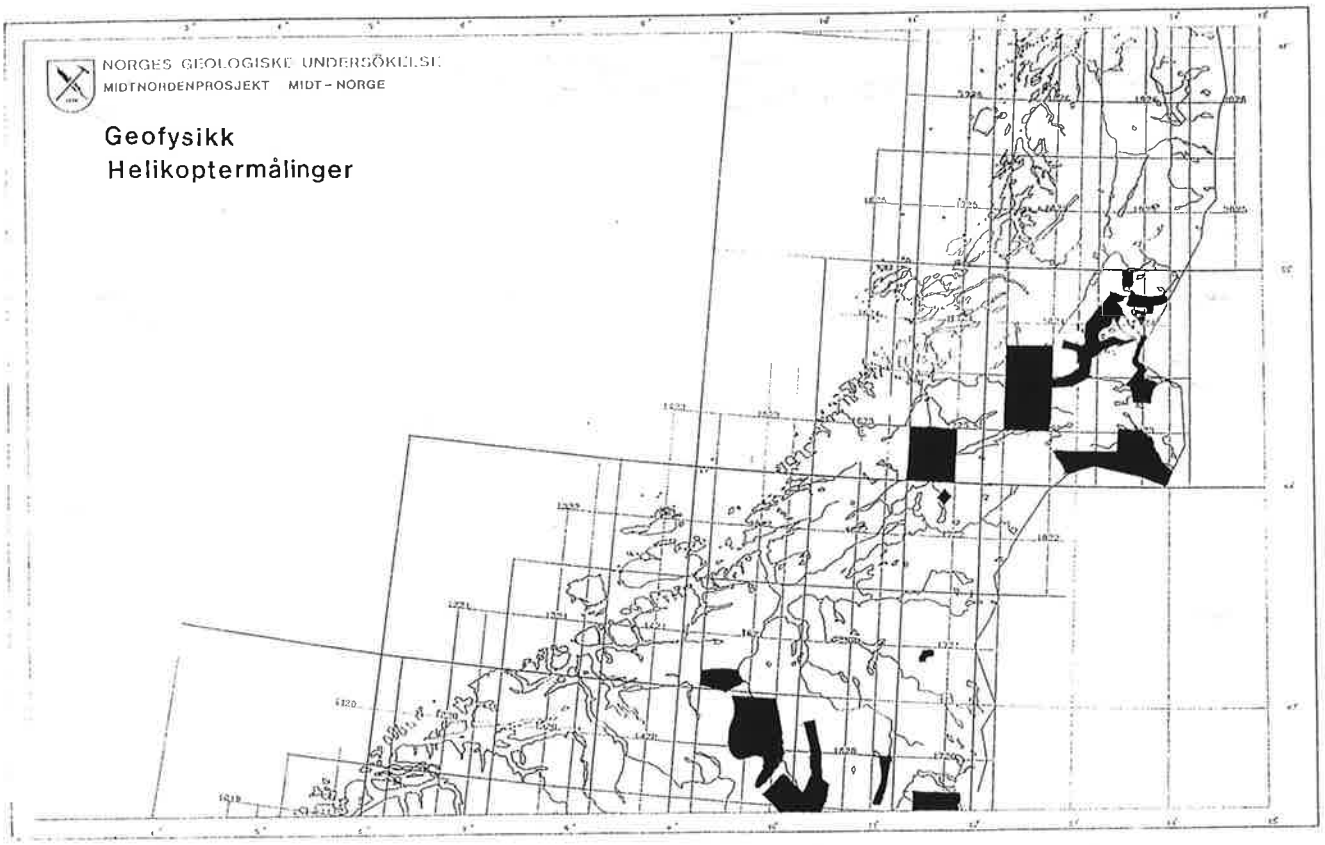

Fig. 10: Coverage of helicopterborne measurements (EM-slingram, EM-VLF, magnetic and radiometric data).

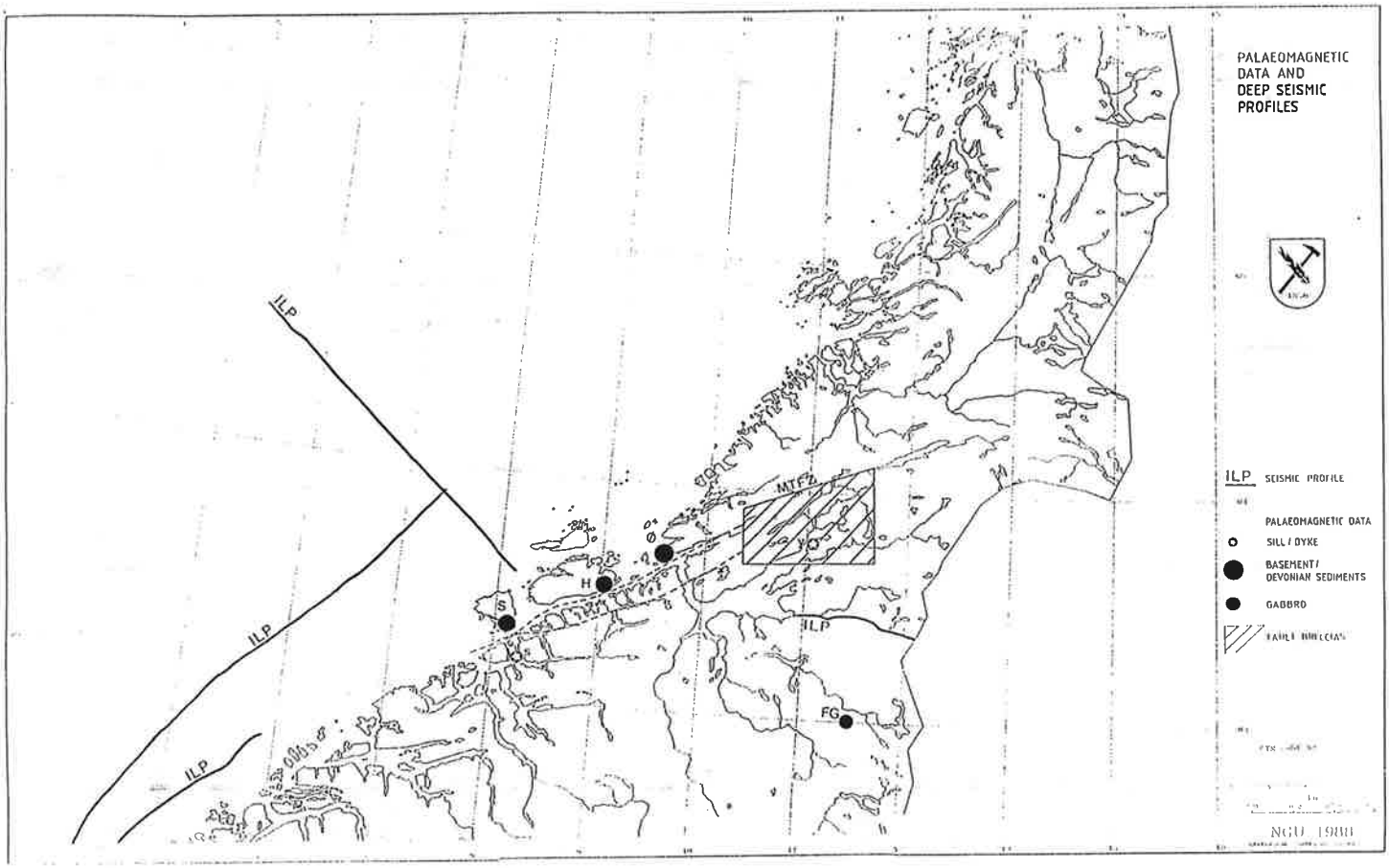

Fig. 11: Location of seismic lines and pålaeomagnetic studies.

- Three deep seismic profiles (Mobil Search) have been shot off the coast of Midt-Norge as part of an ILP project (Fig. 11). A deep seismic study of the Storlien (Sweden) - Stjørdal (Trondheimsfjord) profile has been initiated (Fig. 11). This profile should be completed in 1989. All the profiles include seismic reflection data.

TASKS

- Collection of rock samples and measurement of petrophysical properties, including magnetic fabric and palaeomagnetic properties.
- Further gravity measurements and interpretation of the resulting data.
- Carry out further helicopterborne measurements (1 1:50 000 scale map-sheet per year).
- Supplement the petrophysics and gravity databases.
- Issue provisional maps annually until the final maps are printed.
- Compile tables and diagrams of petrophysical, magnetic 'fabric' and palaeomagnetic data.
- Produce derived maps (e.g. relief maps, gravity residual maps) as an aid to interpretation of aeromagnetic and gravimetric data. Eventually one should evaluate publication of these at a small scale (e.g. 1:4,000,000) in a plate along with other thematic maps, e.g. of petrophysical and palaeomagnetic data.
- Interpretation of gravity and aeromagnetic data (incl. helicopter geophysics) using the same methods as in the Nord-Trøndelag Program. Interpretation of palaeomagnetic and deep seismic data must be included in interpretation of the geology at depth. Magnetic fabric maps are a very important aid to mapping the structural geology, while palaeomagnetic data are used for age determination and in tectonic modelling.

Months	1988	1989	1990	1991	1992	1993	SUM
Transformation of data to new coordinates	1	2					3
Sampling (petrophysics)		5	5	4			14
Gravity fieldwork		4	4	2			10
Aerogeophysics		12	12	12	12	4	52
Interpretation		3	5	6	3		17
Map production		2	2	2	4		10
Reporting/publication				1	3	2	6
Sum	1	28	28	27	22	6	112

Costs (in 1000 kr)	1988	1989	1990	1991	1992	1993	SUM
Salaries	40	1050	1050	1010	820	230	4200
Fieldwork	-	350	350	250	60	-	1010
Helicopter	-	400	400	400	400	-	1600
Travel	20	50	50	50	50	50	270
ADP	-	50	50	50	50	50	250
Map production	-	-	-	-	100	100	200
Sum	60	1900	1900	1760	1480	430	7530

Table 5: Resource estimate for the Geophysics subproject.

7. SUBPROJECT: GEOCHEMISTRY

PERSONELL

Per Ryghaug: subproject leader
Tor Erik Finne

OBJECTIVES

- To provide maps and data on the natural distribution of elements and the results of anthropogenic pollution of natural waters and overburden.

- To map the susceptibility to acidification of natural waters and overburden,

- To provide basic geochemical data for establishing alert, warning and emergency criteria for action against past and present pollution of waters and soils,

- To provide background geochemical data for the planning of an appropriate number and locations for pollution monitoring stations,

- To produce geochemical maps of the contents of harmful as well as essential elements in waters and soils in order to provide basic background data in silvicultural and agricultural planning,

- To provide general geochemical data for use in general planning, for example contribute to the knowledge of which areas are suitable/not suitable for drinking water supplies or waste disposal,

- To provide (province-, country-, municipality-wide) geochemical data for human and animal epidemiological research within the field of environmental geochemistry and health (geomedicine),

- To contribute to the studies of global changes due to human activities in the environment,

- To discover geochemical distribution patterns that may be important in mineral exploration,

- To discover provinces and structures that point to the need for new approaches in the interpretation of regional geology,

- To provide data that will throw light upon such geochemical problems as:
  - the interpretation of geochemical anomalies and provinces,
  - the establishment of geochemical standards,
  - the effect of weathering on the geochemistry of soils,
  - the importance of airborne transportation from marine, volcanic and other sources in natural geological processes.

PRODUCTS

- an atlas including maps of raw data, thematic and interpretation maps, such as natural and anthropogenic distribution patterns of elements, degree of pollution, susceptibility of soil to acidification, lime requirements of soil, release of Al and other elements from soil due to acid rain, maps from other subprojects as an aid to interpretation and a short text.

- a bank for storage and retrieval of digital data for map presentations, statistical treatment and interactive interpretation with other data,

- progress reports, final reports and scientific publications.

The geochemical maps should show point symbols (one colour + black/white) and running medians (colour). More than one scale should be used. The most important being 1:5 mill. which allows the whole Mid-Norden area to be shown on the A3 size format.

EXISTING MATERIAL

The whole area is covered with low density sampling (1 sample per 500 km^2) (Fig. 12). Stream sediments have been sampled at different sampling densities within 70% of the area (Fig. 12). Till samples (1 sample per 50 km^2) have been collected from 60% of area. Stream water, stream moss and stream organic matter have been sampled at a density of 1 sample per 30 km^2 in 15% of the area, and humus samples have been collected at a

sampling density varying between 1 per 30 km^2 to 1 per 10 km^2 in 35% of the area (Fig. 14). However, very little sample material is left for further analysis from these projects.

METHODS

It would be desirable to collect the same sample types in the Mid-Norden project as in the Nordkalott project in order to obtain compatible geochemical data for the whole area north of 63°. However, this does not seem to be possible, because of the different types of national geochemical information that already exist in Finland, Norway and Sweden within the Mid-Norden area.

Sample spacing will be dictated by the funding available but should be linked to that of the Nordkalott project. The following programme is proposed for the Mid-Norden survey area:

1. Collect uniformly distributed samples of till, stream water and stream plant roots at a spacing of 1 sample per 50 km^2.

2. Select uniformly distributed soil sample reference stations and collect samples of 4 soil horizons, humus layer (A^<o^>), bleached layer (A_0), bleached layer (A_2), enrichment zone (B_2) and parent material, (C) at each station. Spacing: 1 station per 300 km^2.

Note to points 1 and 2.

If the funding precludes sampling with a density of 1 sample per 50 km^2, then a less dense sampling (e.g. 1 sample per 300 km^2) should be preferred to taking fewer types of samples.

The samples should be analysed with a variety of methods. Suggested determinations of elements are:

- totals
- acid soluble
- plant available
- susceptibile to acidification

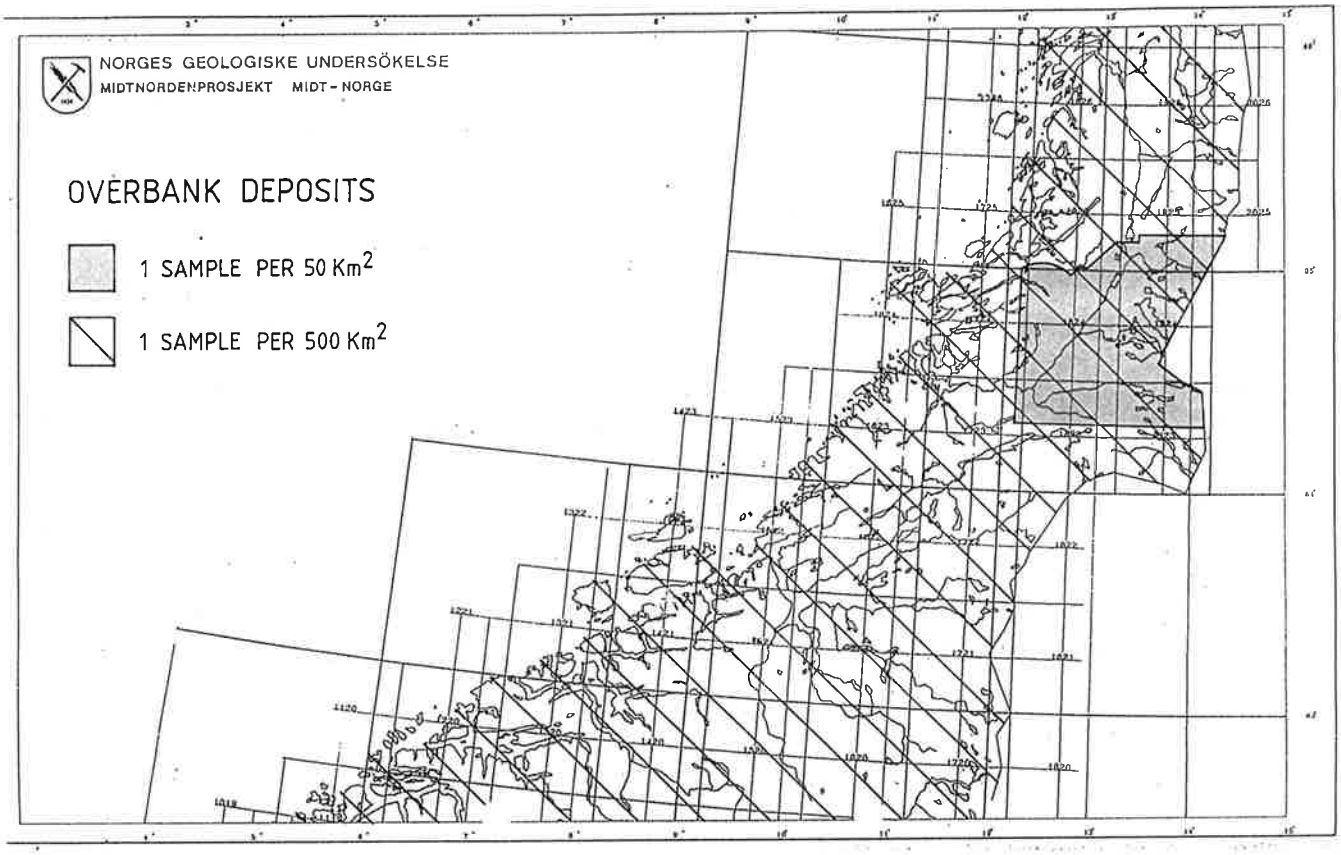

Fig. 12. Sampling density for overbank deposits.

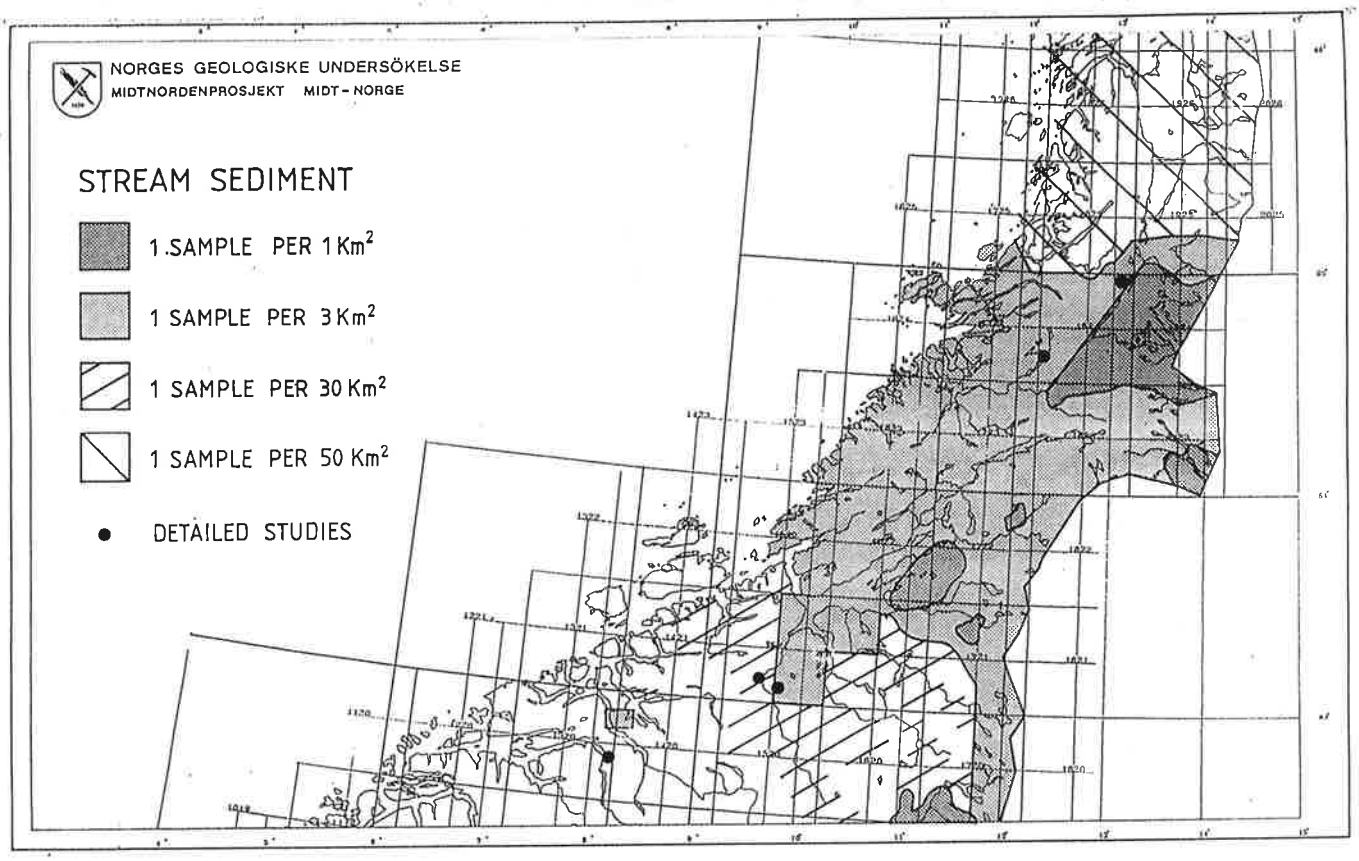

Fig. 13: Sampling density for stream sediments.

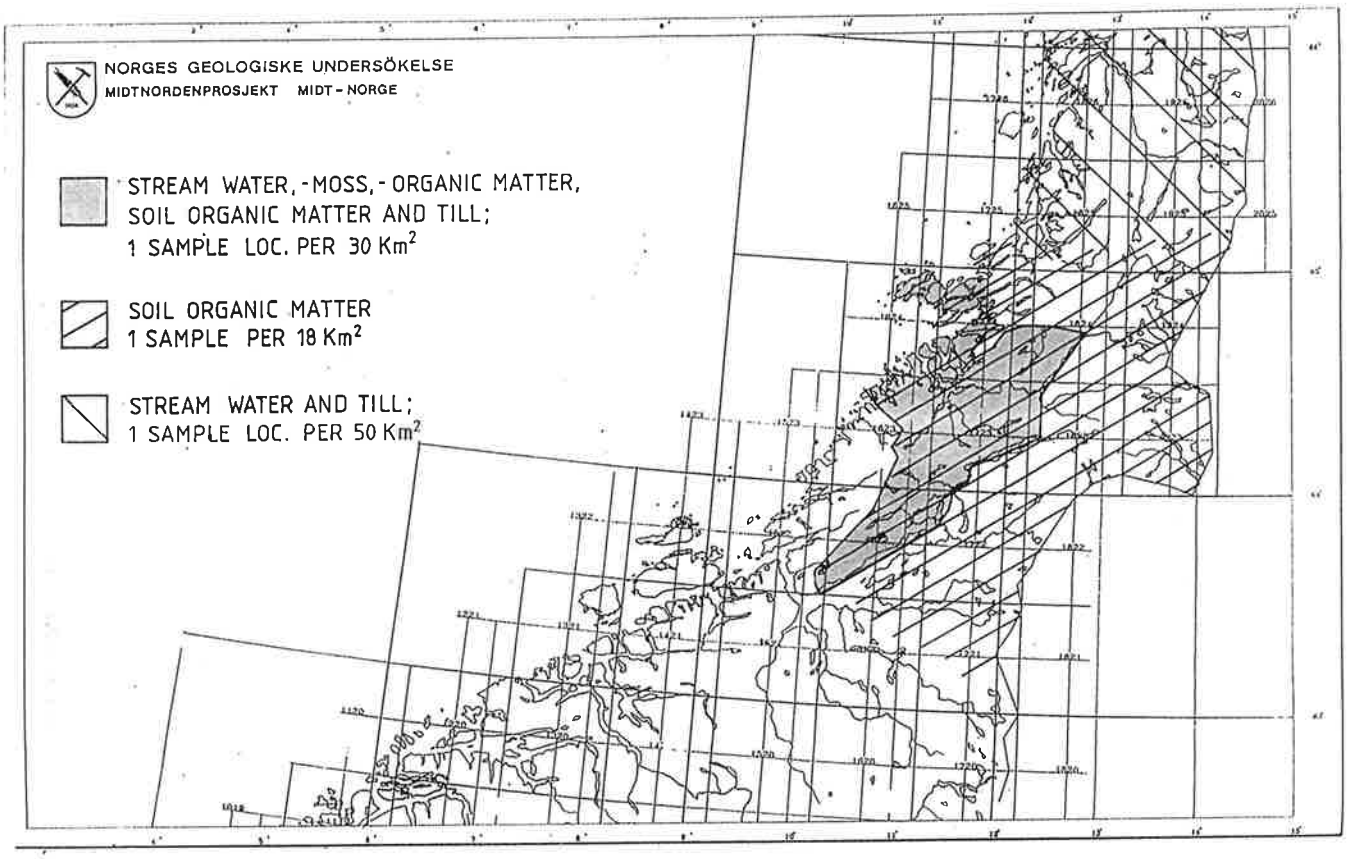

Fig. 14: Sampling density for other media.

During 1989 pilot studies will be done for each method mentioned above. Thereafter final decisions about analytical methods will be made.

All analyses of a certain type should be done after all samples have been collected, in random order for all three countries, with a number of standard samples and by one laboratory for each method.

TIME SCHEDULE

Technically it is possible to do the sampling in one year (1989), and the analyses within two years. This will make it possible to support the Environmental geology and the Metallogeny subprojects with some preliminary data in 1992. However the funds necessary for fieldwork are 2 mill. Nkr. (1 sample/50 km^2).

With a lower density sampling (1 per 300km^2) the total costs will be 0.7 mill. Nkr., and the preliminary results will be available one year earlier (1991).

At least one year should be reserved for data processing and interpretation.

All geological, geophysical and geochemical raw data maps should be completed one year before termination of the project.

RESOURCE REQUIREMENTS

Estimates of the costs of the proposed geochemical sampling program for sampling densities of 1/50 km^2 and 1/300 km^2 are shown in Tables 6 and 7.

For the Norwegian part of the area this will result in 1220 sample sites and 200 sample sites respectively. The highest density sampling will require the use of a helicopter in remote areas to obtain a good geographical distribution of sample sites.

The existing sample collection at NGU will only have a minor influence on the cost of the geochemical fieldwork. A possible calculation of saving the collection of c. 500 till samples in the area already sampled, is limited by the shortage of old sample material, podzol profile sampling has so far

not been carried out. Stream roots have not been sampled in Norway so far, and obviously we want to collect fresh stream water samples from the sample site.

The fact that the travel distance will be more or less the same for both sampling densities, and the need to collect samples of 4 soil horizons in all locations in the 1/300 km^2 samplingnet, is taken into consideration.

The cost estimates are based on experience from carrying out the Nordkalott and the Nordland/Troms projects. The cost of analysis is based upon what it will cost to analyse the Norwegian samples at NGU laboratories, and calculated as salaries. The external analysis includes analyses of plant-available elements.

In calculating the financial requirements all salaries for NGU personel, except for the external field workers, are deducted from the total resource requirements.

For the Norwegian part of the geochemical subproject this results in total financial requirements of 2.86 mill. Nkr or 1.41 mill. Nkr. for the two alternatives.

Years	1988	1989	1990	1991	1992	1993	SUM
Planning	0.1	0.2	0.1	0.1	0.1	0.1	0.7
Fieldwork		2.5					2.5
Analysis			3.0	3.0			6.0
Data Processing				0.5	0.5		1.0
Map production ¼ul 1				0.2	0.5	1.0	1.7
Reporting					0.5	1.5	2.0
Sum	0.1	2.7	3.1	3.8	1.6	2.6	13.9

Costs (in 1000 Nkr.)	1988	1989	1990	1991	1992	1993	SUM
Salaries:							
Planning	45	90	45	45	45	45	315
Prep. fieldwork	20	55					75
Fieldwork		740					740
Analysis (internal)			1150	1150			2300
Data proc./map prod.				225	320	320	865
Reporting					160	480	640
Other costs:							
Nordic travel	30	80	80	80	80	100	450
External analysis			250	250			500
Fieldwork travel		1000					1000
Materials		230			100	100	430
Data Processing ¼ul 1				100	50	50	200
Printing						300	300
Sum	95	2195	1525	1850	755	1395	7815

SUMMARY

Costs (in 1000 Nkr.)	1988	1989	1990	1991	1992	1993	SUM
Planning	65	145	45	45	45	45	390
Nordic travel	30	80	80	80	80	100	450
Fieldwork		1970					1970
Analysis			1400	1400			2800
ADB/map prod.				325	470	470	1265
Reporting/printing					160	780	940
Sum	95	2195	1525	1850	755	1395	7815

Table 6: Resource estimate for geochemistry subproject (sampling density 1/50 km^2).

Years	1988	1989	1990	1991	1992	1993	SUM
Planning	0.1	0.1	0.1	0.1	0.1	0.1	0.6
Fieldwork		0.8					0.8
Analysis			0.9	0.9			1.8
Data Processing				0.4	0.4		0.8
Map production				0.2	0.2	0.4	0.8
Reporting					0.5	1.0	1.5
Sum	0.1	0.9	1.0	1.6	1.2	1.5	6.3

Costs (in 1000 Nkr.)	1988	1989	1990	1991	1992	1993	SUM
Salaries:							
Planning	45	45	45	45	45	45	270
Prep. fieldwork	10	25					35
Fieldwork		180					180
Analysis (internal)			350	350			700
Data proc./map prod.				190	190	130	510
Reporting					160	320	480
Other costs:							
Nordic travel	30	80	80	80	80	100	450
External analysis			40	40			80
Fieldwork travel		400					400
Materials		130			80	80	290
Data Processing				50	25	25	100
Printing						200	200
Sum	85	860	515	755	580	900	3695

SUMMARY

Costs (in 1000 Nkr.)	1988	1989	1990	1991	1992	1993	SUM
Planning	55	70	45	45	45	45	305
Nordic travel	30	80	80	80	80	100	450
Fieldwork		710					710
Analysis			390	390			780
ADB/map prod.				240	295	235	770
Reporting/printing					160	520	680
Sum	85	860	515	755	580	900	3695

Table 7: Resource estimate for geochemistry subproject (sampling density 1/300 km^2).

GEOCHEMICAL MAPPING			1/50KM^2	1/300KM^2
TOTAL RESOURCE REQUIREMENTS			7815	3695
Fieldwork in Nord-Trøndelag	368	148		
NGU Salaries	4585	2135		
	4953		4953	
		2135		2135
MARGINAL COSTS			2862	1412

Table 8: Comparison of costs for alternative sampling densities in the geochemistry subproject.

8. SUBPROJECT: METALLOGENY

PERSONNEL

Gunnar Juve: subproject leader
A.N. Other (N-Trøndelag Program)
A.N. Other (Ore Section)

OBJECTIVES

Assessment of the potential occurrence of metals by documentation of known, probable and possible mineralizations, individually and as provinces.

Mineralization types considered will include all economic metals,- from the traditional base, alloy and noble metals to "new" high-technology metals. (The traditional subdivision of economic minerals according to specific gravity and optical opacity is thus abandoned).

Where appropriate, they will be presented together with related industrial minerals and "exotic" chemical elements.

Assessments and prognoses will be given according to single-element or combined occurrences.

PRODUCTS

- Metallogenetic and ore assessment map (1:1,000.000). Mineral deposits represented by evocative symbols. Metallogenetic provinces shown with various patterns for known and presumed extent.

- Description volume giving a broad documentation of deposits and provinces, arranged according to dominant metal, genetic type and geological/ geographical distribution.

- Geological profiles (also on the map).

- Charts of time, space and substance for correlation of data on stratigraphy, structure, age, mode of formation, chemistry and mineralogy.

Comments reg. charts:
When deposits and provinces show direct signatures of geochemical and geophysical (and other) character, these may be shown on the map. (Ex.: a copper deposit in a fracture giving a linear copper anomaly has a direct signature). This is more difficult when the signature is indirect. (Ex.: deposit gives anomaly of other metals in other structures than its own setting). Charts and profiles are important tools for the illustration of both direct and indirect signatures and for their correlation with new and classical ore-formational concepts and nomenclature.

Regional geochemical and geophysical information will be made more easily available on charts than on the map alone. With the risk of overloading the map, many zones of possible or probable influence of a metal would overlap each other, which again would inhibit a realistic evaluation of metal potential.

EXISTING MATERIAL AND METHODS

The starting point will be the register of ore deposits at NGU (Bergarkiv). The Metallogenic Map of Norway (1:2.000.000) (in press) shows 145 deposits between 62ºN and 66ºN, of a total of 1098 in the Bergarkiv within this area. In addition a considerable number of less important deposits are registered with eight different parameters (geographical, geological and economical). This information can be reproduced by ADP at any scale needed.

Data from IGCP Project 60 (Correlation of Caledonian Stratabound Sulphides), including the map at 1:1,500,000 (Zachrisson 1986) will likewise be incorporated directly.

Our products will build on information from the other subprojects and projects already in progress (e.g. the N-Trøndelag Program). The time schedule for delivery (or mutual exchange) of data and drafts will have to be precise from the beginning and in realistic balance with the rest of the project. Geochemical data will be needed at an early stage. Hard-rock geochemistry on main lithological units is particularly important here.

It is anticipated that there will be a limited amount of traditional fieldwork but that the subproject will involve many reconnaissance visits.

Some effort must be devoted to the testing of various methods for graphical representation.

Map compilation of existing data should commence at once with the production of a draft map and charts showing all the deposits for which we have data which meets our requirements (i.e. c. 150). Methods to be considered for the resource assessment should be discussed in 1989-90. Description of deposits and provinces as well as data processing for the assessment of ore potential should start as early as possible.

A system of mutual refereeing between the countries is necessary, both for graphic and descriptive material.

TASKS

- Production of a map of the deposits on a geological base map provided by the Bedrock subproject.
- Description of the deposits.
- Prognoses on the possible extent of presently known or new ore provinces: results should be incorporated on the map and on charts and profiles in the descriptional volume.

Months	1988	1989	1990	1991	1992	1993	SUM
Data compilation	1	3	3	3	6	6	22
Fieldwork		6	6	6	6		24
ADP		1	1	1	2	1	6
Map production				2	2	4	8
Reporting				2	4	4	10
	1	10	10	14	20	15	70

Costs (in 1000 kr)	1988	1989	1990	1991	1992	1993	SUM
Salaries	40	800	800	800	800	600	3840
Fieldwork	-	200	200	200	200	-	800
Travel	30	40	40	40	40	40	400
Chemical analyses	-	100	100	100	100	-	400
Report/map production	-	40	80	80	80	80	360
	70	1380	1220	1220	1220	720	5630

Table 9: Resource estimate for metallogeny subproject.

9. SUBPROJECT: INDUSTRIAL MINERALS

PERSONNEL:

Henri Barkey: subproject leader
Svein Olerud
Odd Øvereng

OBJECTIVES/PRODUCTS

- To provide an overview of all known deposits of industrial minerals and building stone in the area.
- Description of the most important deposits, including their tonnage, quality, products, their applications and production volume.
- Consideration of all available data in order to provide an assessment of the potential for new deposits.

EXISTING MATERIAL/METHODS

- Reports.
- NGUs database for deposits registered in the Bergarkiv (FORIBA).
- Information from companies, county geologists, mines inspectors, etc.
- Fieldwork incl. visits to deposits in production.

Months	1988	1989	1990	1991	1992	1993	SUM
Data compilation	0.5	0.5			1	1	3
Fieldwork		3	3	3	3		12
Map production					1	1	2
Reporting		1	2	2	2	2	9
	0.5	4.5	5	5	7	4	26

Costs (in 1000 kr)	1988	1989	1990	1991	1992	1993	SUM
Salaries	20	240	240	240	280	160	1180
Fieldwork		100	100	100	100		400
Travel	10	20	20	20	20	20	110
Chemical analyses		40	40	40	40		160
Report/map production		20	40	40	40	40	180
	320	420	440	440	480	220	2030

Table 10: Resource estimate for Industrial Minerals subproject.

10. SUBPROJECT: ENVIRONMENTAL GEOLOGY

PERSONNEL

Fredrik Chr. Wolff: project leader
Ingvar Lindahl, radiation from bedrock & soil
Bernt Malme, hydrogeology/pollution
Peer-Richard Neeb, sand, gravel and aggregates
Rolf Tore Ottesen, geochemistry/pollution

DEFINITION

Environmental geology is the study of the interaction between man and his geological environment. It builds on all forms of geological data and on an understanding of geological processes and forms part of the basis for environmental-, resource- and land-management.

OBJECTIVES

Local, regional and national authorities, industry including agriculture and research institutions of many kinds are involved in the management or study of environmental problems and are therefore potential users of products within environmental geology.

One goals are:

- To collect, systematise and integrate geological data for use in regional planning, land use planning, the construction industry, agriculture, forestry and public health service etc.

- To pinpoint conflicts between different claims for land use and for environmental protection.

- To identify areas worthy of special protection.

PRODUCTS

NGU has initiated a programme for environmental geology which aims to develop and test various types of thematic map and handbook which can be used in this field: this work will be carried out in close collaboration with the Department for the Environment. Its initial phase will be completed in 1991 and will obviously give experience which will be applied in the Mid-Norden project.

The following maps are tentatively planned:

- Maps of areas that should be reserved for extraction of ores, industrial minerals, building materials and energy resources, such as are described elsewhere in this report.

- Maps of groundwater quality and quantity (for selected areas and at a large scale)
  - Groundwater in Quaternary deposits
  - Groundwater in bedrock

- Maps of geochemical parameters, including:
  - Buffer capacity of soil
  - Nutrient elements (Ca, K, Mg?, P etc.)
  - Toxic elements (Al, As, Cd, Hg, Fe, Mn, S etc.)

- Waste disposal sites. Maps of areas geologically suitable for evaluation for:
  - near-surface deposition of inert or active (hazardous) wastes
  - underground storage of toxic, radioactive and other hazardous waste

- Hazards. Maps of hazardous ground (for selected areas and at a large scale)
  - areas of unstable ground, occurrence of unstable soils (quick clay or sand etc.)
  - radon risk areas with radon gas emission from soil or bedrock
  - seismically active zones.

METHODS

Maps will be prepared in cooperation with the other subprojects and after discussions with planners to ensure the focus and applicability of the products to the their problems. The following map types should be obtained from local authorities.

- Land use claim maps, showing the utility claims of the different sectors of society.
- Conflict maps, showing conflicts between the several land-use claims within one and the same area.

  Using these maps from the planners and the different maps from the subproject a geoscientific land-use priority map can be produced. This map should give recommendations as to how an area should best be used.

SCALE

The scale chosen for the Mid-Norden project is 1:1,000,000. This scale is too small for many of the topics involved in planning. We should consider compiling a set of maps at a larger scale (1:50 000) for certain densely populated, developing or otherwise critical areas in each of the participating countries.

Schedule:

1988: Planning stage - meeting early September in Uppsala with subproject leaders from all three countries to discuss objectives and methods (legends and scales etc.).
Late November Uppsala - Further discussion based on plans arising from agreements at the past meeting (Sept.)

1989-90: Data acquisition

1991-92: Further acquisition and starting integration of data.

1992-93: Compilation of maps.

1993: Preparation of maps for printing and reports for publication.

Costs (x 1000 NOK)

	1988	1989	1990	1991	1992	1993	Total
Salaries	50	270	360	360	360	360	1.760
Research exp.	30	150	150	120	120	150	720
Travel abroad	15	30	30	30	30	30	165
Chem. anal.	-	30	40	15	15	-	100
ADP	-	30	40	40	40	40	190
NGU Total	95	510	620	565	565	580	2.935

Table 11: Budget for the Environmental Geology subproject.

11. BUDGET

	1988	1989	1990	1991	1992	1993	Total
DATA							
Salaries	20	500	180	100	100	40	940
Travel	10	30	30	30	30	30	160
Other	-	500	800	-	-	-	1300
Sum	30	1030	1010	130	130	70	2400
BEDROCK GEOLOGY							
Salaries	110	2890	2810	2700	1990	980	11480
Fieldwork	20	650	650	400	130	-	1850
Travel	70	20	60	60	50	50	310
Analyses	-	100	100	100	100	-	400
Other	-	-	-	-	-	150	150
Sum	200	3660	3620	3260	2270	1180	14190
QUATERNARY GEOLOGY							
Salaries	20	1750	1560	1725	525	975	6555
Fieldwork	-	350	350	450	100	-	1250
Travel	20	50	50	50	50	50	270
Other	-	-	-	-	100	100	200
Sum	40	2150	1960	2225	775	1125	8275
MARINE GEOLOGY							
Salaries	20	140	140	120	360	240	1020
Travel	5	10	10	10	10	10	55
Sum	25	150	150	130	370	250	1075
GEOPHYSICS							
Salaries	40	1050	1050	1010	820	230	4200
Fieldwork		750	750	650	460	-	2610
Travel	20	50	50	50	50	50	270
Other		50	50	50	150	150	450
Sum	60	1900	1900	1760	1480	430	7530
GEOCHEMISTRY							
Salaries	65	885	1195	1420	525	845	4935
Fieldwork	-	1000	-	-	-	-	1000
Travel	30	80	80	80	80	100	450
Analyses	-	-	250	250	-	-	500
Other	-	230	-	100	150	450	930
Sum	95	2195	1525	1850	755	1395	7815
METALLOGENY							
Salaries	40	800	800	800	800	600	3840
Fieldwork	-	200	200	200	200	-	800
Travel	30	40	40	40	40	40	230
Analyses	-	100	100	100	100	-	400
Other	-	40	80	80	80	80	360
Sum	70	1150	1220	1220	1220	720	5630
INDUSTRIAL MINERALS							
Salaries	20	240	240	240	280	160	1180
Fieldwork	-	100	100	100	100	-	400
Travel	10	20	20	20	20	20	110
Analyses	-	40	40	40	40	-	160
Other	-	20	40	40	40	40	180
Sum	30	420	440	440	480	220	2030
ENVIRONMENTAL GEOLOGY							
Salaries	50	270	360	360	360	360	1760
Fieldwork	30	150	150	120	120	150	720
Travel	15	30	30	30	30	30	165
Analyses	-	30	40	15	15	-	100
Other	-	30	40	40	40	40	190
Sum	95	510	620	565	565	580	2935
ADMINISTRATION							
Salaries	60	80	80	120	120	120	580
Travel	25	30	30	30	30	30	175
Sum	85	110	110	150	150	150	755
Sum NGU	730	13305	12555	11730	8195	6120	52635

Table 12: Total cost estimate for Norwegian participation in the Mid-Norden project.

	1988	1989	1990	1991	1992	1993	Total	
DATA								
Salaries	20	100	180	100	100	40	540	
Travel	10	30	30	30	30	30	160	
Sum	30	130	210	130	130	70	700	
BEDROCK GEOLOGY								
Salaries	110	480	480	480	720	980	3250	
Fieldwork	20	100	100	100	50	-	370	(370)
Travel	70	20	60	60	50	50	310	
Analyses	-	100	100	100	100	-	400	(400)
Other	-	-	-	-	-	150	150	(150)
Sum	200	700	740	740	920	1180	4480	(920)
QUATERNARY GEOLOGY								
Salaries	20	790	600	525	525	975	3435	
Fieldwork	-	100	100	100	100	-	400	(400)
Travel	20	50	50	50	50	50	270	
Other	-	-	-	-	-	150	150	(150)
Sum	40	940	750	675	675	1175	4255	(550)
MARINE GEOLOGY								
Salaries	20	140	140	120	360	240	1020	
Travel	5	10	10	10	10	10	55	
Sum	25	150	150	130	370	250	1075	
GEOPHYSICS								
Salaries	40	480	480	480	480	230	2190	
Fieldwork	-	100	100	100	-	-	300	(300)
Travel	20	50	50	50	50	50	270	
Other	-	50	50	50	150	150	450	(450)
Sum	60	680	680	680	680	430	2210	(750)
GEOCHEMISTRY								
Salaries	65	885	1195	1420	525	845	4935	(430)
Fieldwork	-	1000	-	-	-	-	1000	(1000)
Travel	30	80	80	80	80	100	450	
Analyses	-	-	250	250	-	-	500	(500)
Other	-	230	-	100	150	450	930	(930)
Sum	95	2195	1525	1850	755	1395	7815	(2860)
METALLOGENY								
Salaries	40	400	400	400	600	600	2440	
Fieldwork	-	50	50	50	50	-	200	(200)
Travel	30	40	40	40	40	40	230	
Analyses	-	100	100	100	100	-	400	(400)
Other	-	40	80	80	80	80	360	(360)
Sum	70	630	670	670	870	720	3630	(960)
INDUSTRIAL MINERALS								
Salaries	40	100	100	100	160	160	660	
Fieldwork	-	25	25	25	25	-	100	(100)
Travel	30	20	20	20	20	20	130	
Other	-	20	40	40	40	40	180	(180)
Sum	70	165	185	185	245	220	1070	(280)
ENVIRONMENTAL GEOLOGY								
Salaries	50	270	360	360	360	360	1760	
Fieldwork	30	150	150	120	120	150	720	(720)
Travel	15	30	30	30	30	30	165	
Analyses	-	30	40	15	15	-	100	(100)
Other	-	30	40	40	40	40	190	(190)
Sum	95	510	620	565	565	580	2935	(1010)
ADMINISTRATION								
Salaries	60	80	80	120	120	120	580	
Travel	25	30	30	30	30	30	175	
Sum	85	110	110	150	150	150	755	
Sum NGU	770	6210	5640	5775	5360	6170	29925	(7330)

Table 13: Marginal costs for Norwegian participation in the Mid-Norden project. (In brackets - marginal costs for which financing must be found).

Table 12 gives an approximation of the total financial effort which NGU regards as desirable in the Mid-Norden part of Norway. It includes both regional mapping of all types within the area, to which we are already in general committed, and the marginal costs of reaching the goals of the Mid-Norden Project. The total cost is c. kr. 53,000,000 of which the marginal costs are c. kr. 30,000,000. A break-down of the marginal costs is shown in Table 13. Almost exactly two-thirds is salary, covered by NGU while travel (Internordic) would be largely covered by the Nordic Council. The remaining running costs total c. kr. 7,500,000 much of which would have to be financed by application to regional and national authorities for individual subprojects. This is not regarded as an insurmountable task particularly for those subprojects for which one can demonstrate direct relevance to data applications which have a high priority regionally and nationally.

APPENDIX

NORDISK MINISTERRÅD
SEKRETARIATET
Postboks 6753, St. Olavs plass - Oslo 1
Telefon: (02) 11 10 52

ANSÖKAN OM PROJEKTMEDEL FRÅN MINISTERRÅDETS ALLMÄNNA BUDGET

Datum: 1986-08-28 1. Projektmedel för år: 1987 2. ÄK / ID-nr.

3. Ansökt belopp	4. Belopp förordat av ÄK	5. Beviljat av Ministerrådet
940.000 kr		

6. Projektets namn

Mittnordenprojektet

7. Projektets innehåll och genomföring

Projektet syftar till att åstadkomma ett modernt geovetenskapligt basmaterial, dels för att få bättre förutsättningar för de omfattande prospekteringsarbeten efter metaller och mineral som pågår inom området och dels för att kunna uttala sig om olika miljöaspekter och geomedicinska frågeställningar. Följande baskartor i skala 1,1,00000 avses att framställas: gravimetrisk karta över bougueranomalier, flygmagnetisk karta, flygmagnetisk tolkningskarta, berggrundsgeologisk karta, strukturgeologisk karta, 5 olika kvartärgeologiska kartor, malmgenetisk karta, industrimineralkarta samt en "mineral assessment" karta. Det geokemiska materialet, som är särskilt viktigt för geomedicinen och miljöaspekterna, redovisas i form av en kartatlas enligt principen en särskild karta för varje kemiskt element och provtagningsmedium. Hela projektet beräknas vara slutfört 1992 om det kan påbörjas 1987. Projektet genomförs huvudsakligen av Finland och Norge som en fortsättning av Nordkalottprojektet mot söder. Sverige har inte möjlighet att inom projektets ram utföra nödvändiga geokemiska provtagningar och geologiska och geofysiska fältarbeten. Det finns dock inom området ett omfattande geovetenskapligt material i Sverige, som delvis kan komplettera de finska och norska undersökningarna. Sverige vill därför under alla omständigheter delta åtminstone som observatör och samarbeta inom ramen för delprojekten. Detsamma gäller Grönland, som framgångsrikt deltog i Nordkalottprojektet, samt Danmark.

8. Projektets målsättning

Definiering av industrimineral- och malmförande formationer och strukturer i Mittnorden med hjälp av regionala geologiska, geofysiska, geokemiska och fotogeologiska undersökningar.
Att skapa ett tillfredsställande geovetenskapligt underlag för att kunna bedöma miljöaspekter och geomedicin. T ex att få fram de naturliga bakgrundsvärdena för ett 40-tal kemiska grundämnen inom området. Detta möjliggör en bedömning av artificiella föroreningars storlek genom industriutsläpp, olyckshändelser m m.

9. Projektets bakgrund

I Norden har de geologiska ämbetsverken under mer än 100 år utfört geovetenskapliga undersökningar med olika målsättningar och olika metoder i respektive land. Då resultaten nåddes under olika tidpunkter är de numera delvis föråldrade och inte jämförbara. För att skapa en bättre och modern geovetenskaplig bas för bedömning av olika miljöaspekter och den inom området pågående prospekteringen efter malm och industrimineral har inom Nordkalottprojektet framtagits ett geovetenskapligt underlag i form av enhetliga kartor, gemensamma rapporter och med statistiska metoder framställda modeller. Nordkalottprojektet håller på att avslutas och bedöms internationellt och i Norden som mycket framgångsrikt. Prospektörerna får t ex det mest allsidiga och bästa geovetenskapliga grundmaterialet för eftersökande av malm- och industrimineralförekomster. Samma sak gäller för miljösidan,

10. Totalkostnad, N.kr.

År 1 (1987)	År 2 (1988)	År 3 (1989)	År 4 (1990)	Totalt (1991-92)
940.000	940.000	940.000	940.000	3.680.000

11. Kostnader

i 1986-priser (N.kr.)

	År 1987	År 1988	År 1989
Lön, arvode			
Sociala avgifter			
Resor	940.000	940.000	940.000
Övriga kostnader			
SUMMA	940.000	940.000	940.000

12. Kostnadsspecifikation

Det förutsätts att lönekostnaderna och resor i det egna landet betalas av de deltagande nordiska länderna.

Det föreslås att Nordiska Ministerrådet finansierar, som i Nordkalottprojektet, nödvändiga internordiska resor och publiceringen av resultaten. Enligt de erfarenheter som vunnits i Nordkalottprojektet beräknas årligen 590.000 kr för internordiska resor. Dessa fördelar sig med 220.000 kr på vardera Finland och Norge samt 100.000 kr på Sverige och 50.000 kr på vardera Danmark och Grönland. 300.000 kr föreslås för projektledningen och ett sekretariat.

För publiceringen av resultaten beräknas sammanlagt 1,8 milj. kronor under projektets två sista år.

Sammanlagda kostnader för Nordiska Ministerrådet under projektiden belöper sig sålunda till 7.440.000 Nkr.

De geologiska ämbetsverken bestrider samtliga löner och andra kostnader för projektet i sina respektive länder. Dessa belopp kommer att motsvara mer än 10 gånger det belopp som ansöks att ställas till förfogande från Nordiska Ministerrådet. I Nordkalottprojektet som håller på att avslutas, har Nordiska Ministerrådet bekostat ca 4 % av totalutgiften.

13. Evaluering

Efter avslutande avrapporteras projektet, i form av internationella symposier och seminar likhet med Nordkalottprojektet

där framförallt det rikhaltiga geokemiska materialet ger de variationer i halterna av ett 40-tal kemiska grundämnen som är resultatet av både naturliga processer och av mänsklig inverkan. Materialet har bl a redan kunnat utnyttjats vid internationella geomedicinska symposier i Oslo 1984 och Manchester 1985.

Finland och Norge önskar därför att fortsätta arbetet mot söder.

G. Kautsky

1986-07-15

MITTNORDENPROJEKTET

Bakgrund

Norra Fennoskandia är genom sin rikedom på malmer och industriella mineral mycket attraktivt för gruvbolagen. Det är också ett av regeringarna i de nordiska länderna prioriterat stödområde. Av naturliga skäl pågår därför inom området en hel rad prospekteringsarbeten,samtidigt som miljöbevarande åtgärder väger tungt i beslutsprocesserna. Såväl för prospekteringen som för miljöaspekterna är ett geovetenskapligt grundmaterial av hög kvalitet en grundförutsättning. Det geovetenskapliga materialet har hittills varit heterogent och delvis föråldrat. De geologiska undersökningarna har arbetat inom området i mer än 100 år och materialet har samlats in under olika tidsperioder. Även när det gäller moderna undersökningar inom geologi, geofysik och geokemi har de nordiska länderna ofta gått skilda vägar och av naturliga skäl även prioriterat olika. Vid flygmätningarna har man t.ex. vid de översiktliga regionala mätningarna haft olika instrumentering och flugit på olika höjd, vilket gör att mätningarna inte är direkt jämförbara. Inom geokemin har man vid provtagningen prioriterat olika medier, i Sverige organiskt material, i Norge bäcksediment och i Finland morän. Det var därför angeläget att få fram en enhetlig, modern berggrundsgeologisk, kvartärgeologisk, geofysisk och geokemisk bild av hela norra Fennoskandia. Detta har skett dels genom bearbetning av äldre material, dels genom insamling av nytt material där så varit nödvändigt.

Med stöd av Nordiska Ministerrådets ämbetsmannakommitté för industri ingångsattes därför Nordkalottprojektet 1979 för att definiera malmgeologiska strukturer på Nordkalotten (området norr om 66^{o} breddgraden) med hjälp av regionala geologiska, geofysiska, geokemiska och fotogeologiska undersökningar. Nordkalottprojektet är nu i sitt slutskede och man kan överblicka resultaten. Projektet avrapporterades i augusti 1986 i samband med ett stort internationellt malmsymposium i Luleå, anordnat av International Association on the Genesis of Ore Deposits (IAGOD).

Området norr om 66° breddgraden har nu ett geovetenskapligt underlagsmaterial som torde höra till det bästa och mest allsidiga i världen. 14 olika geologiska och geofysiska kartor som täcker hela området är publicerade. Det geokemiska materialet har presenterats i form av en geokemisk kartatlas innehållande 150 kartor, vilka visar fördelningen av kemiska element i olika medier och det kemiska mönstret av dessa element på Nordkalotten. Kartmaterialet (med undantag för de kvartärgeologiska kartorna) finns också i databaser, vilka lätt kan hållas aktuella och ur vilka till en ringa kostnad olika sorters temakartor eller kartor i andra skalor kan produceras. Ett databaserat fyndighetsregister kompletterar kartorna. En "mineral resource assessment" karta, som utnyttjar alla delprojektens resultat för malmprognoser utgör ett försök till en integrerad utvärdering av hela projektet ur malmgeologisk synvinkel.

De hittills framkomna resultaten har sedan projektets början i ökad omfattning utnyttjats av de olika prospekteringsorganisationer, som arbetar inom området. Materialet har även visat sig mycket värdefullt från miljösynpunkt. Sålunda har Nordkalottprojektets geokemiska material som en "spin off" effekt kunnat utnyttjas för geomedicinska ändamål. Ett internationellt geomedicinskt symposium anordnades 1984 i Oslo, vid vilket Nordkalottmaterialet tilldrog sig mycket stort intresse. Ett likartat symposium har hållits 1985 i Storbritannien. Även där har Nordkalottmaterialet spelat en framträdande roll. De geokemiska kartorna visar de i olika områden mycket varierande naturliga bakgrundsvärdena för ett 40-tal kemiska grundämnen på Nordkalotten. Detta möjliggör en bedömning av artificiella föroreningars storlek genom industriutsläpp, olyckshändelser m.m.

Nordkalottprojektet finansierades av de deltagande länderna själva genom de centrala geologiska ämbetsverken. Ca 4 % av kostnaderna -- internordiska resor och publiceringskostnader - har bekostats genom Nordiska Ministerrådet. De direkta kontakt- och arbetsmöjligheter mellan vetenskapsmännen i de olika nordiska länderna som därmed skapades var en förutsättning för projektets framgångsrika genomförande. Personal från Grönlands geologiska undersøgelse har mycket aktivt deltagit i projektets arbete. -

Beskrivning

Eftersom Nordkalottprojektet kan betraktas som en klar framgång är det naturligt att fortsätta projektet mot söder, i ett Mittnordenprojekt, så att ett enhetligt geovetenskapligt basmaterial erhålls över alla de områden som innefattar de stora malmprovinserna i Fennoskandia. Väljes 63 breddgraden som sydgräns faller i Finland Outokumpu- och Vihantifälten, i Sverige Skelleftefältet, blymalmer i fjällranden och Stekenjokk samt i Norge Grongfältet och Trondheimsfältet inom området. Man har därmed täckt halva Fennoskandia.

En intressant ny aspekt är "off shore" geologin i Bottniska viken som bör inkluderas i Mittnordenprojektet. Genom magnetiska och gravimetriska mätningar samt geologisk utvärdering av dessa kommer en enhetlig och bättre bild av de geologiska sammanhangen mellan Finland och Sverige tvärs över Bottniska viken att erhållas. De tektoniska sammanhangen, t.ex. eventuella unga rörelser m.m., sóm kan ha betydelse för slutlagringsproblematiken beträffande radioaktivt avfall, kommer bättre att kunna bedömas.

Vid bearbetningen av Nordkalottmaterialet har avsaknaden av kemiska analyser av bergarterna upplevts som en påtaglig brist. Detta bör kompletteras i Mittnordenprojektet. Berggrundsgeologer och geofysiker insamlar ett stort antal berggrundsprover, bl.a. för geofysiska parametermätningar. Detta omfattande material, som återspeglar de inom området förekommande bergarterna, kan på ett billigt sätt kemiskt analyseras på ca 30 grundämnen med plasmaspektrometri och XRF.

När det gäller berggrundsgeologi, kvartärgeologi och geofysik kan samma framgångsrika arbetsteknik tillämpas som i Nordkalottprojektet. Den pågående utvärderingen av Nordkalottprojektet, utvecklingen inom analystekniken, och en önskan att göra resultaten ännu bättre användbara för miljöaspekter och geomedicin har inom geokemin lett till önskemål om förändringar såväl vid provtagningen som vid analyseringen. Sålunda minskar man provtagningstätheten från 30 km^2 till 50 km^2 per station. De inom Nordkalottprojektet provtagna sex medierna kan inom

Mittnordenprojektet begränsas till fyra, nämligen morän, bäcksediment, bäckvatten och humus. Provmedierna kompletteras med berggrundsprover insamlade av geologer och geofysiker enligt ovan. För att kunna använda geokemiresultaten bättre inom miljösektorn och geomedicinen föreslås även bestämning av grundämnena selen, arsenik, kvicksilver och bor.

Datagruppen kommer att behandla Mittnordenprojektets data på samma sätt som i Nordkalottprojektet.

Organisation

Nordkalottprojektets organisation har visat sig ändamålsenlig och effektiv och väl anpassad till den geologiska infrastrukturen i de nordiska länderna. Arbetet utförs av blandade arbetsgrupper med personal från de deltagande geologiska undersökningarna. En högkvalificerad geolog med kännedom om problematiken inom området samordnar och leder arbetet som projektledare. Styrgrupp B består av cheferna för de deltagande geologiska undersökningarna och styrgrupp A av representanter för Nordiska Ministerrådet och ministerierna som har ansvaret för projektet.

Med hänsyn till projektets omfång torde det krävas sex år för dess genomförande.

Mittnordenprojektet har inför avslutningen av Nordkalottprojektet diskuterats i styrgrupp B och A. I styrgrupp B råder enighet om att, med tanke på de utomordentliga resultat som Nordkalottprojektet gett som bas för miljö- och prospekteringsarbete, det är mycket angeläget att kunna fortsätta i ett Mittnordenprojekt. I styrgrupp A vill Norge och Finland utföra och finansiera Mittnordenprojektet. Det är viktigt att Mittnordenprojektet kan påbörjas i direkt anslutning till Nordkalottprojektet för att kunna utnyttja den befintliga organisationen. Sverige kan inte finansiera ett fullt deltagande i Mittnordenprojektet men vill åtminstone delta som observatör. Befintligt svenskt geomaterial kan säkert i stor utsträckning utnyttjas av Finland och Norge inom Mittnordenprojektet. Även Grönland önskar delta som observatör och i vissa arbetsgrupper i Mittnordenprojektet.

Kostnader i 1986 års priser

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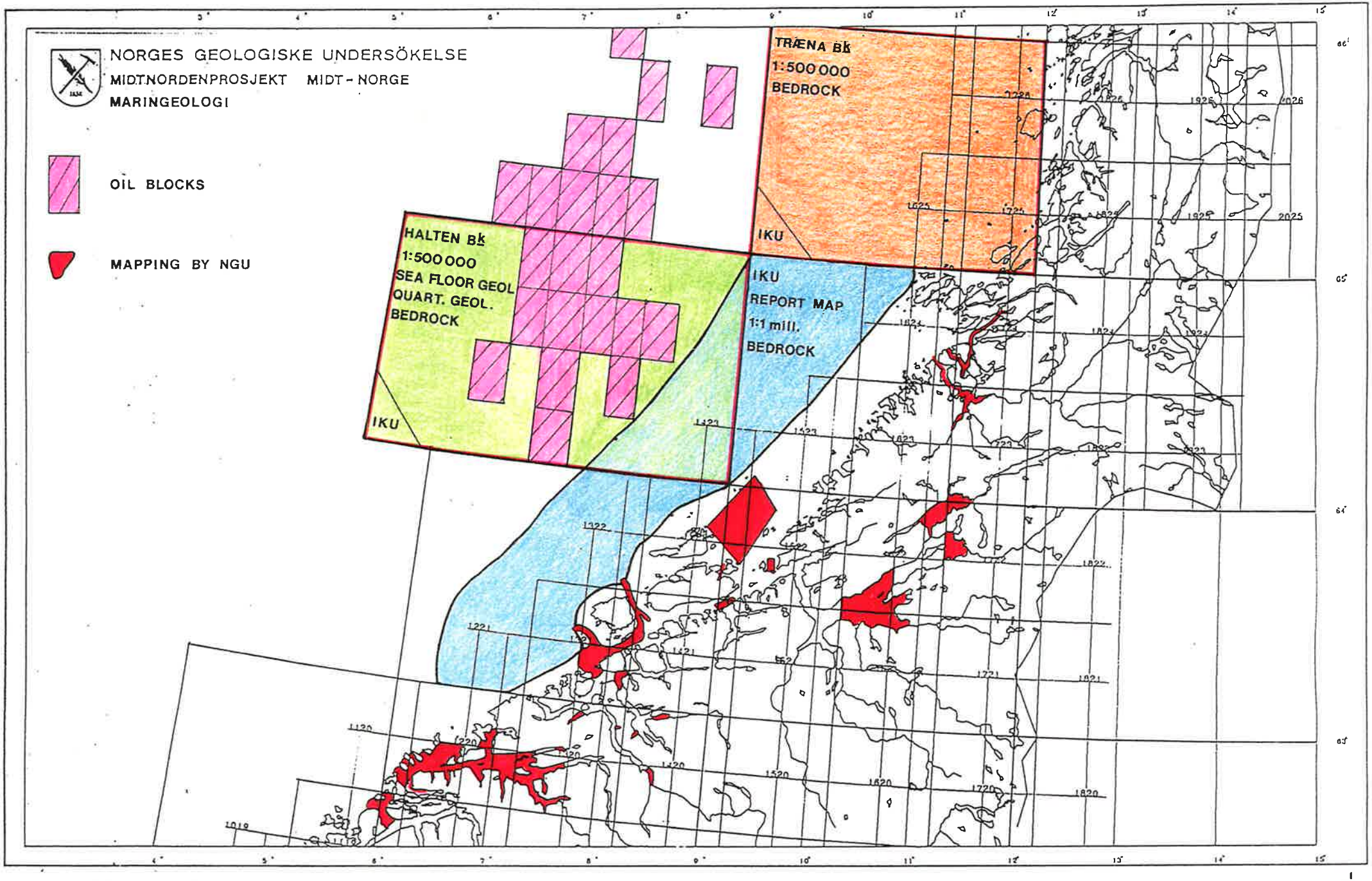

Fig. 6: Coverage of maps of solid geology / superficial deposits in offshore areas.