

Swedish National Seismic Network (SNSN)

A short report on recorded earthquakes during the fourth quarter of the year 2006

Reynir Böðvarsson
Uppsala University, Department of Earth Sciences

January 2007

Svensk Kärnbränslehantering AB

Swedish Nuclear Fuel
and Waste Management Co
Box 5864

SE-102 40 Stockholm Sweden

Tel 08-459 84 00
+46 8 459 84 00

Fax 08-661 57 19
+46 8 661 57 19



ISSN 1651-4416

SKB P-07-16

Swedish National Seismic Network (SNSN)

A short report on recorded earthquakes during the fourth quarter of the year 2006

Reynir Böðvarsson

Uppsala University, Department of Earth Sciences

January 2007

Keywords: Seismic network, Earthquakes.

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author and do not necessarily coincide with those of the client.

A pdf version of this document can be downloaded from www.skb.se

Abstract

According to an agreement with Swedish Nuclear Fuel and Waste Management Company (SKB) and Uppsala University, the Department of Earth Sciences has continued to carry out observation and additional construction of new seismic stations within the Swedish National Seismic Network (SNSN). This short report gives some information about the recorded seismicity during October through December 2006.

The Swedish National Seismic Network consists of 59 stations in operation and additional two under construction. During October through December, 1,675 events were located whereof 101 are estimated as real earthquakes, 1,160 are estimated as explosions, 341 are induced earthquakes in the vicinity of the mines in Kiruna, Malmberget and Zinkgruvan, and 73 events are still considered as uncertain but these are mainly located outside the network.

The largest earthquake with magnitude $M_L = 2.7$ occurred on October 24th, 3 km SW of Lidköping. An earthquake with magnitude $M_L = 2.6$ occurred on October 20th, 42 km south of Sundsvall. Additionally twelve earthquakes reached magnitudes between $M_L = 2.0$ and $M_L = 2.5$ during the period.

Sammanfattning

Enligt avtal mellan Svensk Kärnbränslehantering AB (SKB) och Uppsala Universitet, Institutionen för Geovetenskaper, fortsätter Uppsala Universitet att driva och bygga ut seismiska mätstationer i det svenska seismiska nätet (SNSN). Denna rapport ger information om registrerade händelser under tidsperioden oktober till december 2006.

Det seismiska nätet består av 59 stationer som nu är i drift. Ytterligare två stationer är under uppbyggnad. Under perioden oktober till december, 2006 var det 1 675 registrerade händelser varav 101 bedömdes som äkta jordskalv, 1 160 bedömdes vara förorsakade av explosioner eller sprängningar, 341 är inducerade skalv i närheten av gruvorna i Kiruna, Malmberget och Zinkgruvan samt 73 var osäkra händelser, men dessa var i huvudsak lokaliserade utanför det seismiska nätet.

Det största jordskalvet med en magnitud på 2,7 inträffade sydväst om Lidköping den 24 oktober. Ett skalv med magnitud 2,6 inträffade den 20 oktober 42 km söder om Sundsvall. Ytterligare tolv skalv med magnituder mellan 2,0 och 2,5 inträffade under perioden.

Contents

1	Introduction	7
2	Objective and scope	9
3	Recorded earthquakes during the fourth quarter of 2006	11
3.1	October	11
3.2	November	15
3.3	December	16
4	Recorded earthquakes during the year 2006	19

1 Introduction

This document reports the seismic events recorded by the Swedish National Seismic Network (SNSN) for the fourth quarter of the year 2006. The work was carried out in accordance with activity plan AP TD F73-01-013. In Table 1-1 controlling document for performing this activity is listed. The activity plan is an SKB internal controlling document.

At present 59 stations are in operation, Figure 1-1. Additional two stations are under construction in southern Sweden.

The report includes fundamental information about the seismic events, including origin time and hypocenter location. Information about the source parameters is not included in the present report but is delivered as separate ASCII-text. This report is a preliminary report including only the automatic and the brief interactive analysis done on the routine bases at SNSN.

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	Number	Version
Drift av seismologiskt nät längs Östersjöns kust	AP TD F73-01-013	

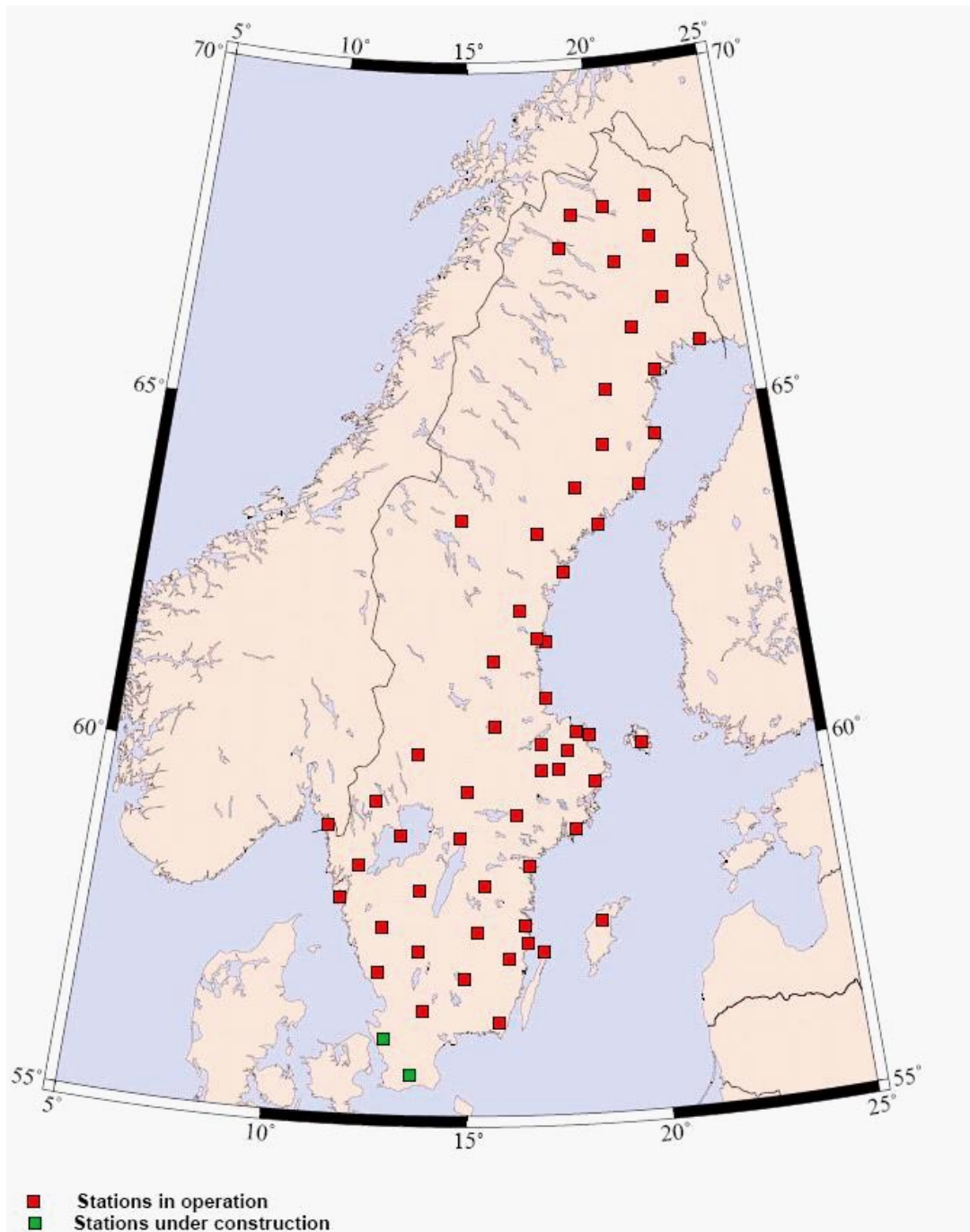


Figure 1-1. The present Swedish National Seismic Network (SNSN).

2 Objective and scope

According to an agreement with Swedish Nuclear Fuel and Waste Management Company (SKB) and Uppsala University, the Department of Earth Sciences continues to carry out observations and additional construction of new seismic stations within the Swedish National Seismic Network (SNSN).

The goal is to complement the existing regional seismic network to establish a local seismic network that also permits registration of small earthquakes in order to obtain relatively long time series and thereby gain a better understanding of the causes of seismic events in the site investigation areas.

Fundamental information about the seismic events, including origin time, hypocenter location and information about the source parameters will be given after every three month period.

The sensitivity of the network allows for complete recording of all earthquakes down to a magnitude of lower than 0.5 within the network and down to magnitude 0.0 near the proposed nuclear waste deposit sites.

3 Recorded earthquakes during the fourth quarter of 2006

Figure 3-1 shows the recorded events in Sweden during October through December. During the period 1,675 events were located whereof 101 are estimated as real earthquakes (which are shown in Figure 3-2). 1,160 are estimated as explosions, 341 are induced earthquakes in the vicinity of the mines in Kiruna and Malmberget and 73 are still considered as uncertain but are most probably explosions and are mainly outside the network. The event classified as induced earthquakes in the vicinity of the mines have been excluded from figures and the lists.

Event lists for October through December 2006 are given in sections 3.1 through 3.3.

3.1 October

An event list for October is given in Table 3-1 with date, time longitude, latitude, X (RT90 km), Y (RT90 km), depth and local magnitude (M_L). In October 29 events were located whereof one with magnitude 2.7 located 3 km SW of Lidköping and one with magnitude 2.6 located 42 km south of Sundsvall. Two earthquakes with magnitude 2.2 were located 57 km west of Pajala and 53 km east of Jokkmokk. One earthquake with magnitude 2.1 was located 52 km west of Övertorneå. Sixteen earthquakes with magnitude equal to or above 1.0 were located. The depth range of the events varies between 0 and 39.8 km.

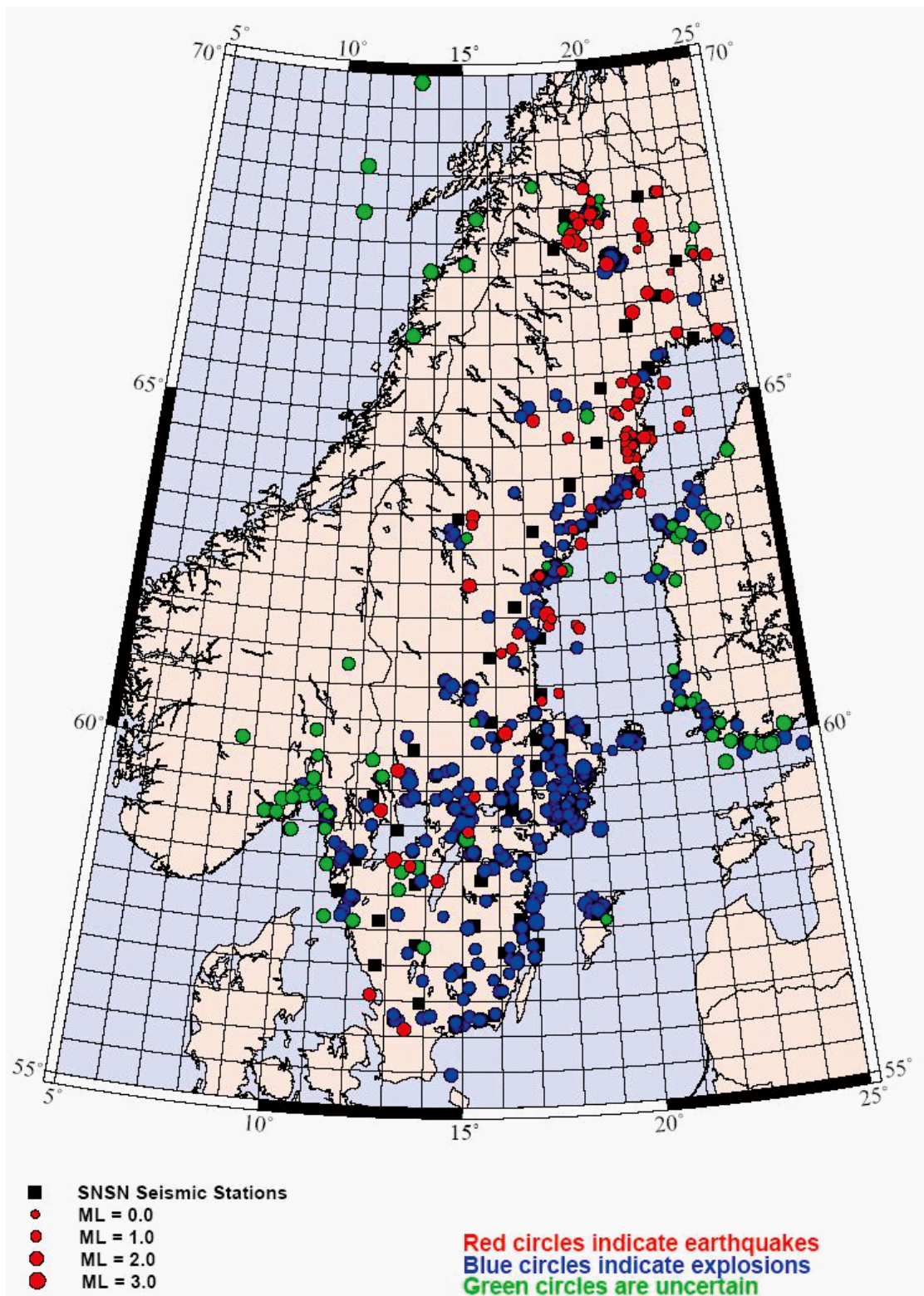


Figure 3-1. Recorded events including explosions in the SNSN network during the period October through December 2006.

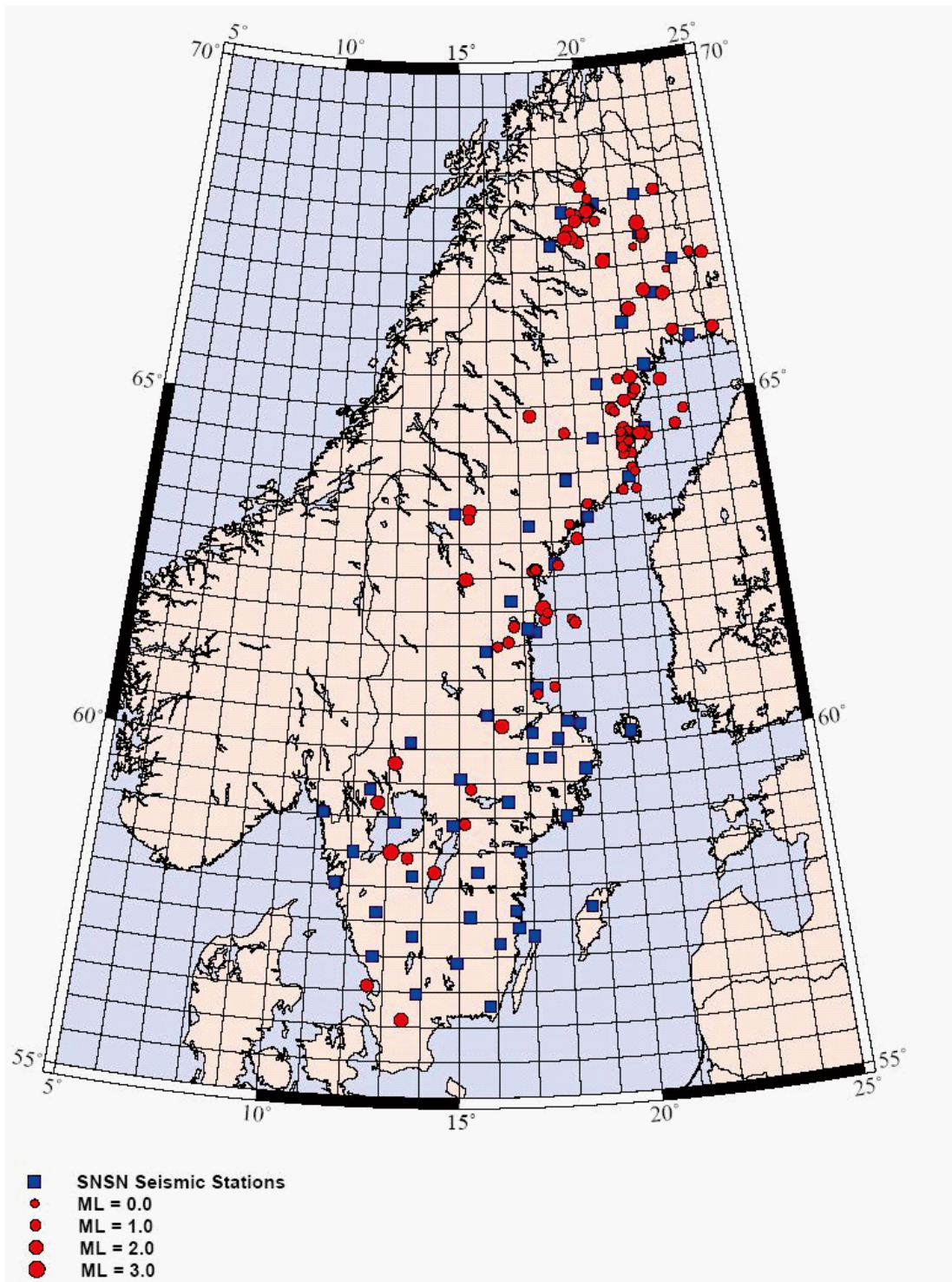


Figure 3-2. Earthquake activity in Sweden during October through December 2006.

Table 3-1. Date, time (UTC), latitude, longitude, X (RT90), Y (RT90), depth and local magnitude (M_L) of recorded earthquakes in October.

Date	Time (UTC)	Latitude	Longitude	X RT90 Km	Y RT90 Km	Depth Km	ML Local Magnitude
20061001	071023.7	61.773	16.689	6,851.3	1,546.5	8.9	1.0
20061003	053822.6	64.869	17.444	7,196.9	1,577.5	0.0	1.7
20061003	193013.6	64.512	21.360	7,167.8	1,766.4	18.6	1.6
20061007	131848.5	65.932	24.237	7,340.2	1,882.7	30.8	1.8
20061009	022234.9	65.149	21.092	7,237.5	1,747.6	24.8	0.5
20061010	102910.2	65.348	21.061	7,259.5	1,744.3	19.2	1.9
20061015	120026.3	64.468	20.771	7,160.6	1,738.5	0.0	1.0
20061015	122331.1	58.213	14.326	6,455.3	1,412.9	0.1	1.9
20061018	034559.5	66.528	22.607	7,397.4	1,801.8	39.6	2.1
20061019	062109.1	67.415	22.114	7,493.6	1,770.0	7.5	2.2
20061020	050738.8	62.032	17.620	6,881.2	1,594.8	11.0	2.6
20061020	135851.5	64.893	20.303	7,206.2	1,712.7	0.0	1.4
20061022	145219.0	62.617	17.380	6,945.9	1,580.7	0.0	0.4
20061023	010624.6	66.613	21.905	7,403.7	1,769.8	3.5	1.9
20061023	032333.8	67.584	19.207	7,502.7	1,644.6	16.5	1.7
20061023	035453.8	61.852	18.499	6,862.7	1,641.6	0.1	0.9
20061023	041845.2	61.802	18.586	6,857.3	1,646.4	19.9	1.3
20061023	062442.3	58.916	15.160	6,532.8	1,462.7	1.6	1.2
20061023	115152.8	60.882	17.858	6,753.4	1,611.3	0.0	0.8
20061024	132111.5	58.501	13.120	6,489.5	1,343.3	10.5	2.7
20061026	173103.6	59.416	15.330	6,588.4	1,472.8	0.1	1.2
20061026	192949.0	67.053	24.287	7,464.6	1,868.1	12.2	1.6
20061028	042621.9	64.857	20.406	7,202.5	1,717.9	39.8	0.5
20061028	231322.6	64.503	20.777	7,164.5	1,738.5	0.1	0.2
20061029	154249.2	63.481	15.331	7,041.3	1,476.2	1.3	1.9
20061030	010139.0	66.353	21.269	7,372.1	1,744.2	17.5	2.2
20061030	024620.8	64.461	21.455	7,162.6	1,771.4	11.9	0.6
20061030	201719.0	61.866	17.657	6,862.7	1,597.3	25.1	1.1
20061031	183429.0	64.015	20.828	7,110.5	1,745.2	0.1	0.9

3.2 November

An event list for November is given in Table 3-2 with date, time (UTC), latitude, longitude, X (RT90 km), Y (RT90 km), depth and local magnitude (M_L). In November 32 events were located whereof two with magnitude 2.3, one located 4 km NE of Garpenberg and the other 32 km NE of Keino. One earthquake with magnitude 2.1 was located 18 km north of Åmål and one with magnitude 2.0 was located 16 km SW of Hässleholm. Additional 11 earthquakes had magnitudes equal to or larger than 1.0. The depth range of the events varies between 0 and 32.8 km.

Table 3-2. Date, time (UTC), latitude, longitude, X (RT90), Y (RT90), depth and local magnitude (M_L) of recorded earthquakes in November.

Date	Time(UTC)	Latitude	Longitude	X RT90 Km	Y RT90 Km	Depth Km	ML Local Magnitude
20061102	061144.6	67.939	19.993	7,544.3	1,675.3	0.1	-0.3
20061102	080206.9	67.760	19.995	7,524.3	1,676.8	0.0	0.2
20061102	114439.4	63.362	15.315	7,028.1	1,475.3	7.2	1.1
20061103	181713.5	65.334	20.615	7,256.3	1,723.7	21.0	0.8
20061104	062614.6	64.351	20.572	7,146.9	1,730.0	15.4	1.8
20061105	211723.3	64.416	20.736	7,154.7	1,737.3	14.7	1.8
20061107	162313.2	62.592	17.448	6,943.2	1,584.2	22.0	1.6
20061107	162536.7	62.606	17.403	6,944.7	1,581.9	0.1	0.7
20061107	213629.6	62.582	17.321	6,942.0	1,577.7	0.0	0.7
20061107	230256.5	65.083	21.102	7,230.3	1,748.7	16.5	0.4
20061110	115606.0	61.963	17.757	6,873.7	1,602.2	22.7	0.6
20061111	063455.7	59.210	12.707	6,569.5	1,322.9	12.8	2.1
20061112	034501.7	63.029	18.817	6,994.4	1,652.2	3.6	1.5
20061112	210924.2	62.608	17.384	6,945.0	1,580.9	0.1	0.4
20061116	004909.5	65.974	22.779	7,336.8	1,816.3	31.0	1.4
20061117	192911.7	68.047	20.100	7,556.5	1,679.0	0.1	0.5
20061118	175721.5	63.535	19.232	7,051.8	1,670.2	16.3	0.8
20061119	031016.6	56.573	12.607	6,276.3	1,303.3	0.1	1.7
20061119	055612.7	63.243	18.602	7,017.8	1,640.3	13.4	0.6
20061119	110556.3	64.599	20.653	7,174.7	1,731.8	0.8	1.5
20061121	093718.2	60.328	16.252	6,690.1	1,524.5	5.8	2.3
20061121	182226.4	67.402	19.622	7,483.4	1,663.5	32.8	1.2
20061122	052509.8	63.699	20.901	7,075.6	1,751.6	12.4	0.6
20061123	093453.4	61.551	16.508	6,826.4	1,537.2	3.0	1.2
20061123	183829.5	67.093	23.804	7,466.3	1,846.6	0.0	0.5
20061128	010545.8	65.006	20.774	7,220.4	1,734.0	14.5	1.6
20061128	090244.8	64.224	20.867	7,133.8	1,745.3	1.1	0.7
20061130	024633.5	67.479	19.338	7,491.2	1,650.8	19.0	2.3
20061130	053907.0	64.359	20.655	7,148.1	1,733.9	22.4	0.9
20061130	062803.8	61.489	16.179	6,819.3	1,519.7	12.0	0.8
20061130	165939.2	56.097	13.513	6,221.0	1,357.2	0.0	2.0
20061130	233425.2	64.433	20.555	7,155.9	1,728.5	28.1	0.2

3.3 December

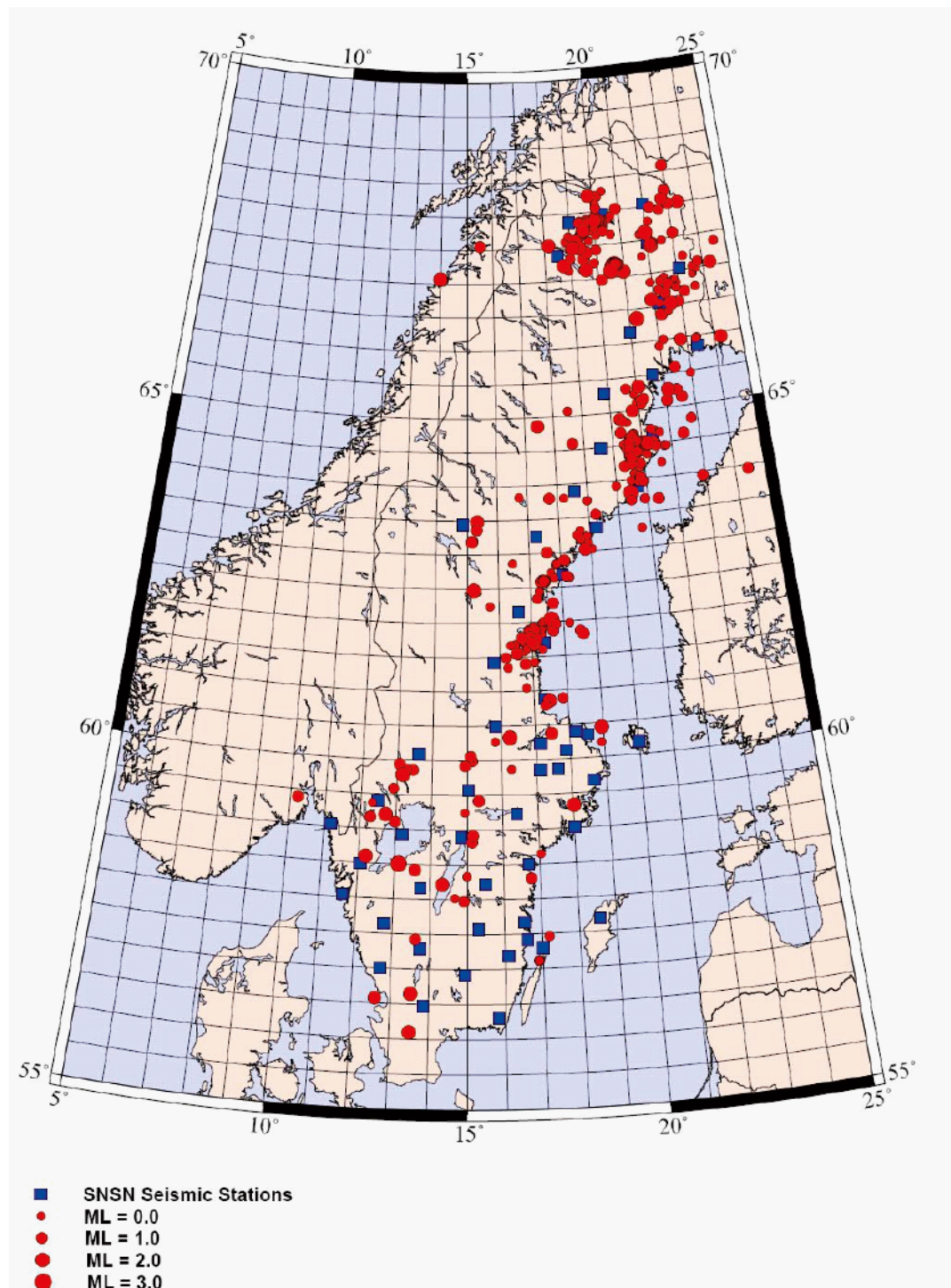
An event list for December is given in Table 3-3 with date, time (UTC), latitude, longitude, X (RT90 km), Y (RT90 km), depth and local magnitude (M_L). In December 40 events were located whereof one with magnitude 2.5 was located 73 km NE of Gällivare and one with magnitude 2.4 was located 10 km SW of Gällivare. One earthquake with magnitude 2.2 was located 35 km NE of Arvika and two with magnitude 2.0 wereof one was located 25 km east of Saltoluokta and one was located 82 km south of Östersund. Additional 15 earthquakes had magnitudes equal too or above 1.0. The depth range was between 0 and 38.5 km.

Table 3-3. Date, time (UTC), latitude, longitude, X (RT90), Y (RT90), depth and local magnitude (M_L) of recorded earthquakes in December.

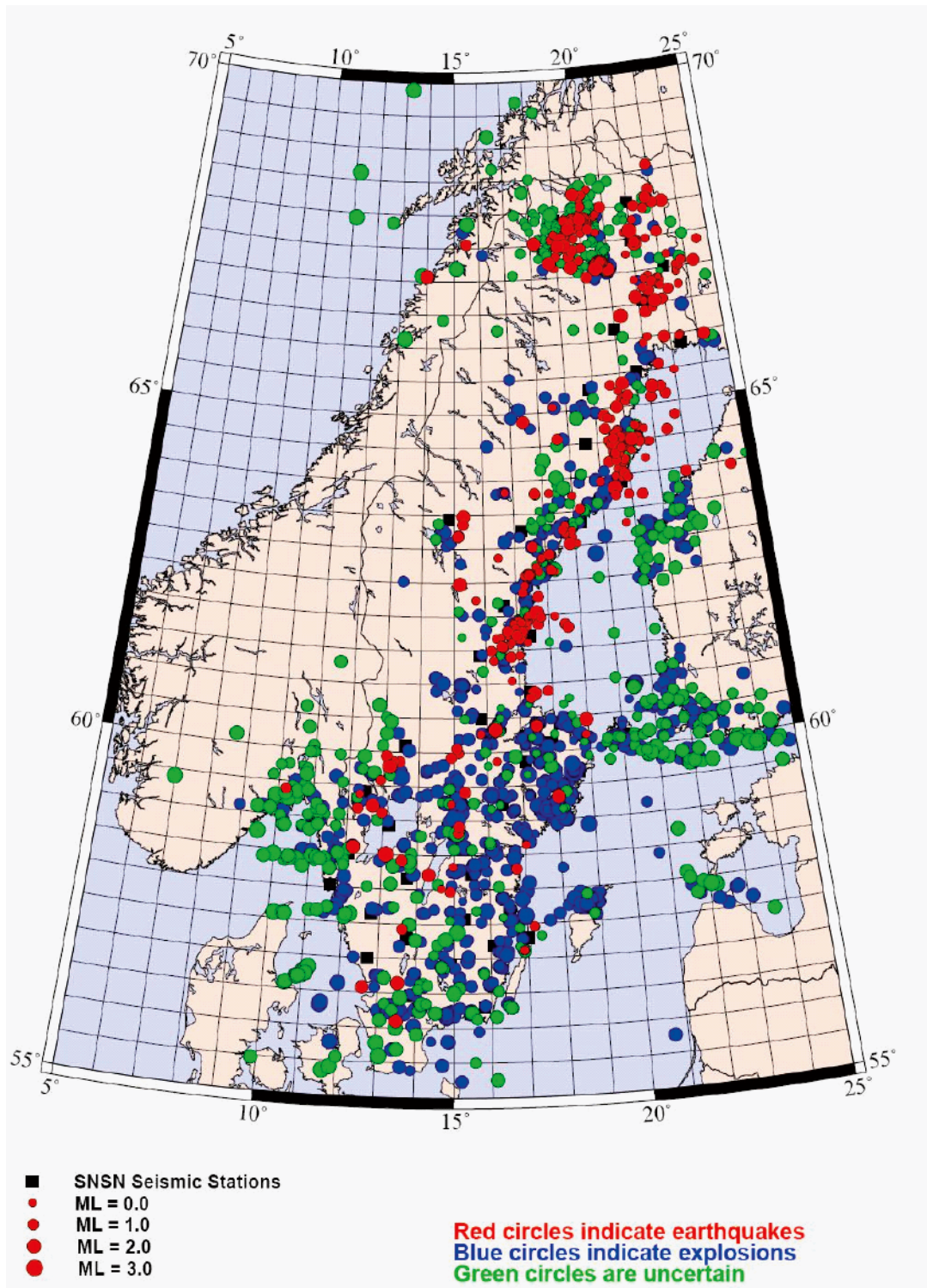
Date	Time (UTC)	Latitude	Longitude	X RT90 Km	Y RT90 Km	Depth Km	M_L Local Magnitude
20061201	120000.5	64.596	22.446	7,182.2	1,817.4	5.3	1.0
20061201	122847.8	64.312	20.675	7,142.9	1,735.3	18.6	0.7
20061202	165829.9	67.884	20.178	7,538.7	1,683.5	0.1	1.4
20061202	222649.2	64.553	20.788	7,170.2	1,738.6	27.1	0.8
20061203	094519.3	67.804	19.558	7,528.0	1,658.0	3.7	1.9
20061203	182110.1	66.878	22.856	7,437.4	1,808.4	16.3	-0.4
20061204	101406.9	62.654	18.154	6,951.2	1,620.2	0.1	0.9
20061205	013542.2	67.887	20.137	7,538.8	1,681.8	0.0	0.8
20061206	014657.7	64.221	20.588	7,132.5	1,731.8	26.4	0.9
20061207	012358.6	64.506	21.193	7,166.5	1,758.4	21.6	1.9
20061209	042410.0	67.860	20.031	7,535.5	1,677.5	30.6	1.7
20061209	214106.5	64.508	20.608	7,164.5	1,730.4	21.8	0.7
20061212	012632.3	65.263	22.104	7,254.5	1,793.7	5.9	1.9
20061212	020856.7	64.802	22.781	7,206.7	1,830.8	12.7	0.8
20061216	091709.4	60.785	17.341	6,741.8	1,583.5	13.0	0.7
20061216	092637.5	67.264	21.713	7,475.1	1,754.4	13.9	-0.2
20061218	032738.3	62.590	17.476	6,943.0	1,585.7	25.8	0.6
20061218	043853.0	58.417	13.566	6,479.2	1,369.0	29.0	1.4
20061218	064500.8	62.592	17.483	6,943.3	1,586.0	27.2	0.3
20061218	105053.5	67.702	20.315	7,518.8	1,690.7	23.3	0.8
20061218	141936.5	67.099	20.499	7,452.3	1,703.6	38.5	2.4
20061218	161139.0	67.443	22.097	7,496.6	1,768.9	2.5	1.3
20061219	023555.6	63.696	20.459	7,073.6	1,729.9	12.1	0.8
20061219	034902.4	63.953	20.901	7,103.8	1,749.4	17.4	0.4
20061221	155312.3	62.592	17.436	6,943.3	1,583.6	25.3	0.9
20061223	185150.2	68.087	22.759	7,571.1	1,789.0	10.7	1.4
20061223	230130.3	67.849	19.391	7,532.6	1,650.7	17.0	0.7
20061223	233035.4	67.481	19.093	7,490.9	1,640.4	25.2	2.0
20061223	235248.9	64.449	20.562	7,157.7	1,728.7	25.1	1.0
20061224	091155.9	64.319	20.588	7,143.4	1,731.0	27.7	0.9
20061224	215607.6	64.589	18.610	7,167.7	1,634.1	0.0	1.0
20061225	083808.8	62.476	15.209	6,929.4	1,469.1	0.1	2.0
20061226	103825.0	67.617	21.960	7,515.3	1,761.1	9.6	2.5
20061226	135130.7	64.545	20.552	7,168.3	1,727.4	28.0	0.6
20061226	143804.5	59.788	13.158	6,632.7	1,351.2	12.6	2.2
20061228	041355.5	65.161	21.203	7,239.4	1,752.7	19.8	1.0
20061228	104900.2	67.727	19.557	7,519.4	1,658.5	0.5	1.5
20061228	164627.6	67.729	19.551	7,519.7	1,658.2	1.3	1.8
20061230	122938.0	64.397	20.800	7,152.8	1,740.6	8.1	0.4
20061231	023428.3	68.246	19.838	7,577.9	1,666.6	3.8	1.7

4 Recorded earthquakes during the year 2006

Figure 4-1 shows earthquake activity in Sweden during the year 2006. During 2006 there were 6,843 located events, Figure 4-2. Out of these 3,802 are explosions, 451 are true earthquakes, 843 are induced earthquakes in the vicinity of the mines in Kiruna, Malmberget and Zinkgruvan, and 696 are still uncertain.



Figur 4-1. Recorded earthquakes during the year 2006.



Figur 4-2. Recorded events including explosions in the SNSN during the year 2006.

The largest events in Sweden were on January 12th, located 4 km NW of Gällivare with magnitude of $M_L = 2.8$ and on October 24th, 3 km SW of Lidköping with magnitude $M_L = 2.7$. On October 24th an earthquake with magnitude $M_L = 2.6$ was located 42 km south of Sundsvall. An earthquake with magnitude $M_L = 2.5$ occurred on April 8th 7.5 km south of Kiruna.

Additional 37 earthquakes had magnitude M_L equal to or above 2.0 during the year and 134 earthquakes with magnitude M_L equal to or above 1.0. The range of hypocentral depth varies from the surface to 39.8 km.