28th NORDIC SEMINAR ON DETECTION SEISMOLOGY

June 16 - 17, 1997

UNIVERSITY OF HELSINKI
Aleksanterinkatu 5, Helsinki

28TH NORDIC SEMINAR ON DETECTION SEISMOLOGY, HELSINKI, FINLAND, JUNE 16 - 17, 1997

PROGRAM

Monday 16th June 1997

11:00 - 12:00	Registration of participants in the main building of the University of Helsinki, address: Fabianinkatu 33 (Entrance also via Aleksanterinkatu 5)
12:00 - 12:05	Opening words Urmas Luosto
Session 1	**Seismic Monitoring of a Comprehensive Test Ban Treaty and Related Topics**
Chairman:	**Heikki Korhonen**
12:05 - 12:20	Statement by the Ministry for Foreign Affairs Kari Kahiluoto
12:20 - 12:40	NOR_NDC; Norwegian National Data Centre Ulf Baadshaug and Svein Mykkeltveit
12:40 - 13:00	Discrimination of Regional Events Using Prototype IDC Event Characterization Parameters Nils-Olov Bergkvist
13:00 - 13:20	Time Delay and Slowness Corrections for NORSAR Array Jan Fyen and Berit Paulsen
13:20 - 14:20	LUNCH

Session 2	**Earthquake Seismology and Tectonics**
Chairman:	**Erik Hjortenberg**
14:20 - 14:40	Event Magnitude, Capability Maps and Magnitude Thresholds Tormod Kværna and Frode Ringdal
14:40 - 15:00	Stress Inversion of Earthquake Focal Mechanism Solutions in Norway Erik Hicks
15:00 - 15:20	How Reliable are the Paleoseismic Data? Kuvvet Atakan
14:20 - 15:40	Seismotectonics in Western Anatolia Kuvvet Atakan, Ridvan M. Karpuz and Orhan Kaya
15:40 - 16:00	COFFEE BREAK
16:00 - 18:00	COASP workshop chaired by Roger A. Hansen
19:00 - 20:00	Reception of the Ministry for foreign affairs at the Premises of the Ministry for foreign affairs , Katajanokka - Helsinki (Tramway #4 or # 2 stop at Aleksanterinkatu 20, opposite to the building of the University "Direction Katajanokka/Skattudden: See Map)

Tuesday 17th June 1997

Session 2 (cont.)	
Chairman:	**Frode Ringdal**
10:00 - 10:20	Earthquake Hazard Zonation in NW-Europe Conrad Lindholm, Hilmar Bungum and Ander Dahle
10:20 - 10:40	Recent Felt Earthquakes in Norway Kuvvet Atakan and Anders Dahle
10:40 - 11:00	Preview of the NEONOR Project; Neotectonics in Norway Erik Hicks

Session 3	**Multinational Cooperation in the Arctic and Europe**
Chairman:	**Roger A. Hansen**
11:20 - 11:40	From SIL to PRENLAB Ragnar Stefansson
11:40 - 12:00	Progress Towards Real-time Seismic Monitoring in the Arctic Roger A. Hansen and Kent G. Lindguist
12:00 - 13:00	LUNCH
13:00 - 13:20	COASP - Cooperative Arctic Seismological project Erik Hjortenberg
13:20 - 13:40	Experiences at the IDC Maija Franssila
13:40 - 14:00	Study of travel-time models for the Barents region E. O. Kremenetskaya, V. E. Asmin and F. Ringdal
14:00- 14:20	COFFEE BREAK
Session 4	**Seismic sounding, prospecting and tomography**
Chairman:	**Urmas Luosto**
14:20 - 14:40	The **Tor** project: 120 seismographs in Sweden - Denmark - Germany The **Tor** working group, Søren Gregersen
14:40 - 15:00	EUROBRIDGE: Deep Seismic Sounding From Sweden To Ukraine Jukka Yliniemi and EUROBRIDGE Seismic Working Group
15:00 - 15:20	Crustal Structure in Southern Finland Pekka Heikkinen and Jari Malaska
15.20 - 15.40	Crust-upper Mantle Tomography for Southern Finland Irina Sanina and Tellervo Hyvönen
15:40 - 16:00	Closing remarks — open discussion

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HOW RELIABLE ARE THE PALEOSEISMIC DATA?

by

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ABSTRACT

Recent developments in paleoseismology and the importance of the data provided by paleoseismological studies in seismic hazard analysis increase the need for systematic treatment of uncertainties. Usually, uncertainties are inherent to the interpretation of geological phenomena based on field observations which may satisfy several alternatives. Such interpretations become useless when alternative solution axist but not documented in detail, and especially when the relative reliability of the favored interpretation with respect to the alternative interpretations is not known. A simple method, based on qualitative description of the uncertainties related to the paleoseismological data and especially in its interpretation, is proposed. Any interpretation of a geological phenomenon involves scientists's judgement of some diagnostic criteria. Once a classification of the disgnostic criteria is prepared, a priority can be given, based on the relative reliability of each. Weighted quality factors can then be assigned for each diagnostic feature used during the consecutive stages of the interpretation process and finally, a cumulative uncertainty can be attached to the final result. This will allow the user from the seismic hazard applications, to account for these uncertainties in a systematic way prior to its use in the analysis. The method will be illustrated through a simple example using logic tree formalism applied to the paleoseismological data interpretation process.

SEISMOTECTONICS OF WESTERN ANATOLIA

by

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(2) Norsk Hydro Research Centre, Bergen, Norway
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ABSTRACT

Western Anatolia is tectonically one of the most active and rapidly deforming regions of the world. Present day seismicity in the region, as expressed by approximately 24.000 recorded earthquakes within period 1904-1988 (ISC), is a manifestation of this ongoing deformation. The general overview of the epicentral distributions correlates well with the regional tectonic features. However, at local scales the lack of detailed studies, except few cases, makes it difficult to outline the fault geometries or fault rupture processes. Previous fault plane solutions indicate almost univocally normal faulting along the boundaries of the E-W oriented grabensystems, which dominate the structural and morphological trends in the region.

Spatial seismicity patterns, based on the International Seismological Centre (ISC) data from 1904 to 1988, revealed some interesting aspects of the active tectonics of the region. In addition to the dominant E-W oriented grabens such as Büyük Menderes, Küçük Menderes and Gediz, a number of NE-SW oriented earlier zones of weakness coincide with distinct epicenter concentrations.

Late Paleogene to Recent extensional tectonic evolution of central Western Anatolia involves three regional-scale and two local basin systems. The regional-scale basinsystems include (i) the Late? Oligocene to Early Miocene, NE-trending graben system, (ii) the Late Miocene thermal sag basin, and (iii) the Quaterny, roughly E-W striking half grabens. The local structures include 8i) the early middle Miocene N-S trending depressions, (ii) the late Middle Miocene initial Büyük Menderes graben, (iii) the latest Miocene? to Pliocene breakway basin, and (iv) the Quaternary satellite half basin.

Extensional episodes are alternated with regional-scale uplifts accompanied primarily by erosion and cessation in magmatism. Major uplifts occurred in Early/Middle Miocene, early Late Miocene, latest Miocene, and Pliocene/Pleistocene time. Uplifts, two periods of organic maturity, and changes in crustal heat regimes and regional stress configurations are explained by underplatingprocesses characteristic for back-arc extensional areas.

RECENT FELT EARTHQUAKES IN NORWAY

by

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ABSTRACT

Seismicity in Norway and the adjacent offshore areas may be regarded as low compared to the active plate bounbdaries. However, a significant amount of earthquakes occur among which some are also felt. In this report, a summary of the recently recorded felt earthquakes in Norway and the surrounding areas will be presented. Among these, special emphasis will be given to a specific earthquake sequence occurred in offshore western Norway. During the last six months of 1995 an increase in the seismic activity in this rea was observed reaching to its maximum in September. Within this sequence four earthquakes had magnitudes larger than 3.0. On 31 October 1996, three other earthquakes in the same area with magnitudes (M_L) 3.4, 3.4 and 3.5, were felt along the western coast. No similar earthquake sequences are observed since 1984 where reliable set of records exist. This sequence can be regarded as the third documented earthquake swarm, after the well-known Meløy (Bungum et al., 1979) and Steigen (Atakan et al., 1994) swarms that both occurred in northern Norway. Another important earthquake was felt in Finnmark on 21 January 1997 (M_L=3.7), northermost Norway, which occurred along the previously known post-glacial fault Stuoragurra. Additionally, there was a significant earthquake west of Svalbard on 20 August 1996, with magnitude of 5.3 (Mb). This earthquake was followed by a number of afterschocks. Relative importance of the above mentioned earthquakes will be discussed in the context of seismotectonics of the region and comparisons will be done to previous occurrences during the last decades.

In addition to the above, there were two very recent events which will be given special attention. On 12 may 1997, at 22:05 (UTC), an earthquakewas felt at Lysefjorden, in SW-Norway, induced probably by tunnel construction related to a power-station. On 13 May 1997, at 22:07 (UTC) another earthquake magnitude (M_W) 3.1 occurred at the northern part of the Troll-field. This earthquake was felt and was followed by a minor shoch approximately 7 hours later.

NOR_NDC, THE NORWEGIAN NATIONAL DATA CENTER

by

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ABSTRACT

The National Data Center is one of the components of the GSETT-3 (Group of Scientific Experts Third Technical Test). The NDCs are established in the participating countries and are responsible for the maintenance of the seismic stations and forwarding of waveforms to the International Data Center (IDC). The NDCs also receive standard products (event bulletins, status reports) produced by the IDC and may request additional data. The Norwegian NDC has also acted as a regional data center, forwarding data to the IDC from stations in other countries: FINESS (Finland), GERESS (Germany), Hagfors (Sweden), Sonseca (Spain) and Nilore (Pakistan). NOR_NDC has further contributed to the supplementary (Gamma) data delivered to the IDC through the Finnish NDC. After describing the work performed at the NOR_NDC during GSETT-3, we will discuss the initial plans for implementing the new stations planned for the upcoming IMS (International Monitoring System) network. The IMS network will be used to monitor the CTBT (Comprehensive Test Ban Treaty) and will comprise 6 stations on Norwegian Territory: 2 seismic primary, 2 seismic auxiliary, 1 infrasound and 1 radionucleide station.

DISCRIMINATION OF REGIONAL EVENTS USING PROTOTYPE IDCVENT CHARACTERIZATION PARAMETERS

by
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ABSTRACT

At the Swedish NDC we have started to investigate the Event Characterization Parameters since recently in routine production at the prototype IDC in Washington.

As a first step we have analyzed frequeny dependent amplitudes from mine explosions, underwater explosions, rockbursts and presumed earthquakes. The explosions and rockbursts are located in Sweden while the presumed earthquakes are located in both Norway, Sweden and Finland. The magnitudes range from 2.3 to 3.7 and station to event distances range from 200 to 1500 km.

For each event max amplitudes of Pn, Pg, Sn and Lg in four different pass-bands have been retrieved from the IDC. In the first run we will focus on the amplitude ratio Pn/Lg with regard to discrimination capability.□

TIME DELAY AND SLOWNESS CORRECTIONS FOR THE NORSAR ARRAY

by

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ABSTRACT

A seismic wavefront crossing a large array will show deviations froma plane wavefront. Using plane wave array beamforming, the calculated time delays will not match the observed time delays.An effort has been made to establish a new time delay correction data base for the NORSAR array that can correct for these deviations.The talk will focus on possible improvements in detectability andprecision of estimated slowness using the corrections obtained.

PROGRESS TOWARDS REAL-TIME SEISMIC MONITORING IN THE ARCTIC

by

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ABSTRACT

Three new initiatives allow for advancement of the COASP project for Arctic Seismic Monitoring in near-real-time. 1) An expanded cooperation with Japanese Universities; 2) The initiation of a Tsunami Hazard Mitigation effort within the Pacific Rim; and 3) Advances in data communication of packetized digital data over TCP/IP long and short haul connections. The University of Alaska maintains seismic networks and arrays that have traditionally been used to monitor seismicity in the interior of the state, developing catalogs that include approximately 5,000 events per year, and about 60,000 events overall. As part of the international working group COASP, we have begun efforts to improve regional monitoring of the entire Arctic region, initially in the Aleutian Islands but also extendable to Kamchatka and elsewhere within the Arctic. We present near-real-time technology based on the Iceworm system, a enhancement of the USGS Earthworm arhitecture, to which we have added the relational database system known as Datascope. The Iceworm system makes automatic phase picks based on comparisons of short-term and long-term averages; associates those phase picks to create hypocentral estimates with a generalized beam-forming technique; and provides a framework for the addition of other processing modules. This will allow the combination of seismic network processing and array processing techniques in cooperation with NORSAR for enhanced regional seismic monitoring. The result is a modern, flexible, database-driven approach to near-real-time regional monitoring that is our first step towards sharing seismic monitoring of the Arctic region with the international Nordic community. In addition to these technological advances, we present an initiative whereby we are expanding the number of broadband seismic stations along the U.S. west coast and Alaska, and improving communications between other U.S. and Japanese regional networks.

STRESS INVERSION OF EARTHQUAKE FOCAL MECHANISM SOLUTIONS IN NORWAY

by

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ABSTRACT

A total of 101 (of which 15 are determined as part of this study) earthquake focal mechanism solutions were compiled for Norway and adjacent margins and shield areas, as a step towards a comprehensive mapping of the present day regional stress field. The new focal mechanisms were determined by first motion polarities in combination with full waveform modeling, and range in magnitude from 1.8 to 4.0.

The focal mechanism solutions were divided into twelve zones, and an inversion with regard to stress was performed on the mechanisms within each zone. The inversion method follows Gephart (1990), and involves searching for the stress tensor that gives the least residual for the focal mechanism solutions within the group. The aim is to reduce the uncertainty inherent in the focal mechanism regarding the angle between the principle stresses and nodal planes, by assuming all mechanisms within the zone are generated by the same stress tensor. The results are in all quite consistent, most areas having a direction of maximum horizontal stress that is compatible with a ridge-push generated regional stress field originating from the North Atlantic ridge. It is notable that areas with low seismicity (and thereby having scarce focal mechanism data) are less consistent with this model than areas with a higher level of seismic activity. This can be interpreted as lowered effective stresses in certain areas, giving a less consistent fault slip pattern.

PREVIEW OF THE NEONOR PROJECT; NEOTECTONICS IN NORWAY

by

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ABSTRACT

Neotectonic crustal deformations have been observed at a large number of locations in Norway, both on local and regional scales, but no major attempt has until now been made in addressing such phenomena through a multidisiplinary approach. A detailed investigation involving examination of new data and a unified interpretation is a prerequisite for improved understanding of the dynamic processes currently active in Norwegian regions.

Such understanding is desirable from a scientific point of view and also has practical implications, including aspects of geological risk. Active faulting in offshore regions may in addition to the triggering of potential submarine slides also have implications for fault sealing.

The NEONOR project will investigate neotectonic phenomena in Norway through the acquisition and processing of new seismological, geodetic and geological data, with focus on sites with existing reports of such phenomena. The project is organized under the combined responsibility of NGU, IKU, NPD, SK and NORSAR, with NGU as main contractor and project manager.

In addition there are several participating sponsors and subcontractors. The project comprises the following activities over the three year timeframe:

* Classification and quality assessment of existing neotectonic reports.
* Detailed mapping of sites where neotectonic phenomena have been reported, and production of a 1:3 mill. map of neotectonic phenomena in Norway.
* Collation and interpretation of shallow seismic data (sparker and high resolution multichannel data) from IKU and OD, aimed at mapping recent off shore faulting.
* Acquisition of new geological and geophysical data at six specified regions expected to have neotectonic potential.
* Acquisition of local seismological data by means of new seismic stations.
* Acquisition of local and regional high resolution geodetic data.
* Joint interpretation of acquired neotectonic data.
* Geodynamic modelling aimed at understanding recent and present day crustal dynamics.
* A post doctorate fellowship and a Dr.scient fellowship over two and four years respectively are essential parts of the project.

COASP - Cooperative Arctic Seismological Project.

by

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ABSTRACT

In 1994 the International Arctic Science Committee (IASC) discussed the need for an international effort to establish a high arctic seismic network and data centre and to carry out a number of data analysis projects.

In 1995 the IASC Council asked an international group of seismologists to discuss the need for cooperation in the field of Arctic seismology. The group was called the COASP ad-hoc group, and held a meeting in Copenhagen in connection with the 26th Nordic Seminar on Detection Seismology.

In 1996 the previous ad-hoc group was adopted as a formal IASC group by the IASC Council and is now a project group according to agreed terminology.

It held its second meeting in connection with the ESC 25th General Assembly in Reykjavik. At the meeting Roger Hansen gave a status report on the COASP pilot project, "Automatic array processing of Arctic earthquakes, with special application to Alaska and adjacent seas seismicity". This pilot project is now called "Arctic Seismicity", and it is planned to make a catalogue of Arctic earthquakes and to submit the hypocentres to ISC.

STUDY OF TRAVEL-TIME MODELS FOR THE BARENTS REGION

by

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ABSTRACT

As part of the Co-operative Arctic Seismology Project (COASP), NORSAR and Kola Regional Seismological Centre (KRSC) have begun a comprehensive study of seismicity, seismic wave propagation and seismic event location in the Barents region. This paper gives initial results from this research program. As is well known, accurate location of seismic events with a regional network requires detailed knowledge of the propagation characteristics of seismic waves in the region. For Fennoscandia, an excellent velocity model (the NORSAR model) has previously been developed, and is being used at both KRSC and NORSAR. In this study, we have applied the NORSAR model to the general Barents region, including Western Russia, and compared it with the IASPEI 91 model which is currently used by the GSETT-3 IDC. We have selected six well-recorded events in the region, including the calibration explosion in Khibiny on 29 September 1996. For this one event the exact location and origin time is known, whereas for the other events we have recomputed the location using available stations in the GSETT-3 network, the Kola network and the IRIS network. In order to minimize the effect of unknown velocity structure, we have used only P-readings in the relocation procedure. This method is less sensitive to regional variations than using a combination of P and S, because a shift in P-velocities will cause a shift in origin time, without influencing signifi- cantly the epicentral estimate. In fact, the IASPEI-91 model and the NORSAR model gives almost identical location estimates when using P-waves only. After locating the events, we have compared predicted and actual P and S-wave travel times, using both models. Our approach has been, for each model, to use the estimated epicenter and origin time based on the P-data for that model, and then compare the predicted and observed S-arrivals. It turns out that the IASPEI-91 model gives S-wave velocities that are consistently too low compared to the observed data. On the other hand, the NORSAR model shows excellent fit between the predicted and observed arrivals. We conclude that the NORSAR model is appropriate not only for Fennoscandia, but for the entire Barents region from Spitsbergen to Novaya Zemlya, and also for Western Russia. Use of this model would be expected to improve location accuracy considerably compared to the use of IASPEI-91, especially when both P and S phases are used in the location procedure. Another conclusion from our study is that in the absence of a well-calibrated velocity model, it seems preferable to make epicenter estimates based on P-phases only, since these location are less sensitive to model errors than locations based on a combination of P and S phases. However, this conclusion is rather preliminary, and we plan to conduct more detailed studies to validate it and to quantify the expected improvements. There are some other interesting observations that will also be subjected to further study. For example, the local velocity structure near Khibiny is highly azimuth-dependent, with low velocities to the north (Lovozero) and high velocities to the south (PLQ). Also, the velocities across the western part of the Barents shelf appear to be even higher than those predicted by the NORSAR model. Admittedly, the difference is small compared to the difference between NORSAR and IASPEI, but it might still be a subject for further investigations.

EVENT MAGNITUDES, CAPABILITY MAPS AND MAGNITUDE THRESHOLDS

by

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ABSTRACT

We have developed an algorithm for obtaining short-term average (STA) based magnitude estimates for all Alpha stations in the current GSETT-3 network.This has been done through analysis of a large event data base, where individualrelations between A/T and STA were found for each station.Preliminary results show that the STA based event magnitudes are in close agreement with the event magnitudes provided by the IDC, and that the STA based station magnitudes have a lower standard deviation than the A/T based IDC station magnitudes.By calculating continuous station magnitudes (noise magnitudes), we have developed a simplified algorithm for assessing the three-station network detection capability. During noise conditions these results are in good agreement with the simulated detection capability of the GSETT-3 Alpha network. But unlike the simulated approach, our approach is able to immediately accommodate variations in detection capability caused by "unusual" conditions like station outages, large earthquakes and aftershock sequences, which may cause the network detection capability to deteriorate for hours.Along the same lines we use the continuous station magnitudes to compute so-called magnitude threshold maps (threshold monitoring, TM). These maps include no assumptions on the SNR required for detection or the minimum number of stations required to generate an event hypothesis, but instead use the observed seismic field to place an upper limit to the magnitude of possibly hidden events. E.g., during background noise conditions we find that for the region north of 30 degrees N, the GSETT-3 Alpha network will generally be unable to detect events below mb 3.5. On the other hand, the threshold map tells us that if there was an event in this region it would need to have a magnitude below 3.0. In somewhat simplified terms, we could say that during noise conditionsthe TM approach is able to "monitor" an area at an mb level 0.5 units lower than the conventional "detection based" approach. During the occurrence of large earthquakes, we will show that this difference can become even larger.

EARTHQUAKE HAZARD ZONATION IN NW-EUROPE

by

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ABSTRACT

Two cooperative efforts are currently organized in order to compute seismic hazard across borders in NW Europe. One effort is linked to the Global Seismic Hazard Assessment Program (GSHAP) and involves Denmark, Finland, Sweden and Norway. The second effort is a cooperation between Norway and Great Britain aiming at harmonizing the zonation work associated with the National Application Document (NAD) as required by the implementation of Eurocode 8, "Design provisions for earthquake resistance of structures". A review of the work carried out so far is made, and some key issues concerning the technical approach are discussed.

FROM SIL TO PRENLAB

by

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ABSTRACT

The SIL project was a project of the Nordic countries in earthquake prediction research. It was funded by the Nordic Council of Ministers, by the Science Foundations of Denmark, Norway and Sweden and by the Government of Iceland. Funding was secured in 1988 and the project ended in 1995. The basic idea behind SIL was to study and monitor the physical processes leading to earthquakes. The main objective of the SIL project was to create a seismic acquisition and evaluation system which in real-time would evaluate information carried by small earthquakes to discover stress changes, fault movements and other possible changes related to earthquake processes.The SIL project was very successful. An automatic acquisition and evaluation system was created, the SIL system, which provides high level bulletin information of earthquakes down to magnitude zero. The small 8 stations network as it was at the start has expanded to 33 station network in Iceland and also to other places and applications. It has been shown that information from small earthquakes reflect tectonic processes and can be used for exact mapping of active faults. Tens of thousands of evaluated earthquakes per year provide fairly continuous monitoring of crustal processes. With the physical approach which was the basis of the SIL project it has opened ways for new approaches, both in the field of mitigating seismic risk as in the understanding the crustal processes and structure in general with f.ex. applications in search for thermal energy.The SIL project has also paved the way for a new European project in the field of earthquake prediction research, the PRENLAB project. The PRENLAB project is a multidisciplinary approach, containing besides significant seismological development, geology to reveal paleostresses and faulting during millions of years, deformation studies by continuous GPS and SAR and theoretical modelling. The PRENLAB project is a continuation of the basic idea of the SIL project, i.e. a physical approach to the understanding of where, how and when dangerous earthquakes strike.

The Tor project: 120 seismographs in Sweden - Denmark - Germany.

The **Tor** working group, reporter and chairman Soren Gregersen, KMS, Rentemestervej 8, DK-2400 Copenhagen NV, Denmark; e-mail: srg@kms.min.dk.

The largest seismic antenna ever in Europe has been in the field this winter 1996/97. The project has been named Tor for Teleseismic Tomography experiment across the Tornquist Zone. It crosses the boundary between **two markedly different crustal domains**, the shield in Sweden and eastern Europe, and the geologically younger central Europe. The Tornquist Zone goes NW-SE through Denmark, Sweden and Poland, so the antenna has been chosen to go NE-SW. The number of seismographs was for most of the half year project period approx. 120, of which 1 out of 5 is broad band, the rest short period seismographs. The field work will finish around the time of our Scandinavian seismology meeting.

In previous deep geophysical studies it was demonstrated that the lithosphere contrast is significant. The aim of the project is to **delineate how the transition occurs**, for geological unravelling of the history. The Tor project has a horizontal **resolution of 20-30** km compared to more than 100 km in the previous studies. The investigation includes **P-wave** teleseismic travel-time tomography plus **S-wave tomography**, **anisotropy** and **many inversion methods**. The project is part of the Europrobe program. It is a cooperation between scientists in 9 European countries and USA.

The Tor line goes along a well studied crustal profile of an earlier project, so that sediments and crustal structure are assumed known, and the inversion efforts are concentrated about the deep lithosphere and asthenosphere differences to depths around 300 km.

The investigation can be called 2½ dimensional, being a 900 km profile with 100 km width plus a few seismographs off the profile. Many good signals have already been extracted from the immense data bank. They show similarity enough for good correlation of signals, and difference enough for exciting interpretation.

EUROBRIDGE: DEEP SEISMIC SOUNDING FROM SWEDEN TO UKRAINE

by

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ABSTRACT

The EUROBRIDGE DSS profile is designed to establish the deep lithospheric structure of the East European Craton between the exposed Archaean and Proterozoic complexes of the Baltic and Ukrainian shields . It is an international collaboration of the Geological Survey of Lithuania, Warsaw Institute of Geophysics, GFZ-Potsdam, Belarussia Institute of Geological Sciences, Ukraine Institute of Geophysics, Moscow Centre of Regional Geological Investigations, and Glasgow, Helsinki, Oulu and Uppsala universities. The first, major phase of onshore data acquisition took place in 1995 across Lithuania. Ten explosive borehole shots were fired at about 30 km intervals along the NW-SE profile. Seismic recorders were deployed at 76 sites over the entire 280 km profile. An eleventh shot was fired near to Gotland. Acquisition was extended through Belarussia in 1996. Along a 544 km transect, 18 shots were fired at 16 points. Recording was undertaken at 128 stations: 20 in Lithuania, 100 in Belarussia, and 8 in the Ukraine (Fig.1).
Seismic traces of both experiments exhibit high quality P- and S-wave arrivals. Clear crustal critical refraction and diving P-waves are observed. First arrivals from the mantle begin at about 200 km offset on the NW-part and about 240 km on the SE-part of the profile. Strong reflections from deep crust and Moho are commonly observed. Several major layers have been identified by 1-D interpretation of the data, followed by 2-D raytrace modelling of the lithosphere beneath Lithuania and Belarussia. Crystalline crust can be divided into an upper crust of P-wave velocities 5.9-6.4 km/s, and a lower crust of 6.6-6.9 km/s for the Lithuanian part and 6.6-7.2 for the Central and SE Belarussian parts of profile. The Moho boundary beneath Lithuania is defined by a sharp P-wave velocity jump from 6.9 km/s to about 8.3 km/s and in Central Belarussia from 7.2 km/s to 8.3 km/s. Moho depth is estimated to be about 44 km in NW and Central Lithuania and increases rapidly to about 50 km in SW Lithuania and Belarussia. The Belarussian crust is laterally more heterogeneous than that below Lithuania. A prominent upper crustal feature with a laterally velocity jump of about 0.2 km/s seems to mark the border between Fennoscandia and Sarmatia. A clear reflection event is observed from an interface at 60-70 km depth below some parts of the profile, especially in Lithuania (see Fig. 2+3 or more?).

Our results suggest that Lithuania and the northern part of Belarussia are parts of Fennoscandia, despite the absence of a 7.0-7.6 km/s deep crustal transition zone in Lithuania. A laterally seismic inhomogeneity in central part of Belarussia may mark the estimated border between the Fennoscandian and Sarmatian part of the East European Craton. Thus, EUROBRIDGE is providing significant information which can be integrated with other geological studies to determine the Proterozoic geodynamic processes that formed the East European Craton and its constitutent parts: Fennoscandia, Samartia and Volga-Uralia.

28th NORDIC SEMINAR ON DETECTION SEISMOLOGY, HELSINKI, FINLAND, JUNE 16-17, 1997

CRUST-UPPER MANTLE TOMOGRAPHY FOR SOUTHERN FINLAND

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Abstract

First results of applying tomography method to local explosion data in southern Finland show similar structure blocking than the stochastic analysis of the same data. The method was applied on the P- and S- arrival time data from local explosions and DSS shots recorded by the seismic net in southern Finland.

Structural inhomogeneities of the size of about *15 km, 30 km, 50-65 km, 80-120 km, 150-200 km* and *300-450 km* were found for the region by using Kolmogorov's structure function (i.e. the mean of squared residual differences as a function of distance difference). Blocks of the same size and similar depths of recflecting boundaries have also been interpreted from the results of the DSS-profiles in the crust and in the upper mantle of the region.

The method of subsequent subtraction of anomalies (Nikolaev & Sanina, 1982) was applied to local P- and S-wave velocities. In the tomography inversion block size of *50 km × 50 km* was used for the region mainly due to the poor ray coverage and the simple ray tracing procedure. The first results show similar behaviour for both P- and S-wave velocities in the upper crust up to the depth of ~ *30 km*. Also comparison with the results of DSS profile SVEKA is in agreement to our findings. At the depth of ~ *77 km* the anomalies change their sign from negative to positive under the NE Moho depression. The zero isolines divide our region into blocks in the crust and upper, with their sizes varying from *50 km* to *200* km. The obtained velocity anomalies indicate also the border zone between the Archaean and Svecofennian domains.

Our results are based on many simplifications in modelling, and thus the next step will be to increase the number of events by adding regional earthquake data, and by applying more sophisticated ray tracing methods.