University of Helsinki
Institute of Seismology

33rd Nordic Seminar on Detection Seismology and Workshop on CTBT Monitoring Technologies

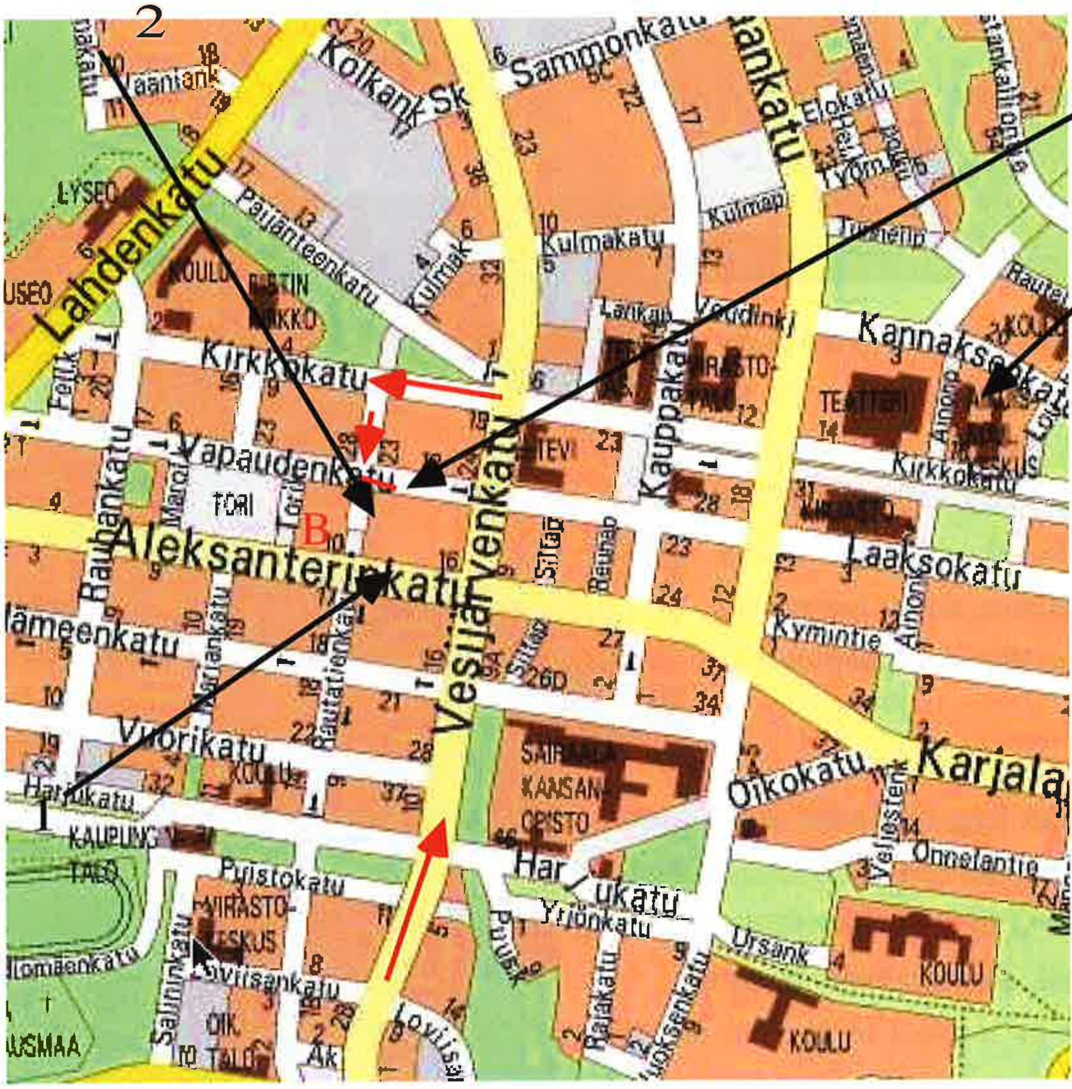
Lahti Adult Education Centre, Lahti, Finland
September 25 - 27, 2002

Lahti (Lahtis in Swedish) is a lively city of 100000 inhabitants. It locates by the Lake Vesijärvi on post-glacial ridges. It has become famous for its excellent winter sports facilities, and it has hosted four times World Championship games.

The city has long traditions of furniture industry. Also, the first radio masts in Finland were erected in Lahti in 1920's, and there locates still today the radio museum.
Lahti can be reached by bus in less than two hours from Helsinki, and there are several direct bus lines from Helsinki international airport. By car the city is easily accessible, along national highway #4.

Weather in this time of the year varies quickly. The maximum day temperatures is around 10°C, but it can reach 15° C (55° F), rains are expectable. For the nights and evenings we recommend that you take warm sweaters. For those you will attend the field trip to FINES casual clothing, rugged boots or footwear are essential. Don't forget raincoats or umbrella

Owing to an IT-conference at the same time in Lahti we were forced to change the hotel to **HOTEL MUSTA KISSA,** address Rautatienkatu 21. In fact the hotel locates in the same block as the former choice Lahden Seurahuone. The map of the Lahti's downtown area is shown below.



1= Hotel Lahden Seurahuone, 2 = Hotel Musta Kissa, 3= University of Helsinki Congress Centre, Palmenia (Adult Education Centre), 4= Hotels' Car park. B= Bus stop.

Those going to Lahti by bus, ask the driver to stop at **Aleksanterinkatu**, and Hotel Musta Kissa (HOTELLI MUSTA KISSA = Black Cat) on a pedestrian zone. Find the hotel logo (shown on right) in front of the hotel. Car drivers please, follow red arrows in the map.

Some of the attendants have done their own reservations in hotel Seurahuone, which is just around the corner in the same block.

BUS DEPARTURES AT THE AIRPORT

At Airport (Platform 1C)	Arrival in Lahti	
01:00	02:25	
01:25	02:45	
02:00	03:15	
03:25	04:50	
04:30	06:00 * Transfer Connection	Only Mo - Sa
06:25	08:00 * Transfer Connection	
07:05	08:40 * Transfer Connection	
08:35	10:05 * Transfer Connection	
10:00	11:25	
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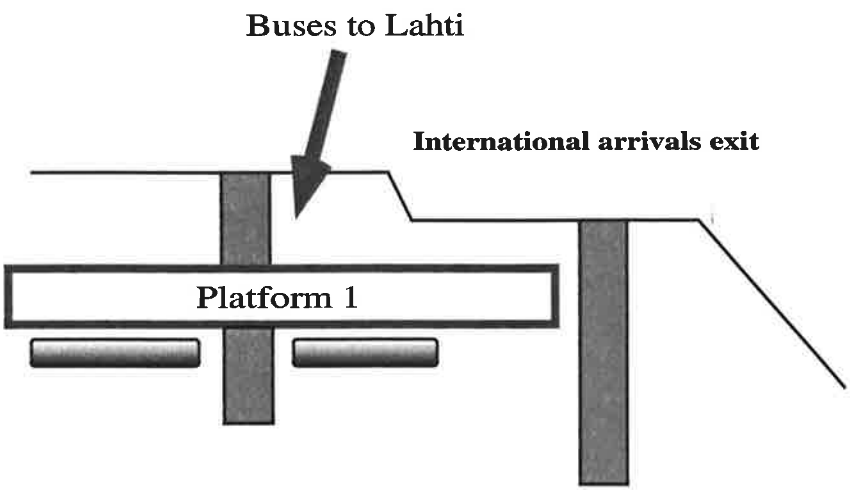

Express bus timetables are available in the hotel's reception.

Those who like to go to Lahti by train, please let me know in the earliest convenience, and I shall provide the timetables and details.

HOW TO GO TO LAHTI BY CAR

At the arrival hall there are many car rentals and evidently you can rent a car already at home. In southern part of Finland traffic sign texts are in Finnish and Swedish. When leaving the airport by car follow at first the sign

After that follow drive toward **HELSINKI**, and after a few kilometres go to the outermost ring and take direction to East (itään/österut).

Drive the Kehä/Ring III approximately 10 kilometres eastward and after that follow the traffic signs, and take the Lahti lane.

Please, note if you miss this intersection you are probably heading for the old Lahti road (road number 140). Do not worry, you will have several accesses to the multilane highway, and of course you can use this, as well, but it takes more time.

As you are on Highway #4 (E75) you will drive approximately 90 kilometres, and there is a traffic sign

Follow the direction "**KESKUSTA**". After passing under the railroad you have entered Vesijärvenkatu. Drive that until Kirkkokatu, then turn to left to Kirkkokatu and immediatelly in the first intersection to the left to Rautatienkatu. One intersection later again to left to Vapaudenkatu, and you should see P traffic sign. Hotel Seurahuone and Hotel Musta Kissa have parking slots in the same building at Vapaudenkatu. Hotel Lahden Seurahuone's address is: Aleksanterinkatu 14 and address of Hotel Musta Kissa is Rautatienkatu 21 (a pedestrian zone).

HOW TO EAT IN LAHTI

Lahti is very popular congress city and there are many national and international cuisine restaurants, pizzerias and cafés close to the workshop venue. Also, many ethnic restaurants are within walking distance from the congress centre, without forgetting omnipresent fast-food restaurants and cafés everywhere in the city centre. In the entrance lobby of the congress centre there is a small lunch cafeteria. On thursday the Institute of Seismology will host the congress lunch in Restaurant Fellmanni.

CURRENCY

Finland belongs to the European Union's monetary system and the currency is euro ( ) which has almost the value parity with USD.

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Congress Centre

Lahti Congress Centre "Palmenia"	**+358 3 892 11**	**Facsimile: +358 3 892 20219**

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Roland Roberts

USA

University of Fairbanks, Alaska

Roger Hansen

PROGRAM

Wednesday 25th September, 2002

12:00	Registration
13:00	Pekka Heikkinen: Opening address
13:05	Pilvi-Sisko Vierros-Villeneuve: Statement of the Ministry for Foreign Affairs of Finland
	INVITED PRESENTATIONS Chair: Pekka Heikkinen
13:20	S. Mykkeltveit: Activities of Working Group B of the CTBTO PrepCom
13:50	J. Fyen: Seismic Monitoring
14:20	D. McCormack: Infrasound Monitoring
14:50	A. Isolankila: Radionuclide Monitoring Technology in The CTBT Verification
15:20	Break
	SESSION I: SEISMOGRAPH STATIONS, MONITORING SEISMOLOGY AND MONITORING TECHNOLOGIES Chair: Matti Tarvainen
15:50	R. Bödvarsson: The New Swedish National Seismic Network - Present Status
16:10	N.-O. Bergkvist, M. Mårtensson, D. Öberg: The New Hagfors Array Station
16:30	J. Havskov: Trends in Seismic Instrumentation
16:50	J. Saari: Two New Microearthquake Networks in Finland
17:10	D. McCormack: Developments in Seismic Monitoring Activities in Canada
17:30	S. Gregersen: Status of ORFEUS

17:40	Poster Presentations
	N. A. Ratchkovski and R. Hansen: New Constraints on Tectonics of Interior Alaska: Earthquake Locations, Source Mechanisms, and Stress Regime
	M. Kuusisto, P. Heikkinen and A. Korja: The Geophysical Study of the Northern Baltic Sea
	P. Lindblom, J. Inkinen and M. Tarvainen: Seismic Background Noise in Estonia
	M. Uski, T. Hyvönen, A. Korja and M.-L. Airo: Is there a correlation between earthquakes and mapped faults in Finland?
17:50	End of Session I
18:00	Ice-breaking Reception (3rd floor)

Thursday 26th September 2002

	SESSION II: EARTHQUAKES, SEISMICITY, SEISMIC RISK AND SEISMIC HAZARD ASSESSMENT Chair: Páll Halldorssón
09:00	C. Lindholm: Induced Seismicity
09:20	H. Bungum, S. Sannan, C. Lindholm and P. Lacroix: A new Stochastic Model for Earthquakes and its Application to Synthetic Catalog Generation
09:40	I. Banitsiotou: Site-specific Probabilistic Seismic Hazard Estimation. Some Applications in Greece
10:00	P. Mäntyniemi, T. M. Tsapanos and A. Kijko: An Estimate of Probabilistic Seismic Hazard for Ten Greek Cities
10:20	S. Gregersen: Earthquakes and Change of Stress Since the Ice Age in Scandinavia
10:40	P. Mäntyniemi and A. A. Nikonov: The Kuusamo, Finland, Earthquake of 1926: A Joint Analysis of Macroseismic and Early Instrumental Data
11:00	Break
	Session II (Cont.) Chair: Pavel Filatov
11:20	M. Roth, V. Øye and H. Bungum: Automatic Microseismic Monitoring
11:40	P. V. Filatov, Yu. V. Fedorenko and E. S. Husebye: SeisSchool Project - Equipment, Database and Network Operation
12:00	H. Bungum and C. Lindholm: Holocene Seismicity and the Norwegian Continental Margin, Observations and Models
12:20	M. Boulaenko and E. S. Husebye: Electronic Learning Modules for Students: E-Module 1 - Plate Tectonics and E-Module 2 - Scandinavian Geophysics
12:40	R. Hansen, E. Suleimani and R. Combellick : Tsunami Hazard Maps of Alaska Communities
13:00	Lunch hosted by the Institute of Seismology in restaurant Fellmanni
	SESSION II (Cont.) Chair: Nils-Olov Bergkvist
14:10	R. Slunga: Results of the Microearthquake Analysis
14:30	P. Hálldórsson: Seismicity and seismic hazard in North Iceland.
14.50	P. V. Filatov, Yu. V. Fedorenko, M. Yu. Fedorenko and E. S. Husebye: SeisSchool Project in Norway — a Platform for Outreach and Research

15:10	M. E. Boulaenko, E.S. Husebye and T. R. M. Kebeasy: The Fennoscandian Earthquake Catalogue – Time and Space Presentation in a Geological Setting
15:30	Break
	SESSION III: VELOCITY MODELS, STRUCTURE OF THE LITOSPHERE, DEEP SEISMIC SOUNDING STUDIES Chair: Roger Hansen
15:50	P. V. Filatov, Yu. V. Fedorenko and E.B. Beketova: On-line Data Processing and Visualization in SeisSchool Project
16:40	Bus departs to the Medieval dinner in Hollola. Also, visit to the Finnish ski museum from 17:00 - 18:30 is arranged.
	PLEASE NOTE! THE BUS WILL LEAVE AT THE PARKING SLOT BEHIND THE CONGRESS CENTRE 20 MINUTES AFTER THE LAST PRESENTATION. THE BUS DOESN'T WAIT.

Friday 27th September, 2002

	SESSION III (Cont.) Chair: Jens Havskov
09:00	P. Heikkinen, I. T. Kukkonen, E. Ekdahl, A. Korja, S.-E. Hjelt, J. Yliniemi, R. Berzin and the FIRE Working Group: FIRE: Deep Reflection Profiles in Finland 2001 - 2003
09:20	E.C. Hicks, T. Kværna, S. Mykkeltveit, J. Schweitzer and F. Ringdal: Travel-times and Attenuation Relations for Regional Phases in the Barents Sea Region
09:40	T.M. Kebeasy, E. S. Husebye anf M. Boulaenko: A finite-difference Approach for Simulation Ground Responses in Sedimentary Basins: Quantitative Modelling of the Nile Valley, Egypt
10:00	S. Gregersen and TOR Working Group: Two-Step Lithosphere Transition from Sweden, Across Denmark and Germany
10:20	E. Kozlovskaya, S-E. Hjelt, J. Yliniemi, J. Korhonen, S. Elo and SVEKALAPKO Seismic Tomography Working Group: Problem-dependent Inversion of P-wave Arrivals from Local Events Recorded During the SVEKALAPKO Deep Seismic Experiment in Finland
10:40	J. Yliniemi, E. Kozlovskaya, K. Komminaho, S-E. Hjelt and SVEKALAPKO Seismic Tomography Working Group: Upper Mantle Structure Beneath the SVEKALAPKO Temporary Seismic Array in Finland Derived from Recordings of Local Events
11:00	A. Korja and P. Heikkinen: Crustal architecture of the Svecofennian - The BABEL collage

11:20	Break
	SESSION IV: OTHER ISSUES Chair: Elena Kozlovskaya
11:40	S. Gibbons, C. Lindholm and T. Kværna: Analysis of Seismic Decoupling
12:00	Discussion of the Future of the Nordic Seminars, and other Issues of Interest
12:30	Closing Remarks
12:40	End of the Workshop

ABSTRACTS

List of Abstracts

Site-specific Probabilistic Seismic Hazard Estimation. Some Applications in Greece

by

Iordana Banitsiotou

A new methodology proposed by Kijko and Graham (1999) for probabilistic seismic hazard analysis is described. The approach combines the best features of the "deductive" (Cornell, 1968) and "historic" (Veneziano et ál.,1984) procedures. It can be called a "parametric-historic" procedure. The approach permits the utilization of incomplete earthquake catalogues. The technique has been developed specifically for the estimation of seismic hazard at individual sites, without the subjective judgment involved in the definition of seismic zones, in which specific active faults have not been mapped and identified, and where the causes of seismicity are not well understood. As an example of the application of the new technique , the results of typical hazard analysis for a few big cities in Greece are presented.

The New Hagfors Array Station

by

Nils-Olov Bergkvist, Malin Mårtensson, Dan Öberg

The main idea in this presentation is to give a brief description of the new Hagfors array station after upgrading to meet the standards in the International Monitoring System (IMS). The upgrading that has been conducted in 2001 and 2002 includes a new array configuration proposed for new seismic array stations in the IMS, the construction of 10 new recording sites as well as new instruments and a new data acquisition system. Data is transmitted to the Provisional Technical Secretariat (PTS) in Vienna and to NORSAR via direct satellite links. Since late August 2002 continuous Hagfors data is also available at FOI in Stockholm via an internet connection to NORSAR. It is expected that the Hagfors station will be certified during the fourth quarter of 2002 after some minor upgrading of the software. An investigation has just started to see how the new array is performing.

Electronic Learning Modules for Students: E- module 1 Plate Tectonics and E-module 2 Scandinavian Geophysics

by

Mikhail Boulaenko and Eystein.S. Husebye

The rapid growth and easy access to the SEIS_SCHOOL/NORWAY network have attracted much attention to geosciences from teachers and students alike in participating schools. This faced us with the challenge of delivering knowledge to students who stay in various locations, require stimulating learning material, and request more new knowledge in short time. The electronic learning is the modern solution to this problem. The learning material is delivered in the form of E-modules - sophisticated interactive multimedia software programs. An E-module is executed on the student's platform and provides exciting interactive learning experience. Production of a high quality module is a complex process. In order to achieve reasonable production cost, while keeping module quality high we follow number of design principles: 1) separation of content and presentation, 2) separation of programming, graphical design, and content management, 3) use of standard technologies. We present the results of our work – two E-modules in geosciences, as well as conceptual model for the modules production.

The Fennoscandinavian Earthquake Catalogue - Time and Space Presentation in a Geological Setting

by

Mikhail E. Boulaenko, Eystein S. Husebye and T. R. M. Kebeasy

Earthquake catalogues may contain many spurious events stemming from human activities like mining operations, industrial construction projects and so forth in addition to real earthquakes. If these false alarms are not removed before performing seismic hazard assessments, seismotectonic studies and so forth their presence may significantly bias the final results. In extreme cases; interpreting explosion events in terms of the geological evolution of a specific area which have repeatedly happen in Fennoscandia are destructive in a scientific context. The commonly used Fennoscandian earthquake catalogue of Ahjos, M. Uski, and E. Pelkonen covering the time period 1375 - present are somewhat error prone for certain areas for the interval 1970 - 2000 coinciding in time with deployment of many new digital seismic stations and high mining activities. However, explosion activities often exhibit remarkable time distribution patterns which may be used in screening catalogues for spurious events. In this talk we demonstrate an interactive procedure tied to time-of-day and day-of-week criteria for eliminating such events. Historical earthquakes are occasionally given very large magnitude values while their epicenters may be located far apart so much subjective judgement are incorporated in the Ahjos, M. Uski, E. Pelkonen catalogue. We address this latter problem with reanalysis of thr Lurøy earthquake of 31 Aug. 1819 claimed to be the largest ever in NW Europe - our conclusion Not L
Hilmar Bungum and Condrad Lindholm argest.

Holocene Seismicity at the Norwegian Continental Margin, Observations and Models

by

Hilmar Bungum and Condrad Lindholm

At present, the seismotectonics of the Norwegian continental margin can be explained only through a complex interaction between a number of crustal stress sources and the tectonic history of the region. Immediately following the deglaciation the seismicity was very high(M7+) as evidenced through recent paleoseismological and other quaternary geological studies. One of these earthquakes may have triggered the subaqueous Storegga mega-slide about 8200 ybp. There are also observations of rock avalanches, landslides and turbidite events in fjords that most likely are related to earthquakes, which, as supported also by global ergodicity-based comparisons, may indicate that the present maximum historical magnitude of 5.8 may reflect a magnitude deficiency in this region.

A new Stochastic Model for Earthquakes and its Application to Synthetic Catalog Generation

by

Hilmar Bungum, S. Sannan, Condrad Lindholm and P. Lacroix

A new stochastic (marked point process) model for earthquake occurrence focusing on spatio-temporal interactions between earthquakes has been developed and tested. The model incorporates the occurrence of aftershocks as well as the build-up and subsequent release of strain, and the parameters of the model are estimated from a Bayesian updating of priors, using empirical data to derive posterior distributions.

Firstly, the model has been tested on a Californian earthquake catalog for 1932-99, simulating the occurrence for 1990-99 with good results. Secondly, the model has been tested on a Norwegian catalog, simulating long term future activity. One interesting application of this method is to provide a better basis for zoning free hazard estimation.

The New Swedish National Seismic Network - Present Status

by

Reynir Bödvarsson

There are now 38 digital broadband seismic stations in Sweden. The first six digital broadband stations in the Swedish National Seismic Network (SNSN) were started in 1998. An additional twelve stations came into operation in September 2000. During the year 2002 additional 20 stations are set in operation. More than 2000 local events have been recorded since September 2000, whereof at least 500 are earthquakes and the remaining are explosions or not yet definitely classified.

Additional 7 stations are now under construction in Lappland, covering the area of the known 6 large post-glacial faults there. The plan is to put these stations into operation at the end of this year.

SeisSchool Project in Norway - a Platform for Outreach and Research

by

Pavel V. Filatov, Yuri. V. Fedorenko, Mikhail Yu. Fedorenko and Eystein S. Husebye

The primary task of our research group is developing processing methods for seismic recordings at local distances. For this reason we need high quality seismic data and advanced network instrumentation. However, data from existing local networks do not meet our requirements here and also popular processing systems have some disadvantages in our view. Thus we have launched a network project locally - Seis/School/Norway - and motivations being i) need for high quality data for basic research, ii) with own network easy to test physically seismic network operation concepts and iii) foster science interest in high schools and having partners for cheap network operations.

Essential elements of our school network to be addressed in this presentations are:

* Advanced data collection and storage system - dimensioned to manage growing data flows, keep logical structure of initial collected data and having complex postprocessing analysis schemes.

* Integrated processing system - for fast probing of processing methods and providing management of complex results. Include high level mathematical language and supports for many programming languages. Compatible with existing applications via standard protocols/interfaces.

* Simplicity of user interfaces - system provide different interfaces for users with varying IT skills, and in extreme provide a professional environment for scientists and analysts.

In this presentation we will describe our software tools and discuss processing methods being with basis in our SeisSchool environment.

SeisSchool Project - Equipment, Database and Network Operation

by

Pavel V. Filatov, Yuri V. Fedorenko and Eystein S. Husebye

Three factors influenced our decision on SeisSchool involvement and development, namely i) problematic to ensure adequate seismic data for our own research from local and international data centers, ii) our avalanche monitoring in Khibiny had demonstrated the feasibility of low-cost instrumentation but high-quality seismic monitoring and iii) alliances with schools would be mutual beneficial - for us free Internet access thus eliminating network operational costs.

SeisSchool stations based on Cossack Ranger seismometer which plug in to a low cost (i486, i586) PC data-logger. The Cossack Ranger Mk. II seismometer consist of following parts: geophone sensors (NS,EW,Z), preamplifier and A/D-converter (19 bits). The geophones are of type GS-11D from Geo Space Corporation; eigenfrequency 4.5 Hz and measure ground velocity. The preamplifier converts velocity to ground acceleration and the design rationale is that the ambient noise is approximately flat in the acceleration domain.

All Norwegian high schools have permanent Internet access which we use to its fullest advantages; i) use the Network Time Protocol (NTP) for time synhronization to within 20 msec ii) monitoring station and update station software from the our offices (Hub) iii) segmented data records transferred to Hub within 5 min of true recording time. The first school installation we did ourselves partly to gain practical experiences but also for producing an installation manual. Three far away stations were installed by school staffers according to our instructions - some of these were oral as well.

In this presentation details are given on design principles, hardware and nearly two years of instructive operational experiences.

On-line Data Processing and Visualization in SeisSchool Project

by

Pavel V. Filatov, Yuri V. Fedorenko and E.B. Beketova

As part of their outreach efforts targeting for better enrollment of high school students many Earth Sciences department are launching EduSeis programs. In this regard an obvious advantage for seismologists is the general interest in earthquakes, in particular the destructive and also the local ones both of which get much media attention. Interest is one thing but the threshold of active student participation is much higher so it is necessary for schools to have their own seismograph installation - a strong motivation factor in our experience.

Traditionally, seismology is a 'closed' science that is not easily accessible for outside scientists and laymen alike. At most, a presumed distinguished seismologist explain an earthquake disaster via obsolete drum recordings on TV and then give Richter number etc. Such knowledge presentation is not very advanced nor instructive and obviously can be improved this is a design goal for our SeisSchool project. In essence, high school students should be just a few clicks away from the same knowledge base as used for TV presentation. Try yourself - visit our Web page on
http://pcg1.ifjf.uib.no

In this presentation we demonstrate how any seismology interested person, laymen and professionals alike, could monitor seismic network operation and locate earthquakes in near real time.

Seismic Monitoring

by

Jan Fyen

ABSTRACT MISSING

Two-step Lithosphere Transition from Sweden, Across Denmark to Germany

by

Søren Gregersen and TOR Working Group

The Tor project was designed to delineate the transition across a significant lithosphere difference, the Baltic Shield edge toward SW, across Denmark and into Germany. The project was named Tor, for Teleseismic Tomography across the Tornquist Zone, which is at least a part of the shield edge. It crosses in a NE-SW direction the Tornquist Zone, perpendicular to its strike. The seismograph array covered areas, where many seismic, crustal studies have been performed, and where tectonophysical interpretations of the crustal structures have identified a crustal boundary between the ancient plates of Baltica and Avalonia, which is not coincident with the important surface feature, the Tornquist Zone. The Tor project was supposed to concentrate on the deep parts of the lithosphere, below this well known sedimentary and crustal structure. The new results of Tor show a sharp and steep subcrustal lithosphere edge below the Tornquist Zone, and a less significant deep lithosphere transition near the crustal edge of the Baltic Shield. The non-coincidence of (1) sedimentary, (2) crustal, and (3) subcrustal lithosphere edges is signifant geographically and physically. The question is how special this is?

Earthquakes and Change of Stress Since the Ice Age in Scandinavia

by

Søren Gregersen

In a small, northern part of Scandinavia, where the present earthquake activity is not significantly different from its surroundings, large surface faults have been interpreted to show the occurrence of large earthquakes about 9,000 years ago. Signs of this are coincident landslides as well as liquefaction in loose sediments, which are very well dated through varv-counting. The interpretation is that the cause is stress release related to the final deglaciation after the last Ice Age. In contrast, the present dominating stress field in Scandinavia as a whole follows the pattern of the World Stress Map Project, namely compression along the absolute plate motion. This compression, NW-SE in Scandinavia, shows little influence of the deglaciation rebound, which is delineated by the area of the present-day lithospheric uplift. Through these observations change of dominating stress is clearly indicated during the last 9,000 years. And the modern earthquake activity of Scandinavia is not concentrated near the old, large earthquake faults. All these arguments influence the modern evaluation of earthquake hazard. This must be based on the present stress field, and not on that of 9000 years ago. The expectation of a large "10,000-year-earthquake" one of these days is zero, with the small uncertainty that such an earthquake could occur unexpected anywhere in a stable continental region.

Seismicity and seismic hazard in North Iceland.

by

Páll Halldórsson

During the last three centuries about 10 earthquakes with magnitude over 6 have occurred in Northern Iceland or off the north coast. Most of them have been damaging. A catalogue of historical events in the region has been compiled, where locations and magnitudes are estimated.

Together with instrumental data this catalogue has been used to estimate the earthquake hazard in the area.

Tsunami Hazard Maps of Alaska Communities

by

Roger Hansen, Elena Suleimani and Rod Combellick

The Geophysical Institute of the University of Alaska Fairbanks and the Alaska Division of Geological and Geophysical Surveys participate in the National Tsunami Hazard Mitigation Program by evaluating and mapping potential inundation of selected coastal communities in Alaska. The communities are selected in coordination with the Alaska Division of Emergency Services on the basis of location, infrastructure, availability of bathymetric and topographic data, and willingness for a community to use the results for hazard mitigation. We work in cooperation with the NOAA'/PMEL Center for Tsunami Inundation Mapping Efforts, which assists in developing bathymetric and topographic data grids for the area of interest. Three communities in the vicinity of Kodiak were the first for which we produced inundation maps. The work is under way for Homer, Seldovia, and possibly other communities along Kachemak Bay.

We use numerical modeling as a primary research tool to study tsunami waves generated by earthquake sources. We consider several hypothetical tsunami scenarios with a potential to generate tsunami waves that can affect the coastal communities. The nonlinear shallow-water wave equations are solved with a finite-difference method. We use embedded grids that increase in resolution from the source area to the target community. State and local emergency planners will use results of the numerical modeling combined with historical observations to develop evacuation plans and to educate the public for reducing risk from future tsunamis.

Trends in Seismic Instrumentation

by

Jens Havskov

Advances in seismology and instrumental development are closely linked. In the early days, all seismographs were specially made and had few, if any standard industrial components. This has gradually changed and the tendency today is that most components in seismic stations and networks are made up with standard industrial components. The main exception is the seismic senor which therefore now tend to be the single most expensive component in a seismic station. Part of this development has been made possible by the use of digital technology throughout, which has also resulted in a large development in programming, both proprietary and public domain. However, even in this field, mass production of sensors for vibration monitoring and seismic exploration has given quality sensors at low prices. So in principle one can build a seismic network with standard components and public domain software. This is not as simple as it sounds and instrument companies are still doing good business by developing cutting edge sensors and digitizers and putting it all together. This is particularly true for portable equipment where special technology is needed. A brief summary of the current development and some hints of where it might go will be given.

FIRE: Deep Reflection Profiles in Finland 2001 - 2003

by

P. Heikkinen, I. T. Kukkonen, E. Ekdahl, A. Korja, S.-E. Hjelt, J. Yliniemi, R. Berzin and the FIRE Working Group:

Project FIRE: Deep reflection profiles in Finland 2001-2003 The aim of the project FIRE (Finnish Reflection Experiment) is to investigate the structure of the crust in Finland along four transects of total length of 1700 km in 2001-2003. The participating institutions are the Geological Survey of Finland and the universities of Helsinki and Oulu. The data acquisition will be carried out by the Russian company Spetgeofizika. Funding of the acquisition is based on the partial compensation of the debt of Russian Federation to Finland.

The transects will cross the major geotectonic units of the Precambrian in Finland. The project FIRE is expected to provide new information on the lithospheric structure and shield evolution of the central part of the Fennoscandian Shield. The field work started in September 2001, and by mid-September 2002 the total length of the measured profiles is about 1000 km.

Acquisition parameters:
- Source: 5 vibrators (15.4 tons each)
- Frequency range 12-80 Hz
- Sweep length 30 sec
- Correlated record record 30 sec
- Shot point interval 100 m
- Geophone group interval 50 m (362 active channels)
- Split spread geometry with maximum offset of 9 km
- Maximum nominal fold 90.

Travel-times and Attenuation Relations For Regional Phases in The Barents Sea Region

by

Erik C. Hicks, Tormod Kværna, Svein Mykkeltveit, Johannes Schweitzer and Frode Ringdal

A database containing 45 events in the Barents Sea region has been compiled and analyzed with the aim of evaluating crustal models, travel-times and attenuation relations in the context of performing regional detection threshold monitoring of this region. The 45 events are mostly located around the circumference of the study area due to the virtually aseismic nature of the Barents Sea itself. Regional Pn and Sn phases were observable for most events in the database, while Pg and Lg phases were only observable for events with ray paths that do not cross the tectonic structures in the Barents Sea. This corroborates a number of previous observations of Lg-wave blockage within the Barents Sea. Three existing velocity models were evaluated, with a model having slightly lower S-velocities than earlier assumed in the upper mantle giving the overall best fit to the observed arrivals. In order to estimate magnitudes, short term average (STA) and spectral amplitude values were calculated in several frequency bands for all phase arrivals in the data base. There were no significant differences between spectral and STA amplitudes, so the latter were used as this parameter is more efficient to calculate in real-time processing. An inversion was performed in order to determine an attenuation relation specific for this region. The resulting magnitudes based on Pn, Pg, Sn and Lg phases gave an internally consistent, reasonably stable set of values, which can be calibrated towards any existing global or regional scale.

Radionuclide Monitoring Technology in The CTBT Verification

by

Arto Isolankila

In the verification regime of the Comprehensive Nuclear-Test-Ban Treaty the radionuclide monitoring technology can provide clear attributes of a nuclear explosion.

The objective of the radionuclide stations in the International Monitoring System is to detect man-made radionuclides in the air. The air samplers are operated manually (filter change, preparation and measurement is done manually) or automatically. The number of air sampler stations will be 80; 40 stations will be equipped also with noble gas detection capability.

The samples are analyzed gammaspectrometrically; nuclides are identified based on their gamma ray energies. The nuclear explosions can be distinguished from nuclear reactor releases by calculating certain nuclide ratios.

Since the number of data from radionuclide stations is high, Finnish NDC applies automated analysis and alarm system based on the hypothesis testing of selected relevant radionuclides. Data that trigger the alarm will be reviewed by human analyst.

A finite-difference approach for simulating ground responses in sedimentary basins: quantitative modeling of the Nile Valley, Egypt

by

T. R. M. Kebeasy, Eystein S. Husebye and Mikhail Boulaenko

On 12 October 1992, Egypt was struck by a moderate size earthquake with Mb = 5.9 or equivalent Ms = 5.2. It occurred southwest of greater Cairo (Cairo and Giza) and was widely felt from Alexandria to Aswan. This earthquake also caused widespread destruction and damages were mostly concentrated in greater Cairo, along the Nile Valley and in the Nile Delta area. The intriguing feature is the wide spread damages caused by this moderate size earthquake, which in turn motivated this study. We compute 2-D finite-difference (FD) synthetic wave field for the Nile valley prototype model with a maximum thickness of the sedimentary basin of 5 km and assumed uniform crustal thickness of 35 km. A variant of the latter model tested is a thin crust beneath the basin. We used a Ricker wavelet source that excite both P- and/or S-waves and are initiated as point sources. Focal depths vary from 5 to 20 km to simulate different scenarios. We investigate how various model features such as source position, deep sedimentary basin, crustal thinning and high attenuation in the shallow sedimentary layers may significantly influence the wave field across the Nile valley. The outstanding result of the wave field simulations is that the Nile Valley sedimentary basin and the associated strong impedance contrast produce significant focusing and amplification effects. It was found that the peak amplitudes may vary by one order of magnitude in the 3 – 8 Hz frequency band, across the Nile valley. Cairo itself is located in the eastern flank of the Valley, which explains quantitatively the extensive damages in the city itself even for moderate size earthquakes. The effects of strong attenuation in the uppermost 500 m and/or crustal thinning beneath the basin reduce the amplitudes but their influences are less significant. These results are interesting on two accounts; i) the extent of variations of synthetic wave field will always be less than the observed ones but unfortunately there are no Egyptian records to corroborate this results and ii) wave field variations are significantly larger than those deduced from ranges of Q-variations and seismotectonic modelling as used in most seismic risk analysis. These results imply that the wave field simulations can be very informative and provide realistic results in particular when accurate structural model information are available and even more if the synthetics can be corroborated with dense seismic network recordings.

Crustal architecture of the Svecofennian - The BABEL collage

by

Annakaisa Korja and Pekka Heikkinen

The BABEL profiles B, C, 1, 2,3,4, 6 and 7 form a 1200 km long nearly continuous cross-section through the Svecofennides. The near-vertical marine reflection profiles display a wide range of crustal structures that can be associated with both the accretionary Svecofennian orogeny (1.9-1.8 Ga) and the following Subjotnian and Jotnian rift-stages (1.65-1.11 Ga). The Svecofennian accretionary orogeny took place, when a number of micro-plates with island arc affinities and surface expression of a large archipelago accreted to the continental Karelian plate. Some of the accreting blocks seem to have had older cores that have acted as crustal indentors during the collision.

BABEL profiles 3 and 4 image a series of collisional terrane boundaries between Karelian continental margin, Savo Belt and Central-Finland Arc Complex (CFAC). In the north, the Karelian margin has been both over- and underthrust by Savo Belt. The Central Finland Arc Complex comprises folded thrust package on top of a continental nucleus and the Savo Belt. The associated subduction zone and accretionary prism are interpreted to lie to the south, underneath the Bothnian Basin area, where prominent NE-dipping, lower to middle crustal reflections are found along BABEL profiles 1 and 4. An oblique collision of the Central Finland Arc Complex and the continent resulted in the development of the transform fault on the young, hot Savo Belt.

BABEL profiles 1, 6, 7,and C images the internal architecture of the Southern and Central Finland Arc Complexes. The unusually thick crust (55-60 km) host unreflective, high density, mafic intrusions, which are here interpreted as a magmatic core of an island arc. To the south a highly reflective ramp anticline structure developed against this structure. The SFAC is an imbrication structure comprising thrust-slices that were stacked on an older continental nucleus (Bergslagen) in the final collision thickening the crust. Prior to the collision the SFAC underwent major extensional period during which the crust was thinned and dismembered.

Profile B images the architecture of the Central and Southern Swedish Svecofennides. Sörmland Basin is interpreted as the accretionary prism of the SFAC. It was thrust on both the SFAC-CFAC conglomerate and on the advancing continent to the south. The southern continent/island arc is characterised by NE dipping crustal reflections and Moho offsets as well as step-wise increasing thickness of the crust. After the final collision large volumes of mantle-derived material intruded the crust as giant mushroom-shaped plutons. It is interpreted to be the source for the TIB magmatism in southern and western Scandinavia.

Problem-dependent Inversion of P-wave Arrivals From Local Events Recorded During the SVEKALAPKO Deep Seismic Experiment in Finland

by

**Elena Kozlovskaya, Sven-Erik Hjelt , Jukka Yliniemi , Juha Korhonen, S. Elo
and
SVEKALAPKO Seismic Tomography Working Group**

The high quality recordings of local seismic events (earthquakes and quarry blasts) registered by the SVEKALAPKO temporary seismic array in 1998-1999 contain a lot of information about the 3-D structure of the upper lithosphere beneath southern Finland. However, the traditional local event tomography of SVEKALAPKO data cannot result in the velocity model valid for proper geological interpretation.

The main reasons for this is the lack of the space resolution, which results in strong non-uniqueness of the traditional tomographic inversion. This problem can be treated by introducing of various kinds of a-priori information into the tomographic inversion algorithm. The a-priori information available for the SVEKALAPKO study area includes not only the crustal velocity model compiled from cross-sections of previous DSS profiles, but also gravity data and petrophysical data collected and processed by the Geological Survey of Finland and the Finnish Geodetic Institute.

Usage of such a non-homogeneous a-priori information required a special problem-dependent algorithm of seismic data inversion, which was developed on the base of non- probabilistic uncertainty measures. An example of this algorithm application to SVEKALAPKO local seismic event data is presented.

The Geophysical Study of the Northern Baltic Sea

by

Minna Kuusisto, Pekka Heikkinen and Annakaisa Korja

In the year 2000, the University of Hamburg organized a marine geophysical student cruise in the northern Baltic Sea. University of Helsinki and University of Tarto took part organizing the cruise and land stations. A total of 16 profiles were measured between 24th August and 7th September 2000 by the research vessel M/s Heincke. The measurements consisted of 1300 km of shallow reflection seismic, gravity and magnetic surveys and 3 field stations recording seismic signal and magnetic field. The profiles were planned to give information on geophysics and geology of the poorly known northern Baltic Sea. The seismic data was processed by using standard data processing tools included in the Seismic Unix software package. The poster gives an overview of the research area, survey methods and preliminary processing results of the seismic data.

Seismic background noise in Estonia

by

Pasi Lindblom, Janne Inkinen and Matti Tarvainen

Seismic noise characteristics were studied in Estonia at three sites. The frequency band of interest was from 0.1 to 30 Hz to search potential seismograph station sites. The power spectral densities were computed for 24 - 48 hours periods during the summer 1999, and the noise samples were retrieved every second hours rejecting all possible interfering transient signals.

The noise level at the sites varied from -40 down to -55 dB relative to $(1\ nm/s)^2/Hz$ at the frequency range from 0.1 to 40 Hz. The diurnal noise level was studied at all sites. The highest noise levels were recorded at Töravare. The most silent site in turn was Särghaua, where the noise level was close to Peterson's low noise model.

Induced Seismicity

by

Condrad D. Lindholm

Induced earthquakes are in one way or another related to human activity, and can be divided in two groups: Triggered and truly induced. The triggered earthquakes are caused by tectonic stresses, they would probably have occurred sooner or later, but their time-space proximity to human activity indicate antropogenic activity as important for the release. The truly induced earthquakes are purely antropogenic in that stress buildup can be traced directly to human activity. For convenience we use the term 'induced' for both types. Earthquakes are mainly induced in three antropogenic settings, (1) in mines, (2) in connection with large water reservoirs and (3) in oil or gas fields where hydrocarbons are extracted. Furthermore earthquakes are induced in hydro-thermal fields, but since this industry is young compared with the tree above less data exist. A review of induced seismicity with particular emphasis on earthquakes within and in the proximity of hydrocarbon reservoirs will be given.

Activities of Working Group B of the CTBTO PrepCom

by

Svein Mykkeltveit

The verification system for the Comprehensive Nuclear-Test-Ban Treaty (CTBT) has been under establishment by the Preparatory Commission (PrepCom) for the CTBT Organization since 1997. Representatives of 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, the current status of development of the various components of the verification system will be summarized. Furthermore, an attempt will be made to identify technical and other challenges in the efforts towards completing the system.

The Kuusamo, Finland, Earthquake of 1926: A Joint Analysis of Macroseismic and Early Instrumental Data

by

Päivi Mäntyniemi and Andrei A. Nikonov

In the present work, the earthquake on 18 August 1926 is investigated. This event in the northeastern part of the country is the largest known within that area during historic times and therefore of importance for both an understanding of earthquake processes and seismic hazard assessment. Renqvist (1926) analysed the macroseismic questionnaire data for this shock but seemingly did not utilise all available information.

The present investigation aims at re-examining the 18 August 1926 earthquake using jointly macroseismic and early instrumental data. The original macroseismic questionnaires collected in Finland were augmented with contemporary press reports by scanning the Finnish press, as well as some foreign newspapers. In addition, a few previously unknown felt observations made inside the Russian territory were now available (Gorshkov, 1947). The early instrumental data comprised the respective arrival times taken from the bulletins for some stations in northern Europe and, in some cases, the original seismograms.

This presentation discusses macroseismic intensity assessment using different approaches and macroseismic parameter determination for the event. Various techniques, including graphical re-location and more modern computer algorithms, were applied to locate the event with the help of the arrival times.

An Estimate of Probabilistic Seismic Hazard for Ten Greek Cities

by

P. Mäntyniemi, Theodoros M. Tsapanos and Andrei Kijko

This study aims at assessing the levels of seismic hazard at the sites of ten Greek cities in terms of the maximum expected peak ground acceleration (PGA). The ten investigated cities were Athens, Heraklion, Jannena, Kalamata, Kozani, Larisa, Patras, Rhodes, Thessaloniki and Volos, the most densely populated and industrialised in Greece.

The methodology for probabilistic seismic hazard assessment developed by Kijko and Graham (1998, 1999) was applied. This approach allows for the use of either historical or instrumental data, or a combination of both. It has been developed specifically for the estimation of seismic hazard at a given site and does not require any specification of seismic source zones.

A new relation for the attenuation of PGA for shallow earthquakes in Greece given by Margaris et al. (2001) was employed. The data were retrieved from the data bank of the Geophysical Laboratory of the University of Thessaloniki. This data bank comprises information on a large number of Greek earthquakes since 550 B.C. (Papazachos et al., 2000).

The analysis of seismic hazard carried out for the ten Greek cities included an assessment of the maximum possible PGA at those sites and the calculation of the probabilities that a given PGA value will be exceeded at least once during time intervals of 1, 50 and 100 years at each site.

The maximum PGA values for the sites were obtained by applying the design earthquake procedure, assuming the occurrence of the strongest possible earthquake at the distance of 15 (±5) km from the site. The respective median values obtained were 0.24*g* for Athens, 0.53*g* for Heraklion, 0.28*g* for Jannena, 0.30*g* for Kalamata, 0.21*g* for Kozani, 0.24*g* for Larisa, 0.30*g* for Patras, 0.43*g* for Rhodes, 0.35*g* for Thessaloniki and 0.30*g* for Volos. The probabilities of exceedance of the estimated maximum possible PGA values were also calculated for the cities to illustrate the uncertainty of maximum PGA assessment. In addition, the effect of soil conditions was taken into account.

New Constraints on Tectonics of Interior Alaska: Earthquake Locations, Source Mechanisms and Stress Regime

by

Nathalie A. Ratchkovski and Roger A. Hansen

The tectonic framework of Alaska is dominated by subduction of the Pacific plate underneath the North American plate. Stresses due to the plate convergence are transmitted across great distances into Interior Alaska (> 500 km) where the deformation causes substantial crustal seismicity. While some of the earthquakes are associated with the large-scale strike-slip fault systems of Denali in the south and Kaltag and Tintina in the north, the majority of the shocks are located in a zone of distributed shear deformation between the two fault systems and compose three major NNE-trending seismic zones. Among the largest earthquakes in the Interior are the three M7+ shocks that occurred in 1900's. The most recent events of note are the three M 5+ events at the southern end of the Minto Flats seismic zone (MFSZ) in 2000. A block-rotation model has been proposed to characterize the deformation in Interior Alaska, in which the crustal blocks are rotating clockwise in a dextral shear zone between the Denali and Tintina fault systems.

Firstly, we use a double difference relocation method to relocate over 4,100 crustal earthquakes that occurred for the past 30 years in interior Alaska. New precise earthquake locations reveal new features in the structure of the seismic zones. The Fairbanks seismic zone (FSZ) is composed of 4 distinct NNE-trends. There is a E-W trending cluster of seismicity south of the FSZ that correlates with the location of the MS 7.2 1947 event which had a thrusting mechanism. The focal mechanisms for events in this area also indicate thrust faulting. The Kantishna cluster located at the southern end of the MFSZ and north of the Denali fault is composed of three distinct earthquake lineations. There is also a number of events within this cluster with the depths around 40-50 km, which do not relate to the seismicity within the subducting or the overriding plate. Relocations of the aftershocks of the 2000 ML 5.6 event indicate that the main shock and the ML 5.0 aftershock of Dec. 12, 2000 ruptured two parallel faults. In addition to AEIC data, we used the data recorded by PASSCAL instruments of the BEAAR experiment (Broadband Experiment Across the Alaska Range) to pick and locate the aftershocks.

Automatic Microseismic Monitoring

by

Michael Roth, Volker Oye and Hilmar Bungum

We have developed a software system for automatic monitoring of microseismic data. The system is designed for 3C seismic sensors deployed in observation wells. It contains modules for the interactive input of geophone positions, data formats, seismic velocities and technical parameters for the individual processing steps. Additionally it provides a module to determine the orientation of the geophones. Usually borehole geophones are gimbal-mounted so that one component is oriented into the vertical direction; the orientation of the horizontal components is random and has to be determined by use of calibration shots. The key elements of the automatic data processing are detection, phase picking, polarization analyses and finally the localization.

We will present the application of the software system to a hydro-fracturing data set. The data were recorded continuously with 12 3C geophones deployed in a vertical observation well about 100 m away from the injection well. The sampling rate was 0.5 ms resulting in a data flow of about 1 Gbyte per hour. During the 1-hour recording period about 1000 microseismic events occurred which exhibit temporal and spatial clustering. The processing and localization could be performed in real-time.

Two New Microearhquake Networks in Finland

by

Jouni Saari

Microearthquakes are a powerful tool for investigating the bedrock in great details and in relatively short time interval. In Finland, this fact has encouraged to arrivals of two new microearthquake network. This presentation introduces these projects.

The island of Olkiluoto in Eurajoki, in the western coast of Finland, has been selected as the site for the final disposal facility of spent nuclear fuel. In March 2002, Posiva established there a seismic network of six three-component accelerometers. The sensors are at the surface of the island surrounding the preliminary location of the final disposal facility. The current network (with a diameter of about 1 km) will possibly be extended to cover an area within few kilometres around Olkiluoto.

The microearthquake measurements in Olkiluoto aim to better understanding the structure, behaviour and long term stability of the bedrock. In the beginning the network monitors only tectonic earthquakes. Later, another important focus of the studies will be excavation-induced seismicity. In 2004, Posiva will start to construct an underground characterisation facility in Olkiluoto. This facility, called ONKALO, will be used to acquire detailed information about the bedrock in Olkiluoto, to be utilised in the planning of the final disposal facility. The construction of the actual final disposal facility is scheduled to start in the 2010s, and the final disposal of spent nuclear fuel can be started in 2020. The above mentioned construction works will change the characteristics (e.g. the stress field) of the virgin bedrock and produce microearthquakes, which can be observed by the seismic network. These observations of the disturbed bedrock give an opportunity to approximate the stability of the rock cavern and the adjustment processes going on in the surrounding rock mass.

Pyhäsalmi Mine, in Central Finland, is the oldest operating metal mine in Finland and the deepest in Europe. The production started in 1962 as an open pit. Underground mining started in 1976. Now the mine has been deepened down to 1441 m level. The products of the mine are zinc, copper and pyrite concentrates. Currently, the production is below 1000 m in "The Deep Ore" and rockbursts are a significant safety problem. At the end of this year, a seismic network of 24 channels will be installed to monitor rockbursts and seismic events occurring further away of the walls. The network will consist of four depth levels: -1100 m, -1200 m, and -1300 m and-1400 m. Each of the levels will have one three component and three single component geophones. The main objectives of the network are to improve the safety in the mines as well to optimise the mining strategy.

Results of the microearthquake analysis in Iceland and Sweden

by

Ragnar Slunga

The microearthquake analysis that was developed at FOA in Stockholm some 20 years ago is in routine use in the microearthquake networks in Iceland and Sweden. Since 1990 some 200,000 microearthquakes have been analyzed in Iceland and since Aug 2000 some 500 microearthquakes have been analyzed in Sweden. The data set from Iceland is very interesting as also a few large earthquakes occurred 1998-2000 within the network. Some interesting precursors will be shown ("everything stated about premonitory activity is supported"). For the Swedish net some results from the multievent analysis will be shown. A detailed physical interpretation of the microearthquake occurrency is possible. Such data will be of importance in modelling the crust and its behaviour under different loading. This will lead to a real understanding of the crustal processes involved in the generation of the microearthquakes.

Is There a Correlation Between Earthquakes and Mapped Faults in Finland?

by

Marja Uski, Tellervo Hyvönen, Annakaisa Korja and Meri-Liisa Airo

The Precambrian of Finland is heavily fractured. Although the distribution of fracture systems has been studied for decades, it has been difficult to determine which of the faults are still active. The stability of fracture zones and the recent bedrock movements are of keen interest today, due to safety estimations for a repository of spent nuclear fuel in Finland.

This poster shows preliminary results from a joint geophysical research focused on determination of source mechanisms for recent earthquakes in Finland, identification of active faults associated with earthquakes, and gaining information on the in situ stresses that cause the earthquakes.

We have determined focal mechanisms for three recent earthquakes located at different seismotectonic regions. In addition, mechanisms of the 1979 Lappajärvi earthquake (ML=3.8) and its' aftershock have been reevaluated. In order to obtain reliable estimates of the source parameters, we have derived local crust and upper mantle velocity models for the source areas. The events have been relocated using P- and S-phase arrival times from the nearest seismic stations and the new velocity models. Fault plane solutions have been calculated using P-wave polarities together with SV/P and SH/P phase amplitude ratios. Synthetic waveform modelling has been used to confirm the focal and structural parameters.

Finally, the obtained focal planes have been plotted on local aeromagnetic and topographic maps. Shaded relief and derivative representations of high-resolution aeromagnetic data have been applied to identify faults and fracture sets. The earthquake mechanisms have been correlated with these lineaments.

Upper Mantle Structure Beneath The Svekalapko Temporary Seismic Array in Finland Derived From Recordings of Local Events

by

Jukka Yliniemi, Elena Kozlovskaya, Kari Komminaho, Sven-Erik Hjelt and SVEKA-LAPKO Seismic Tomography Working Group

The SVEKALAPKO temporary seismic array consisting of 85 short period and 39 broad band stations was originally designed for studying the lithosphere structure beneath southern Finland by means of teleseismic events. In addition, the high quality recordings of about 580 local seismic events registered by the SVEKALAPKO array contain a lot of information about the upper lithosphere structure. These events are mainly strong underground explosions and quarry blasts from the mining sites in Finland, northwestern Russia, Estonia and northern Sweden. The body and surface waves from strongest local events were recorded at offsets up to 800 km from the source. Almost all the record sections of P- and S- waves demonstrate strong reflections from the Moho boundary. The refracted Pn and Sn phases can be seen as first arrivals at distances of about 200-600 km from the source. At offsets of about 400-800 km the P- and S- wave phases reflected from heterogeneities in the uppermost mantle were recorded. The forward ray tracing modelling of reflected and refracted upper mantle phases revealed strong velocity variations and differently oriented reflectors in the upper mantle beneath southern Finland. These upper mantle inhomogeneities can affect results of local event location based on standard 1-D velocity models.