Veðurstofa Íslands
Report

Ragnar Stefánsson

SIL project - final report

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SIL Project

Final report

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Contents

Summary

The SIL project is a cooperative Nordic project for earthquake prediction research in the earthquake-prone area of the South Iceland Lowland (SIL). Scientists and technical engineers from all the Nordic countries have cooperated on this project since 1986 and came to a formal end on November 21, 1995. The real start of the project was after its funding was secured in 1988. The project was financially supported by the Nordic Council of Ministers, by the Science Foundations of Denmark, Norway and Sweden and the Government of Iceland.

The basic idea behind the SIL project was to study and monitor the physical processes leading to earthquakes. It was concluded that small earthquakes would carry the most significant information about crustal processes in the focal regions of large earthquakes. Small earthquakes (microearthquakes) occur very frequently in earthquake zones. So if it would be possible to extract information from them, an almost continuous information would be gained about the stress conditions in the crust. Therefore 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 if stresses were changed, if faults were moved or other possible changes premonitory to earthquakes.

The main results of the SIL project can be summarized as follows:

1) An automatic seismic acquisition and evaluation system was successfully developed and has been in automatic operation since July 1991. This system automatically locates earthquakes within minutes of their occurrence and provides increasing amount of information of crustal processes related to the occurrence of the earthquakes. Since the autumn of 1992 an alert system has been in operation which provides information about changes in earthquake activity. The SIL system which was developed on basis of 8 seismic stations in South Iceland is now covering almost all of the plate boundary in Iceland, presumably with 33 SIL stations at the end of 1996. The SIL system is widely known as being in the forefront in the world in processing information carried by microearthquakes. Besides being of a scientific value the SIL system is already a practical tool for mitigating seismic and volcanic risk in Iceland.

2) It has been shown that small earthquakes reflect tectonic processes. Small earthquakes can be used for exact mapping of active faults in the crust and the movements along these faults. They can be used for observing stresses and stress changes.

3) The technology developed parallel with the SIL system has opened various applications for the SIL network. The quality of the system to trace active faults at depth can be applied in monitoring the effects of thermal energy excavation from depth and for finding water-carrying veins at depth. The system is now a basis for developing a new portable seismic system in Sweden.

4) The SIL project and the SIL system are the main pillars of a new EC project, Earthquake Prediction Research in a Natural Laboratory (PRENLAB). It is a project of 6 European countries and it is in many ways a continuation of the SIL project.

Earthquake prediction is one of the most pressing challenges of geosciences, i.e. to know where a dangerous earthquake will strike, how it will strike and when. The SIL project has paved the road for earthquake prediction research in Iceland and is a significant contribution of the Nordic countries to other earthquake-prone countries of the world.

1 The background of the SIL project

The general objective of the SIL project is a concerted research effort among the Nordic countries towards earthquake prediction and mitigation of earthquake risk in the earthquake-prone area of the South Iceland Lowland (SIL).

In a letter to the Nordic Council of Ministers dated November 3, 1986, 8 Nordic scientists applied for funds to carry out the project which was thoroughly described in the report Seismiskt datasamlingssystem för Södra Islands Lågland (Stefánsson et. al. 1986).

However, the discussions for a Nordic earthquake prediction research proposal started much earlier. Its origin was in an ad hoc committee (CAHRT) set up in 1980 by the Council of Europe. The objective of CAHRT was to create an European earthquake prediction program. In the resolution of the committee, special emphasis was placed on concerted research efforts in five so-called test areas, among them the South Iceland Lowland, which is cut through by the South Iceland seismic zone. Following these recommendations the chairmen of CAHRT, Luis Mendes-Victor from Portugal and Ola Dahlmann from Sweden visited Iceland on behalf of the committee and stressed the importance of Iceland as a test area in their report (Dahlmann and Mendes-Victor 1983).

During a meeting of Nordic seismologists, i.e. at the 15th Nordic Seminar on Detection Seismology in Tällberg, Sweden, in 1984, concerted Nordic efforts for creating a prediction research program based on South Iceland Lowland as the test area was discussed and a group emerged to specify a project which could provide the necessary background for an application to the Nordic Council of Ministers. The next step was a meeting of a group of seismologists and engineers in Oslo in April 1986 which laid the basis for the report and the application as mentioned above to the Nordic Council of Ministers in November 1986.

2 The basic objectives of the SIL project

The main objective of the project was outlined in the report as follows:

"This earthquake monitoring project aims to reduce losses due to damaging earthquakes, primarily by achieving a deeper understanding of where and when great earthquakes can occur. It is our judgement that the best results can be achieved by acquiring a knowledge of the physics and dynamics of the crustal deformations taking place in the region. The acquisition of such knowledge and its use for earthquake risk assessment by deterministic modelling of the dynamics of the area, will result in scientific advancement of general interest and of value to other earthquake-prone regions of the world.

The physics of crustal deformation processes will therefore be one of the main targets in this project."

It was stated that the study of frequently occurring microearthquakes was of central importance for understanding the physics of the earthquake source zones, and by their frequency they would give a semicontinuous record of changes in the regions of possible large earthquakes. It was stated on basis of some experience from microearthquake studies in Sweden and Denmark that earthquakes down to magnitude 1 may be related to regional tectonic stress field and this indicated that data extracted from microearthquakes give direct information about ongoing crustal deformations that may be the same process that produces damaging earthquakes.

Therefore the creation of and installation of a data acquisition system capable of collecting and evaluating high quality seismic data from microearthquakes was proposed. To be able to cope with the enormous amount of information carried by microearthquakes the evaluation had to be automatic, making use of the fast development in modern computer techniques leading to very powerful and cheap computers on the mass market. The new system should also be semi real-time system so the information carried by the microearthquakes could be used for warning purposes, as the microearthquakes would in many cases be the first indication about changes in and near the source region.

Besides the creation of the acquisition system a minor request for research was included in the application to the Nordic Council of Ministers. This was mainly thought of for a research fellowship, i.e. a researcher from outside Iceland who would help to bring to Iceland relevant knowhow and experience from the other Nordic countries. This was modified later, and in the "Second general report" (Stefánsson et al. 1989) is written about how to use the research part of the fund: "Research which in first hand has the objective to improve the parameter settings of the system and to collect and prepare high quality data on earthquakes and earthquake related phenomena".

The total amount of money applied for to the Nordic Council of Ministers was 6.9 MSEK for a 5-6 years project aiming at creating a seismic acquisition and evaluation system. The cost applied for included initial cost for equipment for 8 SIL stations in the South Iceland Lowland and the SIL center at the Icelandic Meteorologcal Office, and for a 5 years project and system operation. Of these 6.9 MSEK, 0.9 MSEK were allocated to research mainly aimed at system development.

The idea was that the scientific objectives of the project should be achieved in first hand through creating high quality data for further research.

3 The design objectives of the SIL network

The design objectives of the SIL network have basically been described (Böðvarsson 1988a; Stefánsson et al. 1989). The basic design criteria can be summarized as follows:

1 To collect wide dynamic range of earthquake data with sensitivity down to magnitude zero.

2 Sampling rate of 100 samples/sec and 1 ms clock accuracy for good resolution of the high frequency local earthquakes.

3 To take advantage of the modern relatively cheap computer technology available on the market to create a system based on much computer power at the station sites, i.e. high level evaluation at the remote sites. The main reason for this was the objective to create a system which would be cheap in operation, i.e. to save money on data transfer, without loosing data from earthquakes with significant information, which means to keep the sensitivity such that earthquakes down to magnitude zero would be recorded. Another reason for having much computer power at the site stations was to make it easy to attach other sensors to the system to monitor other earthquake related geophysical data.

4 To follow intensively changes in ongoing deformation processes, by fast automatic evaluation of data. To reveal in semi real-time as much information as possible from microearthquake recordings as well as from other available geophysical recordings about processes which could be precursory to earthquakes.

4 The main achievements of the project

The main achievements of the SIL project can be summarized as follows:

A seismic acquisition and evaluation system has been created and operated which renders in semi real-time (a few minutes off real-time) information about locations and a multiplicity of source parameters of at least, according to experience, 1000 earthquakes per day. The system to some extent collects data from other geophysical sensors. The system also now collects automatically teleseismic data of significance for those who are working on global tomography.

The system renders in real-time (within seconds) information of site station evaluations of great value for alert purposes.

An alert system has been built on the top of the SIL evaluation system which is now the main alerting system in Iceland concerning seismic and volcanic activity.

The significance of the system for risk mitigation is twofold. Firstly the early information and alerting capabilities of the system and secondly the existing capabilities and the potential capabilities of the system for mapping subsurface faults and fault instability.

Significant scientific outcome of the project are both based on direct scientific work within the project as well as on work carried out on basis of evaluated data from the SIL system.

It is a significant achievement of the SIL project that 18 stations in Iceland are operated from the SIL center at the end of 1995, compared to the 8 in the original project. During 1996 15 new permanent stations are presumed to be installed in the SIL system.

The installation cost for the 25 stations already in operation or planned, in addition to the original SIL stations, is estimated 4 MSEK. The yearly operation cost of the additional stations is 1200 KSEK. Most of this contribution stems from the recognition of the significance of the system for mitigating seismic and volcanic risk, and the significance of the system towards earthquake prediction and risk mitigation. Some of the contribution stems from the significance of the system for scientific work in general, especially studies of faults, stresses and tomography.

It is a significant achievement of the SIL project that the research project "Earthquake Prediction Research in a Natural Laboratory" (Stefánsson 1995) has now been promised 500.000 ECU, i.e. 4.3 MSEK. It is a two years project and it is a continuation of the SIL project and based on its achievements. Of this amount 55% will be entirely devoted to research projects based on data from the SIL system. The other 45% go to projects that are closely related to the SIL project and to the SIL system achievements.

4.1 The SIL system achievements

For information on the SIL system achievements and facilities, see the following reports and other publications: Stefánsson et. al. 1993, 1995; Böðvarsson 1996; Böðvarsson & Rögnvaldsson 1992; Böðvarsson et al. 1996; Slunga et al. 1994b and the attached documentation.

The outcome of the SIL project can be summarized as follows:

1 The SIL system was in partial operation from the autumn of 1990, and in full operation since the end of 1990. From July 1991 the system has been in full automatic operation. The system is very stable in operation and the up-times for individual site station operation is well over 95% of the time.

2 Automatic alert system based on central evaluation of a multiplicity of information (central alert) has been in practical operation since the autumn of 1992. It provides automatic alarm if certain parameters describing the situation within defined earthquake or volcanic zones are surpassed.

3 Station alert has been in operation since early 1995. It indicates increased noise, directivity and large earthquakes. It alerts within a few seconds. The station alert also includes strainmeters. The station alert is still more or less in a testing period and its practicability is so far not as much as the central alert.

4 The SIL system provides automatically and on a routine basis information on earthquakes, down to the sizes of microearthquakes which occur almost continuously. This is information on:

- Hypocenter locations
- Fault plane solutions
- Magnitudes based on maximum velocity amplitudes and moment magnitudes based on spectral amplitudes and focal mechanism
- Source parameters like corner frequency, radius of source, slip on the earthquake fault and stress drop in the earthquakes

5 Detection algorithms for safer detection of phases are under steady development, more accurate time picking and better characterizing. Neural network analysis is used in practice for distinguishing between P and S on the site stations. In preparation is to use on-line neural network analysis for more purposes, for example for picking polarities of phases.

6 Multievent analysis for very exact relative (10 meters) and absolute location of similar events is available in the system and used in mapping active minifaults and fault segments at depth and is the basis for inverting for the stress tensor. The multievent location analysis can now be run automatically on a daily basis. This has been done for testing purposes. The goal is to run this analysis on-line, as a part of the on-line automatic analysis.

7 There are several processes available at the SIL center for manual analysis and for reviewing the automatic analysis. Still there is a manual supervision and control of all the automatic analysis. This is done for safer results and for creating a better learning set for neural net analysis.

Among significant tools in the SIL center for manual analysis can be mentioned:

- OK: A tool for analysis of waveform data
- QUAKE-LOOK: A tool for recognizing and mapping active faults at depth

There are several tools available for displaying and following up seismic activity.

8 The experience with the SIL system indicates that the goal of a completely automatic source monitoring is within sight. This means that the automatic source monitoring is so good that little would be gained by transmitting the waveforms. This is of great significance for remote areas where the only communication might be satellite communication and for areas where seismicity is very high for example in volcanic areas or in the preparatory period of large earthquakes, in which cases manual interpretation is not practically possible in the given time space.

9 A "SIL User Manual" covering all the system is now available.

4.2 Scientific achievements

Some overview on the scientific achievements can be obtained in the following papers and reports: Stefánsson et al. 1993, 1995; Slunga et al. 1994b; Rögnvaldsson and Slunga 1994a; Böðvarsson 1996. The scientific outcome is to a large extent linked to the technical development as most of the research was as planned devoted to "improve the parameter settings of the system and to collect and to prepare high quality data on earthquakes and earthquake related phenomena". Some significant scientific results will be outlined below.

1 With the good hypocenter locations achieved in the SIL system evaluation and the large amount of earthquakes monitored, a detailed picture of the seismicity of Iceland has emerged, significantly more detailed than earlier was possible to obtain.

2 By comparison between fault plane solutions of earthquakes evaluated by the SIL system it has been shown that microearthquakes express the regional stress field and known tectonic features. This is significant in light of the views that prevailed for a while among many seismologists that such information could not be read from microearthquakes.

3 Depth distribution of earthquakes in the South Iceland seismic zone is linked to stable motion at depth, and thus supports the existence of and contributes to the explanation of strain waves as a significant factor in variable seismic rate.

4 By a method of "multievent analysis of similar events" which has been developed and verified by using SIL data, exact locations and exact mapping of active fault segments have shown to be possible. The resolution is within tens of meters. This achievement has paved the road for application of the SIL system for monitoring the effects of extraction of hydrothermal energy from depth and for application of the SIL system for mitigating seismic risk. This also helps to invert fault plane solutions for stress tensor monitoring in seismic zones and also to improve crustal models.

5 It has been shown that it is possible with fully automatic processes and in real-time to obtain high level source information carried by microearthquakes. These automatic evaluation processes can be steadily enhanced to provide early signs of changes in the focal region of earthquakes, giving a better hope for detecting precursory changes.

6 Information of structural features are gradually emerging from evaluation of SIL data besides the information on faults and cracks. The existence of anisotropy expressed in S-wave splitting has been demonstrated. The velocity models have been refined on basis of information from microearthquakes recorded in the SIL system.

7 From observing seismic activity several examples have been seen of features expected or physically plausible in the preparatory period of intermediate size earthquakes. Among such features are quiesence, clustering and migration.

4.3 Achievements for risk mitigation

The achievements of the SIL project and of the SIL system for risk mitigation are manifold. Reports and articles include: Stefánsson et al. 1995; Stefánsson 1995; Rögnvaldsson and Björnsson 1995; Linde et al. 1993; Böðvarsson 1996. Some of the most significant are listed below.

1 The fast automatic recognitions and evaluations of weak earthquakes are of great significance for volcanic warnings and for giving early information of what is going on in earthquake-prone areas. The alert system which has been built onto the SIL system for taking advantage of these properties of the system are used in practice in Iceland for mitigating risk.

2 The possibility of detecting and mapping active faults at depth and stress tensor monitoring will become a significant contribution to hazard assessment. It will create a physical basis for understanding where fault will open to the surface in the next large earthquake. This is among the most challenging goals of seismology. The potential destruction near open faults is usually by far the most severe.

3 The SIL system capabilities have found new applications for monitoring the environmental effects of water and energy extraction from hydrothermal areas and in general for understanding better the hydrothermal systems and for mitigating risks there.

4 Even if it cannot be claimed that earthquake prediction will be possible, generally speaking, the follow-up and the understanding of physical processes connected with deformation in earthquake-prone areas may lead to useful short term predictions. The SIL system can provide such information in real-time. This is also of significance after the start of large earthquake sequences, when it may be vital to know what happens next.

5 The SIL steering committee, overview of activities

In a letter to the Nordic Council of Ministers dated November 3, 1986 the following 8 Nordic scientists applied for funds to carry out the SIL project:

Hilmar Bungum, NORSAR, Kjeller, Norway
Reynir Böðvarsson, Uppsala University, Sweden
Páll Einarsson, University of Iceland, Reykjavík, Iceland
Jörgen Hjelme, KMS Office of Seismology, Copenhagen, Denmark
Eystein Husebye, University of Oslo, Norway
Heikki Korhonen, University of Helsinki, Finland
Ragnar Slunga, FOA, Stockholm, Sweden
Ragnar Stefánsson, Icelandic Meteorological Office, Reykjavík, Iceland

These persons created a steering committee which had a meeting in Helsinki, October 3, 1987, coinciding with the meeting of the Nordic Seminar on Detection Seismology, an open Nordic group of seismologists which traditionally meets once a year in one of the Nordic countries. From this on all steering committee meetings have coincided with the Nordic Seminars.

An executive committee was also created at the meeting in Helsinki for a more effective operation and for saving travel cost. It consisted of R. Stefánsson (chairman), R. Böðvarsson, J. Hjelme and E. Husebye. The executive committee held 5 meetings during 1988 and 1989, sometimes coinciding with the yearly meetings of the steering committee.

The executive committe held the following meetings:

Copenhagen, January 12-13, 1988
Copenhagen, July 11-12, 1988
Reykjavík, September 10-12, 1988
Bergen, February 13-14, 1989
Sunne, September 24, 1989

At the SIL steering committee meeting in Sunne, September 28, 1989, the executive committee was dissolved.

As is explained elsewhere the 3 main financial pillars behind the project were:

Firstly a support of the Nordic Council of Ministers, secondly of the Research Councils of Sweden, Denmark and Norway for initial costs, development and research, and thirdly a support from the Icelandic Government (through Veðurstofa Íslands, the Icelandic Meteorological Office) for operation of the SIL project and of the emerging SIL system.

At an early stage a contract was signed between the Nordic Council of Ministers and Veðurstofa Íslands for the managing of the project and a contract was agreed between Veðurstofa Íslands and the SIL steering committee about a common responsibility for carrying through the project. In that agreement it was declared that Veðurstofa Íslands would provide localities for researchers devoted to work for the project.

Ragnar Stefánsson was elected project manager at the SIL steering committee meeting in Helsinki 1987 and Reynir Böðvarsson was elected to lead the technical development work.

Following steering committee meetings were held:

Helsinki, October 3, 1987
Oslo, October 6, 1988
Sunne, September 28, 1989
Copenhagen, October 3, 1990
Reykjavík, June 12, 1991
Espoo, September 4, 1992
Bergen, June 18, 1993
Stockholm, August, 1994

There was a change in the SIL steering committee, when Jens Havskov, University of Bergen, formally replaced Eystein Husebye at the steering committee meeting on June 12, 1991. Urmas Luosto replaced Heikki Korhonen at the meeting on June 18, 1993.

The staff members of the research unit of the Nordic Council of Ministers have always obtained information about the SIL steering committee meetings, but they have only once attended such a meeting, i.e. in Oslo in October 1988.

A more detailed description of the work carried out during the time of the SIL project can be found in the two major general progress reports (Stefánsson et al. 1986, 1989), and in the annual and the semiannual progress reports listed below.

The SIL project was originally planned as a 5-6 years project. After funding was secured the project could be started fully in 1988. The steering committee has continued its work even if the 5-6 years estimated project time has elapsed. The reason is that even if it can be claimed that the SIL project had fulfilled its original goals two years ago, the SIL system has been in steady development and the steering committee has considered it useful for the development to be able meet yearly for consultations.

The development of the SIL system has been both as concerns its acquisition and evaluation capabilities and as concerns its extensions exceeded by far its original scope. This extension and further development has in first hand been supported by Icelandic authorities, hazard defence and communities. All this support has been offered because of the risk mitigating capabilities of the SIL system. Thus the SIL steering committee has considered it to be its duty to continue while it was considered useful for the development.

One significant reason for not dissolving the SIL steering committee is that it is considered significant to document the SIL system as a whole and there are still some money left over to enhancing this documentation.

The "SIL User Manual" is available now. It contains all information needed for implementation and operation of a network utilizing the SIL concept. Recent documentation work, earlier reports and international publications with additions and modifications have been assembled in this manual. However, a software user manual is never complete. More work needs to be done on troubleshooting, operational examples and last but not least a detailed section on how to install and implement the SIL system at new sites. This section would include description of hardware, acquisition software and processing software ranging from phase detections to fault plane solutions.

6 Financial overview

The income and expenditure in the SIL project can be divided into two branches. In first hand the funds that were received and accounted for by Veðurstofa Íslands. An overview of income and expenditure is shown (Appendix 4) revised by the Icelandic State Revision. The other branch is the Institute of Geophysics, Section for Solid

Earth Physics, University of Uppsala. That institution received all the funds allocated from the Swedish Science Foundation (Naurvetenskapliga Forskningsrådet, NFR) for the SIL project, to be spent there for development work, supervised by the NFR (Appendix 5).

The total amount of the funds received by Veðurstofa Íslands for the project were ISK 40.056.824. The funds were received from the Nordic Council of Ministers and science foundations in Denmark and Norway, and the total amount also includes rent (Appendix 4). The amount of funds received by University of Uppsala was SEK 832.000 (Appendix 5).

Of the funds received by Veðurstofa Íslands ISK 38.571.630 were used for equipment and development work as specified in Appendix 4. This leaves ISK 1.485.194. At the final meeting of the SIL steering committee in Copenhagen, November 21, 1995, it was decided that all which was left over at the formal end of the SIL project should be used for necessary documentation of the SIL project and for reporting as said in minutes of the SIL steering committee meeting November 21, 1995 (Appendix 1) and the statement of the SIL steering committee (Appendix 2). Appendix 3 contains a signed declaration of Reynir Böðvarsson and Ragnar Slunga about the formal ownerships of the software which is used in the system.

From the beginning of the SIL project the Icelandic Government has provided the funds for operation, including of course significant part of the development. The yearly cost of operation was during the time period from 1987-1992 as is shown in Table 1. After late 1992 the SIL network started to be extended very fast and the involvement of the Icelandic state increased.

Table 1. Operation-cost of SIL system and SIL project in ISK and KSEK

1987	1988	1989	1990	1991	1992
500.000	3.705.585	4.908.769	7.299.823	8.049.665	8.496.287
(82KSEK)	(507 KSEK)	(557 KSEK)	(340 KSEK)	(822 KSEK)	(856 KSEK)

7 List of publications related to the SIL project or based on SIL data

Atakan, K., B. Brandsdóttir, P. Halldórsson & G.Ó. Friðleifsson 1995a. Some comments on the local site effects: A case study from Iceland. In: Abstracts from the 18th European Regional Earthquake Engineering Seminar, September 4-8, 1995, Lyon, France.

Atakan, K., B. Brandsdóttir, P. Halldórsson & G.Ó. Friðleifsson 1995b. Effects of local geology on seismic records: A case study in the South Iceland seismic zone (in preparation).

Ágústsson, K. 1994. Volumetric strain measurements in southern Iceland, January 1990 - November 1993. In: Abstracts from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Ágústsson, K. & R. Stefánsson 1992. The eruption of Hekla and its relation to strain release in southern Iceland. In: Abstracts from the 20th Nordic Geological Winter Meeting, 7-10 January, Reykjavík. The Icelandic Geoscience Society, The Faculty of Science - University of Iceland.

Ágústsson, K., A.T. Linde & R. Stefánsson 1993. The Hekla (Iceland) 1991 eruption: Continuous strain data require a compound source model. In: Abstracts from the AGU Spring Meeting, May 24-28, Baltimore, Maryland.

Björnsson, G. & S.Th. Rögnvaldsson 1995. Upptök jarðskjálfta á Hengilssvæði árin 1992-1994 (Epicentral distribution of earthquakes in the Hengill area 1992-1994). National Energy Authority, Reykjavík. In Icelandic.

Böðvarsson, R. 1988a. Design of the data acquisition system for the South Icelandic Lowland (SIL) project. Veðurstofa Íslands.

Böðvarsson, R. 1988b. Short description of a layered data network. Veðurstofa Íslands.

Böðvarsson, R. 1988c. SIL project. Status report. Veðurstofa Íslands.

Böðvarsson, R. 1989a. Status of the SIL-data acquisition system. In: Abstracts from the 20th Nordic Seminar on Detection Seismology, 26-28 September, Sunne.

Böðvarsson, R. 1989b. SIL data acquisition system. Status report. Veðurstofa Íslands.

Böðvarsson, R. 1991a. The SIL system, a new tool for earthquake acquisition. In: Abstracts from the 22nd Nordic Seminar on Detection Seismology, Hveragerði, Iceland, June 9-11, 1991. Veðurstofa Íslands.

Böðvarsson, R. 1991b. Possible future development of the SIL system. In: Abstracts from the 22nd Nordic Seminar on Detection Seismology, Hveragerði, Iceland, June 9-11, 1991. Veðurstofa Íslands.

Böðvarsson, R. 1991c. The SIL system, a new tool for earthquake acquisition. In: Abstracts from the AGU Fall Meeting, December 9-13, 1991, San Francisco, California.

Böðvarsson, R. 1991d. The SIL project. SIL reference manual.

Böðvarsson, R. 1992a. The SIL system, a new tool for earthquake acquisition. In: Abstracts from the 20th Nordic Geological Winter Meeting, 7-10 January, Reykjavík. The Icelandic Geoscience Society, The Faculty of Science - University of Iceland.

Böðvarsson, R. 1992b. A manual for an alert system. Veðustofa Íslands.

Böðvarsson, R. 1993. Artificial neural networks and genetic algorithms: Basic theory and some seismological applications. In: Abstracts from the 24th Nordic Seminar on Detection Seismology, June 16-18, 1993. University of Bergen.

Böðvarsson, R. 1994a. The SIL-data acquisition and the monitoring system. In: Abstracts from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Böðvarsson, R. 1994b. Application of genetic algorithms in the SIL project. In: Abstracts from the 25th Nordic Seminar on Detection Seismology, Stockholm, Sweden, August 23-25. National Defence Research Establishment.

Böðvarsson, R. 1994c. The Icelandic seismic network for monitoring, automatic evaluation and alerts. In: Abstracts from the workshop Monitoring and research for mitigating seismic and volcanic risk, October 20-22, 1994. Icelandic Meteorological Office and Commission of the European Communities, Directorate General XII/D-2, Science, Research and Development.

Böðvarsson, R. 1995. The use of artificial neural network and genetic algorithms in the South Iceland Lowland (SIL) project. In: Abstracts from the XXI IUGG General Assembly, Boulder, Colorado, July 2-14, 1995.

Böðvarsson, R. 1996. The Icelandic seismic network for monitoring, automatic evaluation and alerts. In: B. Þorkelsson & M. Yeroyanni (editors), Seismic and volcanic risk, Proceedings of the workshop on Monitoring and research for mitigating seismic and volcanic risk, Reykjavík, Iceland, 20-22 October 1994. European Commission, Environment and Climate Programme.

Böðvarsson, R. & R. Slunga 1988. Multistation analysis at the central computer. SIL report. Veðurstofa Íslands.

Böðvarsson, R. & S. Jakobsdóttir 1989. SIL prototype station at Bjarnastaðir. Status report. Veðurstofa Íslands.

Böðvarsson, R. & R. Slunga 1989. Discussion of the detector- and selector functions. SIL report. Veðurstofa Íslands.

Böðvarsson, R. & S.Th. Rögnvaldsson 1992. The SIL acquisition system, a new tool for earthquake prediction research. Proceedings of the International Conference on Preparedness and Mitigation for Natural Disasters 28-29 May, 1992, Reykjavík Iceland.

Böðvarsson, R., S. Jakobsdóttir & R. Stefánsson 1992. Seismological network with no waveform data transfer. In: Abstracts from the 23rd Nordic Seminar on Detection Seismology, Espoo, Finland, 2-4 September, 1992. Institute of Seismology, University of Helsinki.

Böðvarsson, R., R. Slunga, S.Th. Rögnvaldsson & R.G. Roberts 1992. Evaluation and optimization of the SIL data analysis. SIL research proposal. Veðurstofa Íslands.

Böðvarsson, R., R. Slunga & S.Th. Rögnvaldsson 1993. Update and documentation of the SIL software. SIL research proposal. Veðustofa Íslands.

Böðvarsson, R., R. Slunga, S.Th. Rögnvaldsson & R. Roberts 1993. Evaluation and optimization of the SIL data analysis. Status report. Veðustofa Íslands.

Böðvarsson, R., S. Jakobsdóttir & R. Stefánsson 1994a. The SIL data acquisition and monitoring system. In: Abstracts from the 25th Nordic Seminar on Detection Seismology, Stockholm, Sweden, August 23-25. National Defence Research Establishment.

Böðvarsson, R., S. Jakobsdóttir & R. Stefánsson 1994b. The SIL data acquisition and the monitoring system. In: Abstracts from the XXIV ESC General Assembly, September 19-24, 1994, Athens, Greece. University of Athens.

Böðvarsson, R., R. Slunga, S.Th. Rögnvaldsson & R. Roberts 1994. Evaluation and optimization of the SIL data analysis and update and documentation of the SIL software. Status report. Veðurstofa Íslands.

Böðvarsson, R., S.Th.. Rögnvaldsson, S. Jakobsdóttir & R. Stefánsson 1995. The SIL system, present status, ongoing development and the future. In: Abstracts from the 26th Nordic Seminar on Detection Seismology, National Survey and Cadastre, Denmark, November 20-22, 1995. Kort & Matrikelstyrelsen.

Böðvarsson, R., S.Th. Rögnvaldsson, S. Jakobsdóttir, R. Slunga & R. Stefánsson 1995. The SIL data acquisition and monitoring system. In: Abstracts from the XXI IUGG General Assembly, Boulder, Colorado, July 2-14, 1995.

Böðvarsson, R., S.Th. Rögnvaldsson, S. Jakobsdóttir, R. Slunga & R. Stefánsson 1996. The SIL data acquisition and monitoring system. Seism. Res. Lett. 67(5), 35-46.

Dahlmann, O. & L. Mendes-Victor 1983. Report of visit to the test zone of the Lowland of South Iceland. European Council, special report. CAHRT 83(4), 1-14.

Davidsson, M., K. Ágústsson, R.T. Williams, I.S. Sacks, R. Stefánsson & E.S. Robinson 1991. Precursors to the 17 January 1991 eruption of Hekla in the data from a recording gravity meter. In: Abstracts from the AGU Fall Meeting, December 9-13, 1991, San Francisco, California.

Department of Geophysics, Icelandic Meteorological Office 1994. [SIL-kerfið - Helstu niðustöður úr SIL skjálftamælanetinu á Suðurlandi]. In: Eðlisfræði á Íslandi VII, Nesjavöllum, 8.-9. október, 1994. Dagskrá og ágrip. In Icelandic.

Guðmundsson, G.B.. 1994. Epicenter distribution in and around the South Iceland seismic zone. In: Abstracts from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Guðmundsson, G.B. 1995. Manual for few SIL applications. Veðurstofa Íslands.

Guðmundsson, G.B. & R. Stefánsson 1995. Earthquake focal depth estimates from a dense network in the South Iceland seismic zone. Veðurstofa Íslands.

Hu, G., W. Menke & S.Th. Rögnvaldsson 1993. A demonstration of the joint use of P-wave polarization and travel time data in tomographic inversion: Crustal velocity structure near the South Iceland Lowland network. Geophys. Res. Lett. 20, 1407-1410.

Husebye, E. 1988a. SIL project - event detection.

Husebye, E. 1988b. The SIL project - task inventory.

Jakobsdóttir, S. 1989. Results of noise- and earthquake measurements obtained in the SIL-area. In: Abstracts from the 20th Nordic Seminar on Detection Seismology, 26-28. September, Sunne.

Jakobsdóttir, S. 1990a. SIL-project, the first data records. In: Abstracts from the XXII ESC General Assembly, Barcelona, 17-22 September, 1990. Servei Geologic de Catalunya.

Jakobsdóttir, S. 1990b. Some characteristics of the first recordings in the SIL-network. In: Abstracts from the 21th Nordic Seminar on Detection Seismology, October 1-3, Copenhagen, 1990. Kort & Matrikelstyrelsen.

Jakobsdóttir, S. 1991a. The SIL system: Phase detector - parameter data. In: Abstracts from the 22nd Nordic Seminar on Detection Seismology, Hveragerði, Iceland, June 9-11, 1991. Veðurstofa Íslands.

Jakobsdóttir, S. 1991b. The overall performance of the SIL network. In: Abstracts from the AGU Fall Meeting, December 9-13, 1991, San Francisco, California.

Jakobsdóttir, S. 1992. The overall performance of the SIL-network. In: Abstracts from the 20th Nordic Geological Winter Meeting, 7-10 January, Reykjavík. The Icelandic Geoscience Society, The Faculty of Science - University of Iceland.

Jakobsdóttir, S. 1994a. The overall performance of the SIL system. In: Abstract from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Jakobsdóttir, S. 1994b. Some aspects of the SIL-system and its extension to the north of Iceland. In: Abstracts from the 25th Nordic Seminar on Detection Seismology, Stockholm, Sweden, August 23-25. National Defence Research Establishment.

Jakobsdóttir, S. 1994c. The detectability of the SIL earthquake monitoring system and the seismicity in Iceland as seen by it. In: Abstracts from the XXIV ESC General Assembly, September 19-24, 1994, Athens, Greece. University of Athens.

Jakobsdóttir, S. 1994d. Ongoing projects for earthquake prediction research in Iceland. In: Abstracts from the workshop Monitoring and research for mitigating seismic and volcanic risk, October 20-22, 1994. Icelandic Meteorological Office and Commission of the European Communities, Directorate General XII/D-2, Science, Research and Development.

Jakobsdóttir, S. 1996. Ongoing projects for earthquake prediction research in Iceland. In: B. Þorkelsson & M. Yeroyanni (editors), Seismic and volcanic risk, Proceedings of the workshop on Monitoring and research for mitigating seismic and volcanic risk, Reykjavík, Iceland, 20-22 October 1994. European Commission, Environment and Climate Programme.

Jakobsdóttir, S. & R. Stefánsson 1988. The vaults. Status report. Veðurstofa Íslands.

Jakobsdóttir, S. & R. Böðvarsson 1991: Can Icelandic scientists predict earthquakes? News from Iceland, June 1991, 6B.

Jakobsdóttir, S., R. Böðvarsson & R. Stefánsson 1992. The overall performance of the SIL-network in South Iceland Lowland. In: Abstracts from the 23rd Nordic Seminar on Detection Seismology, Espoo, Finland, 2-4 September, 1992. Institute of Seismology, University of Helsinki.

Jakobsdóttir S. & R. Böðvarsson 1993. The evaluation and optimization of the SIL-data analyzes. In: Abstracts from the 24th Nordic Seminar on Detection Seismology, June 16-18, 1993. University of Bergen.

Jakobsdóttir, S. & G. Guðmundsson 1994. Jarðskjálftamælingar Jarðeðlissviðs Veðurstofu Íslands. SIL-netið. In: Þ. Arason (editor), Eðlisfræði á Íslandi VII. Ráðstefna Eðlisfræðifélags Íslands á Nesjavöllum, 8.-9. október, 1994. Eðlisfræðifélag Íslands. In Icelandic.

Jakobsdóttir, S. & F. Scherbaum 1995. Effects of the acausal response of zero phase FIR filters on the onset time determination of P waves for intermediate and big earthquakes. In: Abstracts from the 26th Nordic Seminar on Detection Seismology, National Survey and Cadastre, Denmark, November 20-22, 1995. Kort & Matrikelstyrelsen.

Linde, A.T., S. Sacks, R. Stefánsson & K. Ágústsson 1991. The mechanism of the 1991 Hekla, South Iceland eruption from borehole strainmeter data. In: Abstracts from the AGU Fall Meeting, December 9-13, 1991, San Francisco, California.

Linde, A., K. Ágústsson, I.S. Sacks & R. Stefánsson 1993. Mechanism of the 1991 eruption of Hekla from continuous borehole strain monitoring. Nature 365, 737-740.

Linde A., S. Sacks & K. Ágústsson 1994. Borehole strain measurements in southern Iceland. In: Abstracts from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Menke, W. & V. Levin 1994. Cold crust in a hot spot. Geophys. Res. Lett. 21, 1967-1970.

Menke, W., G. Hu & S.Th. Rögnvaldsson 1994. Crustal structure in the South Iceland seismic zone determined through the inversion of P wave azimuth and travel-time anomalies. In: Abstracts from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Menke, W., B. Brandsdóttir, S. Jakobsdóttir & R. Stefánsson 1994a. Seismic anisotrophy in the crust at the mid-Atlantic plate boundary in South Iceland. In: Abstracts from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Menke, W., B. Brandsdóttir, S. Jakobsdóttir & R. Stefánsson 1994b. Seismic anisotrophy in the crust at the mid-Atlantic plate boundary in South-West Iceland. Geophys. J. Int. 119, 783-790.

Menke, W., V. Levin & R. Sethi 1995. Seismic attenuation in the crust at the mid-Atlantic plate boundary in South-West Iceland. Geophys. J. Int. 122, 175-182.

Ólafsson, S. 1990. Operation of the SIL system. Report. Veðurstofa Íslands.

Roberts, R., G. Lindfors, A. Christoffersson, R. Böðvarsson & S.Th. Rögnvaldsson 1993. Three-component data as an aid to seismic event detection and association: A case study using data from the SIL (Iceland) network. Computers and Geosciences 19(2), 123-134.

Rögnvaldsson, S.Th. 1991. SIL project. 3-dimensional presentation of focal parameters. SIL research report, August 1991. Veðurstofa Íslands.

Rögnvaldsson, S.Th. 1992. Fault plane solutions by combined use of polarities and body wave amplitudes. Dissertation for licentiate degree, Uppsala University.

Rögnvaldsson, S.Th. 1993. A geometrical spreading function for South Iceland. The SIL project - achievements and future prospects. In: Abstracts from the 24th Nordic Seminar on Detection Seismology, June 16-18, 1993. University of Bergen.

Rögnvaldsson, S.Th. 1994. Microearthquakes in South Iceland, fault plane solutions and relative locations. PhD thesis, Uppsala University, ISSN 1104-232X.

Rögnvaldsson, S.Th. & R. Slunga 1991. Fault plane solutions using amplitude observations - a test with synthetic seismograms. In: Abstracts from the 22nd Nordic Seminar on Detection Seismology, Hveragerði, Iceland, June 9-11, 1991. Veðurstofa Íslands.

Rögnvaldsson, S.Th., R. Slunga & R. Böðvarsson 1992. Evaluation and optimization of the SIL data analysis. Present status. Veðurstofa Íslands.

Rögnvaldsson, S.Th. & R. Slunga 1993. Routine fault plane solutions for local networks: A test with synthetic data. Bull. Seism. Soc. Am. 83(4), 1232-1247.

Rögnvaldsson, S.Th. & R. Slunga 1994a. Single and joint fault plane solutions for microearthquakes in South Iceland. Tectonophysics 237, 73-86.

Rögnvaldsson, S.Th. & R. Slunga 1994b. Relative location techniques applied to SIL data-preliminary results. In: Abstracts from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Rögnvaldsson, S.Th. & G. Björnsson 1995. Upptakagreining smáskjálfta á Nesjavöllum í ársbyrjun 1995 (Microearthquakes near the Nesjavellir geothermal field in the first months of 1995). Report, OS-95034/JHD-05, National Energy Authority, Reykjavík. In Icelandic with English summary.

Rögnvaldsson, S.Th., R. Böðvarsson, R. Slunga & S. Jakobsdóttir 1995. The transfer function of the SIL seismic data acquisition system. Technical report. Veðurstofa Íslands.

Rögnvaldsson, S.Th., R. Slunga, P. Einarsson & R. Stefánsson 1995. Mapping active faults in the Tjörnes fracture zone, Iceland. In: Abstracts from the 26th Nordic Seminar on Detection Seismology, National Survey and Cadastre, Denmark, November 20-22, 1995. Kort & Matrikelstyrelsen.

Shimamura, H., R. Stefánsson, T. Watanabe, G.B. Guðmundsson, P. Einarsson, S. Kodaira & H. Shiobara 1994. An extremely narrow zone of seismicity along the crest of the Reykjanes Ridge revealed by a dense ocean bottom seismographic survey. In: Abstracts from the 27th General Assembly of IASPEI, Wellington, New Zealand, January 10-21, 1994.

Slunga, R. 1988. Scientific objectives of the seismic data acquisition system for the lowland of southern Iceland. Veðurstofa Íslands.

Slunga, R. 1991a. The SIL report. Implementation of software for earthquake analysis in the SIL system. Veðurstofa Íslands.

Slunga, R. 1991b. The SIL center automatic selection and event analysis. In: Abstracts from the 22nd Nordic Seminar on Detection Seismology, Hveragerði, Iceland, June 9-11, 1991. Veðurstofa Íslands.

Slunga, R. 1991c. Experiences of the earthquake analysis implemented at the SIL (South Iceland Lowland) seismic network. In: Abstracts from the 22nd Nordic Seminar on Detection Seismology, Hveragerði, Iceland, June 9-11, 1991. Veðurstofa Íslands.

Slunga, R. 1994a. The seismological routine analysis of microearthquakes implemented into the SIL-system. In: Abstracts from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Slunga, R. 1994b. Principles of the automatic multistation analysis of the SIL network. In: Abstracts from the 25th Nordic Seminar on Detection Seismology, Stockholm, Sweden, August 23-25. National Defence Research Establishment.

Slunga, R. 1994c. Search for subsurface faults and fault movement in the South Iceland seismic zone. In: Abstracts from the workshop Monitoring and research for mitigating seismic and volcanic risk, October 20-22, 1994. Icelandic Meteorological Office and Commission of the European Communities, Directorate General XII/D-2, Science, Research and Development.

Slunga, R., S.Th. Rögnvaldsson & R. Böðvarsson 1994a. Absolute and relative locations of similar events with application to microearthquakes in South Iceland. In: Abstracts from the 25th Nordic Seminar on Detection Seismology, Stockholm, Sweden, August 23-25. National Defence Research Establishment.

Slunga, R., S.Th. Rögnvaldsson & R. Böðvarsson 1994b. Absolute and relative locations of similar events with application to microearthquakes in South Iceland. Geophys. J. Int. 123, 409-419.

Slunga, R. 1996. Search for subsurface faults and fault movements in the South Iceland seismic zone. In: B. Þorkelsson & M. Yeroyanni (editors), Seismic and volcanic risk, Proceedings of the workshop on Monitoring and research for mitigating seismic and volcanic risk, Reykjavík, Iceland, 20-22 October, 1994. European Commission, Environment and Climate Programme.

Stefánsson, R. 1988a. Seismometer selection, a short overview. Veðurstofa Íslands.

Stefánsson, R. 1988b. Report on the activities of the executive committee of the SIL project, October 3, 1987 - October 6, 1988. Veðurstofa Íslands.

Stefánsson, R. 1988c. Report on the activities of the executive committee of the SIL project. Veðurstofa Íslands.

Stefánsson, R. 1989a. SIL-projektet, en översikt. Veðurstofa Íslands. In Swedish.

Stefánsson, R. 1989b. SIL project. An activity report Oktober, 1988 - September, 1989. Veðurstofa Íslands.

Stefánsson, R. 1989c. SIL-research plan. In: Abstracts from the 20th Nordic Seminar on Detection Seismology, 26-28 September, Sunne.

Stefánsson, R. 1990a. SIL-project, scientific background. In: Abstracts from the XXII ESC General Assembly, Barcelona, 17-22 September, 1990. Servei Geologic de Catalunya.

Stefánsson, R. 1990b. SIL related research. In: Abstracts from the 21th Nordic Seminar on Detection Seismology, October 1-3, Copenhagen, 1990. Kort & Matrikelstyrelsen.

Stefánsson, R. 1990c. SIL project. Report, October 3, 1990. Veðurstofa Íslands.

Stefánsson, R. 1991a. SIL project. Report, February 1991. Veðurstofa Íslands.

Stefánsson, R. 1991b. SIL project. Report, June 1991. Veðurstofa Íslands.

Stefánsson, R. 1991c. SIL project. Report, November 5, 1991. Veðurstofa Íslands.

Stefánsson, R. 1991d. The SIL project. Towards earthquake prediction in the South Iceland Lowland. In: Abstracts from the AGU Fall Meeting, December 9-13, 1991, San Francisco, California.

Stefánsson, R. 1992a. Earthquake prediction and the Nordic SIL project. In: Abstracts from the 20th Nordic Geological Winter Meeting, 7-10 January, Reykjavík. The Icelandic Geoscience Society, The Faculty of Science - University of Iceland.

Stefánsson, R. 1992b. SIL project. Report, March 18, 1992. Veðurstofa Íslands.

Stefánsson, R. 1992c. Earthquake prediction research in southern Iceland. A CEC research proposal. An Environment Project, Area IV.1.1., Seismic Hazard.

Stefánsson, R. 1992d. SIL project. Report, August 1992. Veðurstofa Íslands.

Stefánsson, R. 1992e. Earthquake prediction in the South Iceland seismic zone - a large scale laboratory experiment. In: Abstracts from the 23rd Nordic Seminar on Detection Seismology, Espoo, Finland, 2-4 September, 1992. Institute of Seismology, University of Helsinki.

Stefánsson, R. 1993a. SIL project. Report, March 1993. Veðurstofa Íslands.

Stefánsson, R. 1993b. The SIL project - achievements and future prospects. In: Abstracts from the 24th Nordic Seminar on Detection Seismology, June 16-18, 1993. University of Bergen.

Stefánsson, R. 1993c. Earthquake prediction research in southern Iceland. A CEC research proposal. An Environment Project, Area IV.1.1., Seismic Hazard.

Stefánsson, R. 1994a. SIL project. Report, August 1994. Veðurstofa Íslands.

Stefánsson, R. 1994b. Iceland mantle plume tectonics. In: Abstracts from the workshop Monitoring and research for mitigating seismic and volcanic risk, October 20-22, 1994. Icelandic Meteorological Office and Commission of the European Communities, Directorate General XII/D-2, Science, Research and Development.

Stefánsson, R. 1995. Earthquake-prediction research in a natural laboratory. An application to the European Commission, Environment and Climate 1994-1998. Icelandic Meteorological Office.

Stefánsson, R. 1996a. Iceland plume tectonics. In: B. Þorkelsson & M. Yeroyanni (editors), Seismic and volcanic risk, Proceedings of the workshop on Monitoring and research for mitigating seismic and volcanic risk, Reykjavík, Iceland, 20-22 October, 1994. European Commission, Environment and Climate Programme.

Stefánsson, R. 1996b. Iceland plume tectonics. In: Annales Geophysicae, abstracts from the XXI General Assembly of the European Geophysical Society, The Hague, May 6-10, 1996.

Stefánsson, R., H. Bungum, R. Böðvarsson, J. Hjelme, E. Husebye, H. Johansen, H. Korhonen & R. Slunga 1986. Seismiskt datasamlingssystem för Södra Islands Lågland. Nordiskt samarbete som syftar till att reducera skador i jordbäviningar och att kunna förutsäga dem. Veðurstofa Íslands. Partly in Swedish.

Stefánsson, R. & S. Jakobsdóttir 1988. Field recordings, noise studies. Veðurstofa Íslands.

Stefánsson, R., R. Böðvarsson & J. Hjelme 1989. The SIL-project. The second general report. Veðurstofa Íslands.

Stefánsson, R., R. Böðvarsson, S. Jakobsdóttir & S. Ólafsson 1990. SIL project. Report, October 3, 1990. Veðurstofa Íslands.

Stefánsson, R. & K. Ágústsson 1991. The Hekla eruption of 1991 and release of stress in the South Iceland seismic zone. In: Abstracts from the 22nd Nordic Seminar on Detection Seismology, Hveragerði, Iceland, June 9-11, 1991. Veðurstofa Íslands.

Stefánsson, R. & R. Böðvarsson 1991. The SIL project. Background and perspectives for earthquake prediction in South Iceland Lowland. In: Scientific-Technical Proceedings of the Council of Europe International Conference on Earthquake Prediction, Strasbourg, October 1991.

Stefánsson, R., B. Þorkelsson & S. Jakobsdóttir 1992. Earthquake prediction research in the South Iceland Lowland and the SIL system. Proceedings of the International Conference on Preparedness and Mitigation for Natural Disasters, 28-29 May, 1992, Reykjavík, Iceland.

Stefánsson, R., R. Böðvarsson, R. Slunga, P. Einarsson, S. Jakobsdóttir, H. Bungum, S. Gregersen, J. Havskov, J. Hjelme & H. Korhonen 1992. The SIL project, background and perspectives for earthquake prediction in the South Iceland seismic zone. Veðurstofa Íslands.

Stefánsson, R. & G. Guðmundsson 1993. The shape of the South Iceland seismic zone based on SIL data. In: Abstracts from the 24th Nordic Seminar on Detection Seismology, June 16-18, 1993. University of Bergen.

Stefánsson, R., R. Böðvarsson, R. Slunga, P. Einarsson, S. Jakobsdóttir, H. Bungum, S. Gregersen, J. Havskov, J. Hjelme & H. Korhonen 1993. Earthquake prediction research in the South Iceland seismic zone and the SIL project. Bull. Seism. Soc. Am. 83(3), 696-716.

Stefánsson, R., K. Ágústsson & P. Halldórsson 1994a. Confirming and monitoring of strainwaves. In: Abstracts from the 25th Nordic Seminar on Detection Seismology, Stockholm, Sweden, August 23-25. National Defence Research Establishment.

Stefánsson, R., K. Ágústsson & P. Halldórsson 1994b. Confirming and monitoring of strainwaves. In: Abstracts from the XXIV ESC General Assembly, September 19-24, 1994. Athens, Greece. University of Athens.

Stefánsson, R., G.B. Guðmundsson, & R. Slunga 1994. Depth of the brittle ductile boundary in the Icelandic crust. In: Abstracts from the 25th Nordic Seminar on Detection Seismology, Stockholm, Sweden, August 23-25. National Defence Research Establishment.

Stefánsson, R., P. Halldórsson & G.B. Guðmundsson 1994. Some features of the seismicity of the South Iceland seismic zone; Relative location techniques applied to SIL data-preliminary results. In: Abstracts from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Stefánsson, R., R. Böðvarsson, R. Slunga & S. Jakobsdóttir 1994. The SIL project approach to earthquake prediction. In: Abstracts from the XXIV ESC General Assembly, September 19-24, 1994, Athens, Greece. University of Athens.

Stefánsson, R., R. Böðvarsson, G. Guðmundsson, S. Jakobsdóttir & R. Slunga 1994. Earthquake prediction research in southern Iceland. The scope of the project and some results. In: Abstracts from the 27th General Assembly of IASPEI, Wellington, New Zealand, January 10-21, 1994.

Stefánsson, R., R. Böðvarsson, S. Jakobsdóttir & R. Slunga 1995. The SIL earthquake prediction project, main results. In: Abstracts from the XXI IUGG General Assembly, Boulder, Colorado, July 2-14, 1995.

Stefánsson, R., R. Böðvarsson, S. Jakobsdóttir, R. Slunga & S.Th. Rögnvaldsson 1995. The SIL earthquake prediction project, main results, or microearthquakes as a tool for earthquake prediction. In: Abstracts from the 26th Nordic Seminar on Detection Seismology, National Survey and Cadastre, Denmark, November 20-22, 1995. Kort & Matrikelstyrelsen.

Vogfjörð, K.S. 1994a. Modeling SIL seismograms from local and teleseismic earthquakes to obtain velocity and Q-structure of the crust and upper mantle. In: Abstracts from the NorFa workshop Earthquake prediction research in the South Iceland test area: State-of-the-art, January 4-7, 1994. Veðurstofa Íslands.

Vogfjörð, K.S. 1994b. Short-period local wave propagation in South-West Iceland. In: Abstracts from the AGU Spring Meeting, May 23-27, Baltimore, Maryland.

Vogfjörð, K.S. 1994c. Short-period local and regional wave propagation in Iceland. In: Abstracts from the 25th Nordic Seminar on Detection Seismology, Stockholm, Sweden, August 23-25. National Defence Research Establishment.

Vogfjörð, K.S. Use of secondary body phases in the SIL data swarms for determining the depth of earthquakes. Work in progress.

APPENDIX 1

Boligministeriet
Kort- og Matrikelstyrelsen
Geodæsidivisionen
Seismologikontoret ref

dato 5 DEC 1995

journalnr

Minutes of SIL (South Iceland Lowland) steering committee meeting 21 NOV 1995.

Present were: Ragnar Stefansson, Steinunn Jakobsdottir, Reynir Bodvarsson, Ragnar Slunga, Conrad Lindholm, Pekka Heikkinen, Soren Gregersen and Niels Petersen from Nordisk Ministerraad, Forskningsafdelingen.

1. Ragnar Stefansson was elected chairman of the meeting.
Soren Gregersen was elected secretary of the meeting.

2. The meeting agenda was accepted.

3. The minutes of the previous steering committee meeting were handed out at the meeting. The most crucial point of the minutes was corrected to : The software implemented into the SIL system was discussed, and it was decided, that Reynir Bodvarsson and Ragnar Slunga should present a statement about the ownership/copy right in written form.

The statement, which was accepted with a small modification, is included with these minutes Appendix 1). It follows the decision of the previous steering committee meeting, that the software is available on a non-commercial basis, but implementation must be done in cooperation with the authors of the software.

4. A draft of the final progress report of the SIL project was handed out at the meeting. Comments by steering committee members will be taken into account until the end of the year 1995.

A SIL Users Manual was given to the SIL steering committee members. In the final report it is mentioned, that this manual is still in the process of improvement. It was decided that the remaining money of the common Nordic SIL project, 176.537 Danish Crowns, will be used for travel to the steering committee meeting in Copenhagen, and for further documentation (see the enclosed general statement of the closing of the common Nordic SIL project, Appendix 2).

A brochure of the SIL project was presented to the steering committee at the meeting.

5. <u>The common Nordic SIL project is hereby decided closed</u> and the steering committee is abolished. International cooperation around the SIL-network of seismographs is continued by some partners in a project funded by the European Union.

6. Reynir Bodvarsson acknowledged the good cooperation, which had prevailed in the common Nordic SIL project.

Søren

Soren Gregersen.

Adresse	Telefon	Telefax	Telex
Rentemestervej 8	35 87 50 50	KMS 35 87 50 51	1 51 84
DK-2400 København NV	35 87 + lokalnr.	GD 35 87 50 52	seismo dk

APPENDIX 2

Updating the SIL software manual.

The SIL steering committee decided to commission to the Icelandic Meteorological Office to update and publish the SIL User Manual. The steering committee agreed to grant 103.800 Swedish Crowns for this purpose. This agreement is acknowledged by the Icelandic Meteorological Office. This updating and publishing must be finished by the end of 1996. The Icelandic Meteorological Office will deliver 10 copies of the updated manual and full accounting to the SIL steering committee at the latest by April 1 1997.

Final reporting.

A draft scientific report has been discussed. The final scientific report and the final accounting to be audited by the Icelandic state auditor will be sent to the organisations, who financed the project: The Nordic Council of Ministers and the national research foundations. The final scientific and financial reports will be delivered at the latest by April 1 1997.

APPENDIX 3

The formal ownerships of the software implemented into the SIL system.

The data acquisition software that has been implemented into the SIL system by Reynir Bodvarsson during support from NFR is according to present rules formally owned by Reynir Bodvarsson. Software developed during later phases of the project is not affected by these rules.

The software for seismological analysis that has been developed at the Swedish National Defence Research Institute and that has been implemented into the SIL system by Ragnar Slunga is formally owned by the Swedish National Defence Research Institute (FOA). Software specifically developed for the SIL project is not affected by these rules of FOA.

The SIL project and in the future the operators of the network (IMO) established by the SIL project have the right to use all of the implemented software.

If the software is to be implemented by IMO outside Iceland this should preferable be done in cooperation with the authors.

Uppsala Nov 16, 1995	Stockholm Nov 16, 1995
Reynir Bodvarsson	Ragnar Slunga

APPENDIX 4

Nordisk Ministerråd

Riksrevisionen har revideret SIL projektet. Projektet startede 1988 og det afsluttede i 1995, men opgørelsestidspunktet er 31. maj 1996.

SIL projektet har fået bidrag fra nogle parter, største del af bidraget kommer fra Nordisk Ministererråd. I noter med resultatsopgørelsen er der en liste over oprindelige bidrag til projektet. Bidragsbeløbet i IKK er afhænget af valutakurs og renteindtægter. På grund af projektet var oprettet en valutakonto, i danske kroner. Næsten alle bidragerne har været indsæt på den, bla. alle betalinger fra Nordisk Ministeretråd. Hver år har et beløb været hævet fra bankkontoen i forhold til projektet's årlige omkostninger. Når bankkontoen var hævet, var det indtægtsført i regnskabet fo Sil SIL projektet. Projektet's omkostninger var bogført I den islandske Vejrisntituts regnskab som en speciel opgave.

Ved afslutningen af SIL projektet var bidragene til projektet ikke helt uddelt, da projektet's indtægter blev større end omkostningerne. Ifølge et brev datoeret den 5. desember 1995 undertegned af Søren Gregersen, besluttede SIL's styregruppe på sit møde den 21. november 1995 at bruge midlerne, der er til rådighed, for dokumentation af projektet og til betaling af rejseomkostningar, der opstår i forbindelse med styremødet i København. Følgende opgørelse, er afslutningsopgørelse for projektet. Riksrevisionen forventer under revisionen i 1996 at undersøge om midlerne bliver brugt i overensstemmelse med styregruppen's beslutning.

Riksrevisionen bemærker at en del af Sil projektets omkostningar ikke var bogfört på projektets særlige konti. Fejlen var rettet og ført i regnskabet, som følge af dette var projektet's bankkonto hævet i mars 1996. Dette forklarer mindre beholdning på bankkontoen, i forhold til den saldo der var vist under styregruppens møde den 21. november 1995. På dette tidspunkt var bankkontoen's saldo DKK 176.537. Riksrevisionen bemærker endvidere at Vejrinstitutet ikke havde krævet refund af moms, på grund af køb af udstyr i 1992 - 1995. Momsbeløbet var indbetalt af Finansministeret i maj 1996. I opgørelsen har bankbeholdningen været indtægtsført i regnskabet i forhold til valutakurs i maj ultimo 1996. Resultatsopgørelsen viser de midler projektet har til rådighed er IKK 1.485.194, i maj ultimo.

Noter

1) På grund af projektet var oprettet en valutabankkonto, da alle bidragerne i DKK er insæt på kontoen. Indtægtsposter (bidrag) i opgørelsen er i IKK. Det samme gælder når bankkontoen er hævet til betalig af omkostninger. Som konsekvens er projektet's indtægter, som består af er bidrag samt renteindtægter med kurssvingninger, summeret i én tal. På opgørelsestidspunktet er bankbeholdning i DKK 69.968, indtægtsført med hensyn til valutakurs maj ultimo 1996.

Den øverste tabell viser projketet's total intægter og den nedeste viser oprindelige bidrag samt renteindtægter. Indtægtsført bidrag samt renteindtægter

Bidrag og renteindtægter	39.263.602
Indtægtsført på bankbeholdning 31.05.1996	793.222
Indtægter ialt	40.056.824

Oprindelig bidrag samt renteindtægter

Nordisk Ministerråd	3.000.000	DKK
Norges Almenvitenskabelige	322.587	DKK
Kort og Matrikastyrelsen	113.466	DKK
Geodædisk Institut	485.333	IKK
Kort og Matrikalstyrelsen	884.127	IKK
Rentetilskrivning	514.465	DKK

2) Kontoen udstyr var bogført med moms total IKK 22.644.701, men momsbeløbet var refunderet IKK 2.092.219. Udstyret's nettobeløb er IKK 20.552.482.

SIL projektet 1988 - 31. maj 1996

Reslutatsopgørelse	Noter	Beløb i IKK
Intægter		
Bidrag og renteindtægter ialt	1)	40.056.824
Udgifter		
Lønomkostninger		2.496.922
Specilalistomkostninger		10.791.890
Køb af tjeneste		492.874
Rejseomkostninger		2.883.301
Bygningsvarer	2)	814.296
Udstyr		20.552.482
Andet		539.865
Udgifter ialt		38.571.630
Overskud		1.485.194

Balance

	Aktiver	Passiver/egenkap
Bankkonto	793.222	
Tilgodehavende hos Vejrinstitutet	691.972	
Egenkapital		1.485.194
	1.485.194	1.485.194

Omstående oplysningers rigtighed bekræftes.

RIGSREVISIONEN, den 12. juli 1996

P. r. v.

Sigurður Þórðarson

Sigurjón I. Haraldsson

APPENDIX 5

UPPSALA UNIVERSITET
Institutionen för geofysik

1996-03-15

Icelandic Meteorological Office
Att: Ragnar Stefansson
Bustadavegur 9
Reykjavik

På begäran ges härmed en översikt över tilldelade medel för projektet *Seismiskt datainsamlingssystem för södra Islands lågland (SIL)* för tiden 1987-1991. Kopior av kontrakt bifogas.

Ingegerd Ohlsson
Ingegerd Ohlsson
högsk sekr

REYNIR BÖDVARSSON

Kontrakt	Projekt	Bidrag	Period	Disp tom	Kontonr	Anm
NFR G-GU 4601-106	SIL	200 000:-	87/88	89-06-30	6030011-8	
NFR G-GU 4601-300	SIL	210 000:-	88/89	90-06-30	6030011-8	
NFR G-GU 4601-301	SIL	222 600:-	89/90	91-06-30	6030011-8	
NFR G-GU 4601-302	SIL	200 000:-	90/91	92-06-30	6030011-8	Slutbidrag
Summa totalt:		832 600:-				

Uppsala University
Department of Geophysics

Postadress
Postal address
Villavägen 16
S-752 36 Uppsala
Sweden

Telefon
018-18 25 00, vx
Phone
+46 18 18 25 00

Telefax
018-50 11 10
Fax
+46 18 50 11 10