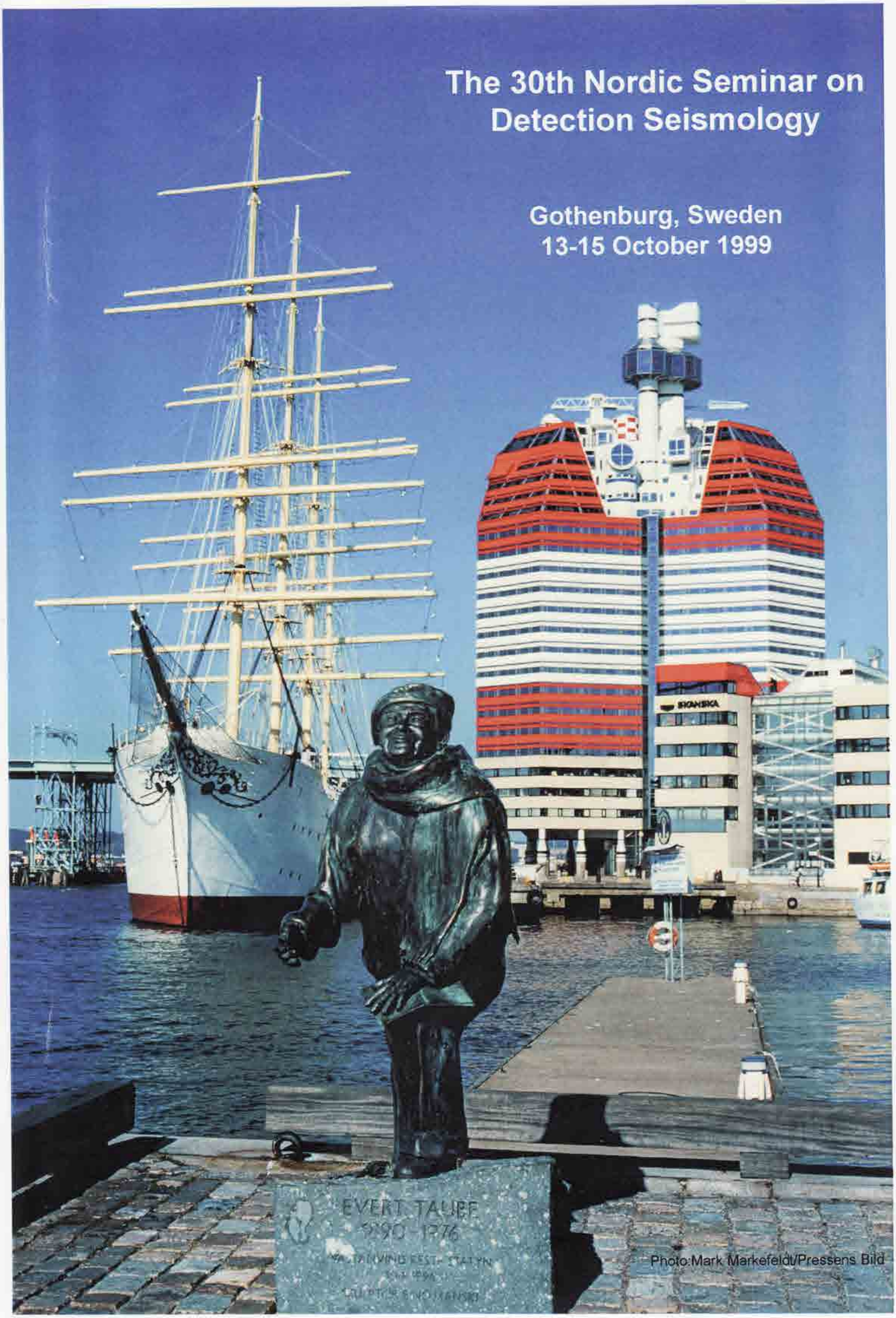
The 30th Nordic Seminar on Detection Seismology

Gothenburg, Sweden
13-15 October 1999



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30 th Nordic Seminar on Detection Seismology
Gothenburg, Sweden, 13-15 October 1999

Wednesday, 13 October

1130	Registration at Riverton Hotel
1200-1300	**Lunch at Riverton Hotel**
1330	**Opening** *Nils-Olov Bergkvist*
1340	Introductory words *Ola Dahlman*
1410-1640	**Comprehensive Test Ban Treaty (CTBT) Monitoring and related topics** **Chairman: Anders Dahle**
1410	Activities of Working Group B of the CTBTO PrepCom. *Svein Mykkeltveit*
1430	Research in Regional Seismic Monitoring *Frode Ringdal*, Tormod Kvaerna, Johannes Schweitzer, Elena Kremenetskaya, Vladimir Asming
1450-1520	**Coffee break**
1520	CTBT related work in Denmark *Erik Hjortenberg*
1540	The Norwegian National Data Center *Ulf Baadshaug*
1600	Continuous Data Transmission *Jan Fyen*
1620	A Radionuclide Monitoring Station for the CTBT *Anders Ringbom*
1750	**Submarine cocktail**
1900	**Dinner on board The Destroyer Småland**

Thursday, 14 October

0900-1440 Seismic networks and data processing
Chairman: Reynir Bödvarsson

0900 The Nanometrics Data Acquisition System
Kamran Iranpour

0920 The new Swedish National Seismic Network
Reynir Bödvarsson, Ota Kulhanek, Björn Lund and Ragnar Slunga

0940 New Challenges of the Millenium for the Finnish National Network
Pasi Lindblom, Matti Tarvainen and Seppo Nurminen

1000-1030 Coffee break

1030 Multievent Microearthquake Analysis at the Icelandic and Swedish Seismological Networks
Ragnar Slunga

1050 HYPOSAT – A New Routine to Locate Seismic Events
Johannes Schweitzer

1125 Guided bus tour in Gothenburg

1230 Lunch at "Sjömagasinet"

1400 Seismic networks and dataprocessing (cont.)

1400 Monitoring the European Arctic Using Regional Generalized Beamforming
Tormod Kvaerna, Johannes Schweitzer, Lyla Taylor and Frode Ringdal

1420 Detection of Arctic Seismicity Missed by Other Regional and Worldwide Catalogs
Kent G. Lindquist, Roger A. Hansen and Tobin Fricke

1440-1520 Earthquake seismology and Tectonics
Chairman: Pekka Heikkinen

1440 Correlation of Microearthquake Body-Wave Spectral Amplitudes
Björn Lund and Reynir Bödvarsson

1500 Concentrated Earthquake Activity from Norwegian Local Seismic Networks
Erik Hicks, Conrad Lindholm and Hilmar Bungum

1520-1640 Poster introduction/Poster session
Chairman: Roger A. Hansen

1540 Coffee break (after poster introduction)

Continuous Assessment of Upper Limit MS
Tormod Kvaerna, Lyla Taylor
Johannes Schweitzer, Frode Ringdal

Earthquake Focal Mechanisms and Stress in Norway
Erik Hicks, Hilmar Bungum Conrad Linholm

Status of Project TOR fall 1999
Peter Voss, Sören Gregersen,

Near Real-Time Integration of Seismic Data from Regional Seismic Networks and the Global Seismic Network
K. Lindquist, F. Vernon, D. Harvey, G. Pavlis,
R. Hansen, D. Quinlan, M. Harkins

The International Arctic Research Center (IARC):
Partnerships in arctic research
Roger A. Hansen

Origin and Emplacement Mechanisms of the Fennoscandian Rapakivi Granite Batholiths - Insights from the Babel Profiles
Pekka Heikkinen and Annakaisa Korja

1800 Preparation for dinner

1900 Dinner

Friday, 15 October

0900-1000 Discussion of Cooperative Arctic Seismological Project (COASP) Open meeting
Chairman: Erik Hjortenberg

1000-1040 Earthquake seismology and Tectonics (cont.)

1000 The Masi-99 Project
Johannes Schweitzer

1020 A New Look at the Segmentation of the Subducted Plate in Southern and Central Alaska
Roger. A. Hansen , N. A. Ratchkovski,

1040-1100 Coffee break

1100 General topics

1100 Y2K-1, a milestone for NORSAR
Anders Dahle

1120 Closing remarks
Nils-Olov Bergkvist

Comprehensive Test Ban Treaty (CTBT) Monitoring and related topics

Chairman: Anders Dahle

Activities of Working Group B of the CTBTO PrepCom

Svein Mykkeltveit

The verification regime for the Comprehensive Nuclear-Test-Ban Treaty (CTBT) is currently being established by the Preparatory Commission (PrepCom) of the CTBT Organization. States Signatories to the Treaty take an active part in this work through discussions and decision-making in PrepCom's working group for verification (Working Group B). In this presentation, an attempt will be made to summarize the work of this Group since its establishment in 1997 and to identify challenges ahead.

Research in Regional Seismic Monitoring

Frode Ringdal
Tormod Kværna
Johannes Schweitzer
Elena Kremenetskaya
Vladimir Asming

We have continued our studies to use data from the regional networks operated by the Kola Regional Seismological Centre (KRSC) and NORSAR to study the seismicity and characteristics of regional phases of the Barents/Kara Sea region. These studies have encompassed the traditional MS:mb discriminant, using surface waves recorded at regional distances, as well as short-period regional discriminants such as the P/S ratio. We have applied these discriminants to events with known source type as well as "unknown" events. The regional MS:mb results are encouraging, whereas the short-period discriminants will need further research, and will probably only be effective after extensive regional calibration and in combination with detailed station-source corrections.

A workshop was held in Oslo, Norway during 12-14 January 1999 in support of the global seismic event location calibration effort currently being undertaken by the Preparatory Commission's Working Group B in Vienna. Among the contributions were recent results provided by NORSAR and KRSC of our joint regional calibration effort in the European Arctic, which has resulted in much improved travel-time models for this region. We show by examples that significant improvements in event location precision can be achieved compared to using the IASPEI model, and we use the regional model to calculate locations of some recent small seismic events in the Novaya Zemlya region of interest in a CTBT monitoring context.

CTBT related work in Denmark

Erik Hjortenberg

The Danish Parlament has ratified the UN nuclear test ban treaty, and it has also passed a law implementing it. This law bans nuclear tests in Denmark and allows Onsite Inspection on Danish territory. The law states, that the ministry of housing may determine the rules for the implementation of these inspections. Kort & Matrikelstyrelsen (KMS) is organized under the ministry of housing and will act as the National Authority as defined in the treaty.

The Royal Danish Ministry of Foreign Affairs takes care of the Danish annual payment to the Comprehensive Test Ban Treaty Organization (CTBTO), and the Danish participation in the Preparatory Commission. When the treaty enters into force they will appoint the participant in the Executive Committee according to the rules in the treaty.

The Danish Permanent Mission to UN in Vienna participate in the Working Group A meetings, this group discuss the financing of Provisional Technical Secretariat (PTS) of CTBTO and its activities of implementing the verification system defined in the treaty. KMS participates in the meetings of Working Group B. This group discuss technical aspects of the International Data Center (IDC) and International Monitoring System (IMS).

KMS will act as a point of contact with CTBTO, and will have access to the IMS data at IDC in Vienna. These data will be used to verify the compliance with the treaty, and they will also be used scientifically, e.g. to determine the earth's heterogeneities. A big job for the next century will be to calibrate the IMS network, to make the location uncertainties smaller. It may well be, that future state conferences will decide on upgrading the IMS network, e.g. by adding more stations, but the job at hand now is to implement the 321 station network. Another possibility would be to add more cooperating national facilities.

KMS will also act as the National Data Centre (NDC) for seismology and be responsible for the Auxiliary Seismic station AS27, SFJ, it is a station established by IRIS/GEOFON in Greenland, and maintained by the US Geological Survey Seismological Laboratory in Albuquerque in collaboration with KMS, the teletechnical department of Kangerlussuaq airport do the tape change and other jobs. The station will need upgrading of its high frequency response, and relocation is also needed, since noise from a nearby radar destroys the high frequency part of the spectrum. This type of station is sometimes called a dual use station because it serves the scientific community and CTBTO.

Another IMS station is also located in Greenland, it is the infrasound station IS18, it will be run by the Danish Meteorological Institute (DMI). This station will also need relocation, since the treaty location Dundas is now a ghost town. It is proposed to place the station at the Geophysical Observatory at Thule, approximately 100 kilometers further north. The station will be installed by PTS in collaboration with DMI.

The IDC will determine characterization parameters for all events, but leave it to the individual NDC's to decide whether or not a suspicious event appears to have taken place. Considering the importance of this decision, I hope for increased support to the Nordic NDC's.

The Norwegian National Data Center

Ulf Baadshaug

NORSAR will be responsible for operating and maintaining the Norwegian stations in the International Monitoring System (IMS) – the network used to verify compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT). This talk discusses the tasks NORSAR will perform to act as the Norwegian NDC.

Continuous Data Transmission

Jan Fyen

The talk will focus on current developments within formats and protocols for continuous data transmission.

A Radionuclide Monitoring Station for the CTBT

Anders Ringbom

As a part of the verification system for the Comprehensive Nuclear Test-Ban Treaty (CTBT), radioactive aerosols and noble gases formed in nuclear explosions are to be detected using a network of 80 stations world-wide. In a first step 40 of these are scheduled to report measurements of radioactive xenon.

FOA is constructing one of the first radionuclide stations for this network, which will be placed in Ursvik, Stockholm. The station will be completely automatic, and will send daily reports of the concentrations of radioactive aerosols and xenon to the International Data Centre (IDC) in Vienna. The noble gas sampling and detection system that has been developed for this purpose will also participate in an international noble gas equipment test together with USA, France and Russia.

Seismic networks and data processing

Chairman: Reynir Bödvarsson

The Nanometrics Data Acquisition System

Kamran Iranpour

The talk will describe some techniques used within the Nanometrics data acquisition system used for the new ARCES array.

The new Swedish National Seismic Network

Reynir Bödvarsson
Ota Kulhanek
Björn Lund
Ragnar Slunga

The new Swedish National Seismic Network (SNSN), which is a digital broadband seismic network, is now under construction. The first part of the network was put into operation in 1998. This part of the network financed by Uppsala University, consists of six station at approximately the same locations as the stations in the old analog network constructed by Marcus Båth in the 1960s.

Additionally twelve stations are under construction along the Bothnian Sea coast. This is a separate project financed by the Swedish Natural Science Research Council (NFR), the Knut and Alice Wallenberg Foundation and the Swedish Nuclear Fuel and Waste Management Co (SKB). The main purpose of this network is to study microearthquake activity along the Bothnian Sea coast to gain better understanding of the ongoing deformation processes in that area.

All stations are equipped with Guralp CMG-3ESPD broadband seismometers with digital output. Characteristics of the instruments are flat to velocity in the period range from 0.02 to 30 seconds. The digital data is time stamped within the sensor using the GPS satellite system. The sampling frequency will be 100 sps at all stations.

The data acquisition system will be the SIL system which was developed within a joint Nordic project for earthquake prediction research in Iceland (1988-1992, SIL project). Description of the status of the new network and future plans will be given.

New Challenges of the Millenium for the Finnish National Network

Matti Tarvainen
Pasi Lindblom
Seppo Nurminen

Seismograph stations in Finland have met and will head for big changes and configurations in 1999 and next year. The certification of the IMS primary station PS17 (FINESS) began in January, and as the final upgradingswill be done, the status of the station changes.

The on-line stations are transformed gradually into dial-up stations. This new upgrading means installations of PC mother board based (LINUX) data loggers at some stations. During this autumn stations: VAF, NUR, KAF and KJN have been equipped with these new instruments. Also, the GS-13 seismometers at VAF were replaced by a GURALP broad-band 3-component unit.

This presentation will show the status of the Finnish national network as it is now, and also some plans in the future will be unveiled.

Multievent Microearthquake Analysis at the Icelandic and Swedish Seismological Networks

Ragnar Slunga

The microearthquake analysis developed in Sweden in the early eighties has been further developed during the implementation and operation at the Icelandic seismological network (the SIL network). The methods will again come into use for Fennoscandian earthquakes within the new seismic network in Sweden. The methods include fault plane solution based on spectral amplitudes, absolute and relative locations based on accurate relative onset times of similar waveforms, and multievent interpretation based on combination of the results of the two main methods. A number of examples from Iceland will be presented.

HYPOSAT - A New Routine to Locate Seismic Events

Johannes Schweitzer

Since the summer of 1996 a program package has been under development that attempts to use as much information as possible to estimate the hypocenter of a seismic source. The following input parameters are used: arrival times, backazimuths, ray parameters (or apparent velocities), and travel-time differences between different phases observed at the same station. The observed standard deviations are used to weight all input parameters and the inversion is done with a generalized matrix inversion code. All partial derivatives are internally recalculated for each iteration. A starting solution with 'a priori' uncertainties can be given or calculated as the intersection of all backazimuth observations. If S observations are also available, a origin time is estimated using the Wadati formula.

Observations of all seismic phases as defined in the IASP91 tables can be used for the inversion. Implemented global Earth models are Jeffreys - Bullen, PREM, IASP91, SP6, and AK135. In addition, user defined horizontally layered local or regional models, or the global crustal model CRUST 5.1, can be used to locate seismic events. For such models, reflections from the Conrad discontinuity (PbP, SbS) or from the Mohorovicic discontinuity (PmP, SmS) can also be used as input.

The observed travel times are corrected for the ellipticity of the Earth, and corrections for the elevation of the seismic stations are calculated using the local P and S velocities below the stations given either as separate input or taken from CRUST 5.1, and the ray parameter of the individual phases. The global crustal model can also be used to correct seismic phases reflected at the Earth's surface (e.g. pP, sP, PP, SS, P̃OP̃Õ,...) for model differences at their reflection points.

Monitoring the European Arctic Using Regional Generalized Beamforming

Tormod Kvaerna
Johannes Schweitzer
Lyla Taylor
Frode Ringdal

We describe some recent improvements made to the Generalized Beamforming (GBF) process which has been running operationally at NORSAR for the past 10 years. The GBF process works from the lists of phase detections at each of the regional arrays in northern Europe to automatically create phase associations and locations of seismic events in the region. Among the improvements are:

- Inclusion of the SPITS array in the GBF procedure
- Expansion of the beam grid coverage, especially in the Arctic region
- Increased density of the beampacking grid to allow more accurate epicenter determinations
- Improved detector and f-k recipes for five of the arrays used in GBF

We have evaluated the improvements relative to the previous version. The coverage of the European Arctic is vastly improved, with a much larger number of valid detected events, and correspondingly better locations. Mainly, this improvement is due to the inclusion of the very sensitive SPITS array. Using various criteria to reduce the occurrence of spurious phase associations, we also conclude that there are significant improvements in the detection and location performance in other regions covered by the regional network. We note that, compared to the GBF-based association process (GA) currently used by the IDC, the NORSAR GBF system is capable of detecting and locating seismic events up to one order of magnitude smaller than the IDC. This is due to a combination of better regional array coverage and less strict event definition criteria.

Detection of Arctic Seismicity Missed by Other Regional and Worldwide Catalogs

Kent G. Lindquist
Roger A. Hansen
Tobin Fricke

The seismicity of the Arctic is interesting for a variety of scientific and monitoring reasons. This has spurred recent interest in constructing thorough catalogs of Arctic seismicity. Previous work has prepared the way for automatic, near-real-time array detection and location of events with Scandinavian and Alaskan seismic arrays over the entire Arctic. We discuss progress in processing four months of Alaskan seismic array data from April through July, 1999, automatically detecting and locating all Arctic events possible with the arrays. We compare the results of this catalog with the regional earthquake catalog from the Alaska Earthquake Information Center, with global catalogs, and with the generalized beam-forming catalog of European Arctic events from the Norwegian seismic arrays processed by Norsar. Of special interest also are those events detected by the Alaskan arrays in the Aleutian Islands, in the Bering Sea Region, in Eastern Siberia, and over the polar cap that do not appear in any other global or regional catalogs.

Earthquake seismology and Tectonics

Chairman: Pekka Heikkinen

Correlation of Microearthquake Body-Wave Spectral Amplitudes

Björn Lund
Reynir Bödvarsson

Originally intended as an aid in the identification of similar focal mechanisms, correlation of direct P and S wave spectral amplitudes can be used in a number of different applications such as studying temporal variations in the seismicity, calculation of composite focal mechanisms, assessment of the similarity of focal mechanisms and identification of the number of independent focal mechanisms in stress tensor inversion applications.

The spectral amplitudes, low frequency asymptotes or DC-levels, are calculated from small time series around the direct P and W wave arrivals. In the SIL system these amplitudes are calculated for each of the rotated components, i.e. vertical and radial P and vertical, radial and transverse S, we, thus, have five amplitude values per station. In the correlation scheme, which we will discuss in detail, we use the linear correlation coefficient which is calculated using all phases that two events have in common. The events are grouped after correlation using a grouping scheme that ensures high homogeneity within the groups.

The groups of well correlating amplitudes can be used to calculate a composite focal mechanism through stacking of the amplitudes and polarities belonging to the individual events. The resulting composite mechanism will, usually, have nodal planes determined with much higher accuracy than the nodal planes of the individual events. Applied to the earthquake sequence preceding the November 1998 Ölfus earthquake we will show an example of how the correlation scheme can be used to infer changes in the seismicity and discuss how this can be implemented in real-time monitoring. Finally w discuss the advantages of the correlation scheme when the focal mechanisms are to be used in stress tensor inversion. Estimating the number of independent focal mechanisms when inverting for the state of stress has always been an issue which we feel is solved by the correlation scheme.

Concentrated Earthquake Activity from Norwegian Local Seismic Networks

Erik C. Hicks
Conrad D. Lindholm
Hilmar Bungum

Abstract: Earthquake swarms in coastal areas of Mid- and Northern Norway are known to occur fairly regularly, the Ms 5.8-6.2 earthquake of 1819 was also located in this area, while the southern parts of the Mid-Norwegian coast have lower levels of activity. Since 1997, a local network in the Rana area (Northern Norway) has located a large number of small, shallow coastal earthquakes (magnitudes up to Ml 2.8). Several new focal mechanism solutions with inverted (90 deg. rotation) horizontal stress directions compared to the regional case have also been determined. The earthquakes show a complicated spatio-temporal activity pattern, with the activity distributed among several distinct groups, all having similar NW-SE elongated trends. There does not appear to be any connection between the observed earthquakes in this area and the nearby Baasmoen fault, a major fault thought to have been postglacially active.

The northern parts of the North Sea have the highest levels of seismic activity in Fennoscandia. Recently, a new local network (in the Bremanger area) has provided new insight into this activity through improved location and detection capabilities. Although detailed correlation of earthquakes and faults is always difficult due to hypocenter location uncertainties and problems in tracing the fault plane with depth, new detailed fault mapping in this area combined with improved earthquake data may be able to provide more insight into the interaction of existing faults and seismic activity.

The Masi-99 Project

Johannes Schweitzer

Abstract: In cooperation with colleagues from the University of Potsdam, NORSAR deployed this summer 13 temporary seismic stations in Finnmark. The 3C MARS-LITE stations of the University of Potsdam were installed at the end of May for about 4 1/5 month at 15 different sites. All data were continuously recorded and copied on CDROMs together with all available date from the permanent stations ARCES, KEV, KTK, and TRO. For the data analysis the following main topics / questions are planned to be investigated:

1) neotectonic movements on the Stuoragurra fault in Finnmark.
2) fault plane solutions for the best observed events in this area.
3) travel-time tables for local/regional P- and S-phases.
4) local/regional amplitude attenuation curves by observing the same events at different distances.
5) the 3C data will give us a much better understanding of the S-phase behavior in Northern Scandinavia.
6) receiver function study for all stations will give us at least a map of the Moho depth in this region.
7) search for sources of the ocean generated microseism.

A New Look at Segmentation of the Subducted Plate in Southern and Central Alaska

N. A. Ratchkovski
R. A. Hansen

The Alaska-Aleutian subduction zone extends along the Aleutian arc and terminates in the Alaskan Interior around 64oN latitude. Previous studies have suggested a segmentation of the Alaskan Wadati-Benioff zone (WBZ) on the basis of earthquake locations, geometry of the volcanic arc, and a variety of other data. The identified blocks are termed the southwestern (Kodiak), central (Kenai), and northeastern (McKinley) segments. The Alaska Earthquakes Information Center (AEIC) records and locates thousands of the subduction zone earthquakes each year. Previous relocation studies of the AEIC catalogs, using the Joint Hypocenter Determination method, have shown that the relocated hypocenters have more accurate relative locations and, therefore, provide more detail on the geometry of the Alaskan WBZ. The purpose of this study is to provide additional evidence for the segmentation of the subducted plate in southern and central Alaska and to create a catalog of the relocated earthquakes for future studies.

The earthquake data was selected from the AEIC catalog according to the following criteria: 1) occur between July, 1988 and July, 1998; 2) local magnitude Ml no less than 2.0; 3) focal depth greater than 25 km; 4) epicenter located between 58oN and 65oN; and 5) number of P and S phases no less than 8 and 4, respectively. In total, 15,552 earthquakes satisfied the above criteria. Since the selected earthquakes occupy a rather large volume (700 km by 700 km by 200 km), we needed to assure that the station corrections are determined for approximately similar ray paths. Therefore, the selected earthquakes were divided into blocks on the basis of their hypocentral locations and each block was relocated separately. We used three depth intervals: 25-50 km, 50- 100 km, and 100-200 km; geographic parallels served as the boundaries between the blocks within the depth intervals. For each block we tested different relocation parameters to assure the most reliable relocation results. In this way, all earthquakes were relocated in 17 individual blocks with the number of events in each block ranging from 77 to 1,677.

Out of the selected earthquakes, 14,102 events were relocated. Maximum hypocentral shifts reach values of 20 km in a few extreme cases. Average epicenter shift is 3.7 km and average upward and downward depth shifts are 4.0 and 4.1 km, respectively (roughly the same number of earthquakes shifted upwards (47%) and downwards (53%)). The overall change in WBZ with respect to the initial locations is that the WBZ seismicity became more compact, revealing details about fine structure within the WBZ. In particular, we were able to identify more precisely the boundary between the Kenai and McKinley blocks. In addition, there is an evidence for a plate segmentation within the McKinley block. These findings may result in improvement of tectonic models for Interior Alaska.

Y2K-1, a milestone for NORSAR

Anders Dahle

Abstract: The 90's represent a decennium of considerable change for NORSAR, culminating in the establishment of NORSAR as an independent foundation 1st of July 1999. A review of NORSARs history from 1968 to date and of present activities and organization will be made.

Poster introduction/Poster session

Chairman: Roger A. Hansen

Poster

Continuous Assessment of Upper Limit MS

Tormod Kværna
Lyla Taylor
Johannes Schweitzer
Frode Ringdal

The continuous seismic threshold monitoring technique (TM) is used to provide a continuous assessment of the size of events that may have occurred in a given geographical area. The main application of this technique has until now been restricted to short-period seismic data, both at regional and teleseismic distances. We have recently initiated an effort to apply the continuous TM technique to long-period data, for the purpose of obtaining a continuous assessment of surface wave magnitude (MS). In principle, this application is straightforward, but in practice one has to take into account many factors, not all of which apply to the short-period case, such as surface wave dispersion, oceanic versus continental propagation paths, the difficulties in calculating surface wave magnitudes at regional distances, regional calibration formulas for log(A/T) vs log(STA) and so on.

Nevertheless, the TM application holds promise to significantly improve monitoring of surface waves. One of the main considerations of TM is that it provides a realistic estimate of network detection thresholds during "unusual" noise conditions, such as in the coda of a large earthquake or during a large aftershock sequence. In the short-period case, we have demonstrated that the global detection capability can deteriorate significantly for many tens of minutes following a large earthquake. In the long-period case, this situation could be expected to be far worse, since surface waves from a large earthquake can last for many hours.

We present initial results from investigating the relation between PIDC station magnitudes and STA based estimates calculated from bandpass filtered data, as well as a case study with monitoring of surface waves from a mining area on the Kola peninsula during and after a MS 7.6 earthquake.

Poster

Earthquake focal mechanisms and stress in Norway

Erik C. Hicks
Hilmar Bungum
Conrad D. Lindholm

A total of just under 100 earthquake focal mechanism solutions from onshore and offshore parts of Norway have been analyzed with regard to crustal stress orientation. The study area was divided into six areas assumed to have a relatively homogeneous stress field, each containing between five and 25 focal mechanism solutions. Inversion of the focal mechanism data within each group for stress was performed, yielding a stress tensor representative for each of the six areas.

Overall, it appears that the regional stress field in Norway has a NW-SE to WNW-ESE orientation of the maximum horizontal stress direction, which can most likely be attributed to the gravitational effect of the mid-Atlantic ridge, the "ridge-push" effect. However, certain areas show a 90 degree rotation (or inversion) of the horizontal stress directions. This is particularly evident for parts of the Northern North Sea and coastal areas in Northern Norway, and is to some extent observable in the Oslo Rift area. This indicates significant influences from regional and/or local stress sources. These same areas also have elevated levels of seismic activity compared to the regional activity.

Poster

Status of Project TOR fall 1999

Peter Voss
Sören Gregersen

Field work of Project Tor , teleseismic tomography across the Tornquist Zone, is over and data processing and preliminary interpretation are well under way. We have distinguished very significant deep lithosphere differences. The seismographs constituted in 1996-1997 the largest seismic antenna ever in Europe, going from south of Hamburg to Stockholm. The Tor project has a horizontal resolution of 20-30 km compared to more than 100 km in previous studies. The Tor area is along a well studied crustal profile of an earlier project, so that the sediments and crustal structure are assumed known, and the inversion efforts are concentrated on the deep lithosphere and asthenosphere differences to depths around 300 km. The investigation can be called two-and-a-half dimensional, being a 900 km profile with 100 km width plus a few seismographs off the profile. The investigation has established a 3D crustal/upper mantle model based on existing data and through ray tracing in the model, a picture of the lower lithosphere/asthenoshere systems influence on the seismic rays is established. For several events of the large data base it is shown that the observed travel time anomalies of 1-2 seconds can be divided almost equally between known crustal effects and lower lithosphere/asthenosphere differences, accounting for about one second of travel time differences.

Poster

Near Real-Time Integration of Seismic Data from Regional Seismic Networks and the Global Seismic Network

F. Vernon
D. Harvey
G. Pavlis
R. Hansen
K. Lindquist
D. Quinlan
M. Harkins

Within the last several years, a new and effective real-time system for transporting and processing seismic data has been developed. The system, known as Antelope, makes it possible to integrate near real-time data from many diverse data sources over the INTERNET into a complete real-time seismic processing system that includes detection, network triggering, event association, and preliminary location and magnitude estimates. In this presentation we have combined near-real-time data from PASSCAL experiments, the ANZA seismic network in southern California, the Kyrgyz Broadband Network (KNET) in central Asia, the Alaska, Nevada, and Washington regional seismic networks, along with real-time stations of the IDA and USGS ASL components of the IRIS Global Seismic Network.

Poster

The International Arctic Research Center (IARC):

Parnterships in Arctic Research

The International Arctic Research Center has been established on the campus of the University of Alaska, Fairbanks to serve as a focal point for excellence in international collaboration in global change, and tectonic hazard research in the Arctic. The mission of IARC is to provide an environment that will nurture higher level multidisciplinary research by integrating and synthesizing past, present, and future efforts. Information on the IARC science plan, facilities, and implementation strategies can be found on the World Wide Web at http://www.iarc.uaf.edu/

Poster

Origin and Emplacement Mechanisms of the Fennoscandian Rapakivi Granite Batholiths - Insights from the Babel profiles

Annakaisa Korja
Pekka Heikkinen

The Fennoscandian rapakivi granites were intruded in the Subjotnian (1500-1650 Ma) within the Svecofennian in an extensional environment that developed 200 Ma after the Svecofennian orogeny (1800-1900). The rapakivi granites are temporally, and often also spatially, associated with gabbros and anorthosites as well as diabase dyke swarms. The Finnish rapakivi granites resulted from the partial melting of intermediate to silicic Svecofennian lower crust. The coeval gabbro-anorthosite rocks and diabase dykes are mantle-derived (Rämö, 1991). On the deep seismic reflection profiles BABEL 1,6 and 7, rapakivi granite and related gabbro intrusions appear as non-reflective laccoliths delineated by listric reflectors interpreted as shear zones and by normal or reverse faults. The listric shear zones flatten out at a detachment zone following the middle to lower crustal boundary or the Moho boundary. The detachment zones are upward concave beneath the batholiths. The lower crust has high velocities (> 7 km/s) and is highly reflective indicating small scale velocity and density contrasts and high average density for the lower crust. From the seismic sections, it is clear that the crustal deformation associated with the formation of the rapakivi granite batholiths are restricted to the underlying crustal section and its immediate vicinity. The following sequence of events is visioned to have led to the present crustal architecture. When mantle-derived magmas increased lower crustal temperatures and extensional environment was created. The upper and middle crust extended along listric shear zones whereas the lower crust deformed via plastic flow. Detachment zones developed at the Moho boundary and at the middle to lower crustal boundary. The continued underplating induced voluminous partial melting of the lower crust. Listric shear zones provided pathways for both mafic and later also for granitic partial melts to intrude and extrude the upper crust. The pronounced curved structure in the lower crust was created as a response to the thinning of the upper and middle crust. This thinning was compensated from below by mantle-derived magmas. Additional thinning of the lower crust was caused by the escaping granitic partial melts. Granitic and gabbroic magmas formed plutons filling the space created by the extension of the upper crust. After cessation of the mantle magmatism, a new Moho boundary developed at the mafic-ultramafic boundary beneath the rapakivi granite batholith. Concurrently the newly formed rapakivi granites cooled and contracted. The thermal dome collapsed and a deep basin formed on top of the collapsed granite. Later the basins were filled with material currently exposed as the Jotnian sandstone sequences. In the following Postjotnian (1100-1200 Ma) underplating of the area, mafic magmas reached the upper crust in large volumes. The magmas formed dolerite sills and dykes that occupy faults as well as planar contacts within the rapakivi granites.

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