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Swedish National Seismic Network (SNSN)

A short report on recorded earthquakes during the fourth quarter of the year 2011

Reynir Böðvarsson
Uppsala University, Department of Earth Sciences

January 2012

Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co

Box 250, SE-101 24 Stockholm
Phone +46 8 459 84 00

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Abstract

According to an agreement with the 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 brief information about the recorded seismicity during October through December 2011.

The Swedish National Seismic Network now consists of 65 stations. During October through December, 2,682 events were located whereof 165 are estimated as real earthquakes, 1,628 are estimated as explosions, 660 are induced earthquakes in the vicinity of the mines in Kiruna and Malmberget and 229 events are still considered as uncertain but these are most likely explosions and are mainly located outside the network.

Seven earthquakes had magnitudes above $M_L = 2.0$ during the period. In October two earthquakes had magnitudes above $M_L = 2.0$. One with magnitude $M_L = 2.2$ was located 24 km SE of Nikkaluokta and one earthquake with magnitude $M_L = 2.1$ was located 28 km SW of Ludvika. In November an earthquake with magnitude $M_L = 2.2$ was located 55 km north of Övertorneå and one with magnitude $M_L = 2.0$ was located 6 km east of Granträsk and 101 km NW of Umeå. In December three earthquakes had magnitudes above $M_L = 2.0$. One had a magnitude of $M_L = 2.8$ and was located 22 km NW of Robertsfors and one earthquake with a magnitude of $M_L = 2.4$ was located 25 km north of Robertsfors. One earthquake with magnitude $M_L = 2.2$ was located 8 km west of Hudiksvall.

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 2011.

Det seismiska nätet består av 65 stationer. Under perioden oktober till december 2011 var det 2 682 registrerade händelser varav 165 bedömdes som äkta jordskalv, 1 628 bedömdes vara förorsakade av explosioner eller sprängningar, 660 var inducerade skalv i närheten av gruvorna i Kiruna och Malmberget och 229 var osäkra händelser, men dessa var i huvudsak lokaliserade utanför det seismiska nätet och är sannolikt förorsakade av explosioner.

Sju jordskalv hade magnituder över $M_L = 2,0$ under perioden. I oktober hade två jordskalv magnituder större än $M_L = 2,0$. Ett med magnitud $M_L = 2,2$ inträffade 24 km sydost om Nikkaluokta och ett med magnitud $M_L = 2,1$ lokaliserades 28 km sydväst om Ludvika. I november inträffade ett jordskalv med magnitud $M_L = 2,2$, 55 km norr om Övertorneå och ett med magnitud $M_L = 2,0$, 6 km öster om Granträsk eller 101 km nordväst om Umeå. I december hade tre skalv magnituder över $M_L = 2,0$. Ett skalv med magnitud $M_L = 2,8$ lokaliserades 22 km nordväst om Robertsfors och ett med magnitud $M_L = 2,4$ lokaliserades i närheten, 25 km norr om Robertsfors. Det tredje skalvet inträffade 8 km väster om Hudiksvall och hade magnitud $M_L = 2,2$.

Contents

1 Introduction

This document reports the seismic events recorded by the Swedish National Seismic Network (SNSN) for the fourth quarter of the year 2011. The work was carried out in accordance with activity plan AP PU 400-06-004. In Table 1-1 controlling document for performing this activity is listed. The activity plan is an SKB internal controlling document.

At present there are 65 stations in operation in the network, Figure 1-1.

The report includes fundamental information about the seismic events, including origin time, 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 i Sverige	AP PU 400-06-004	1.0

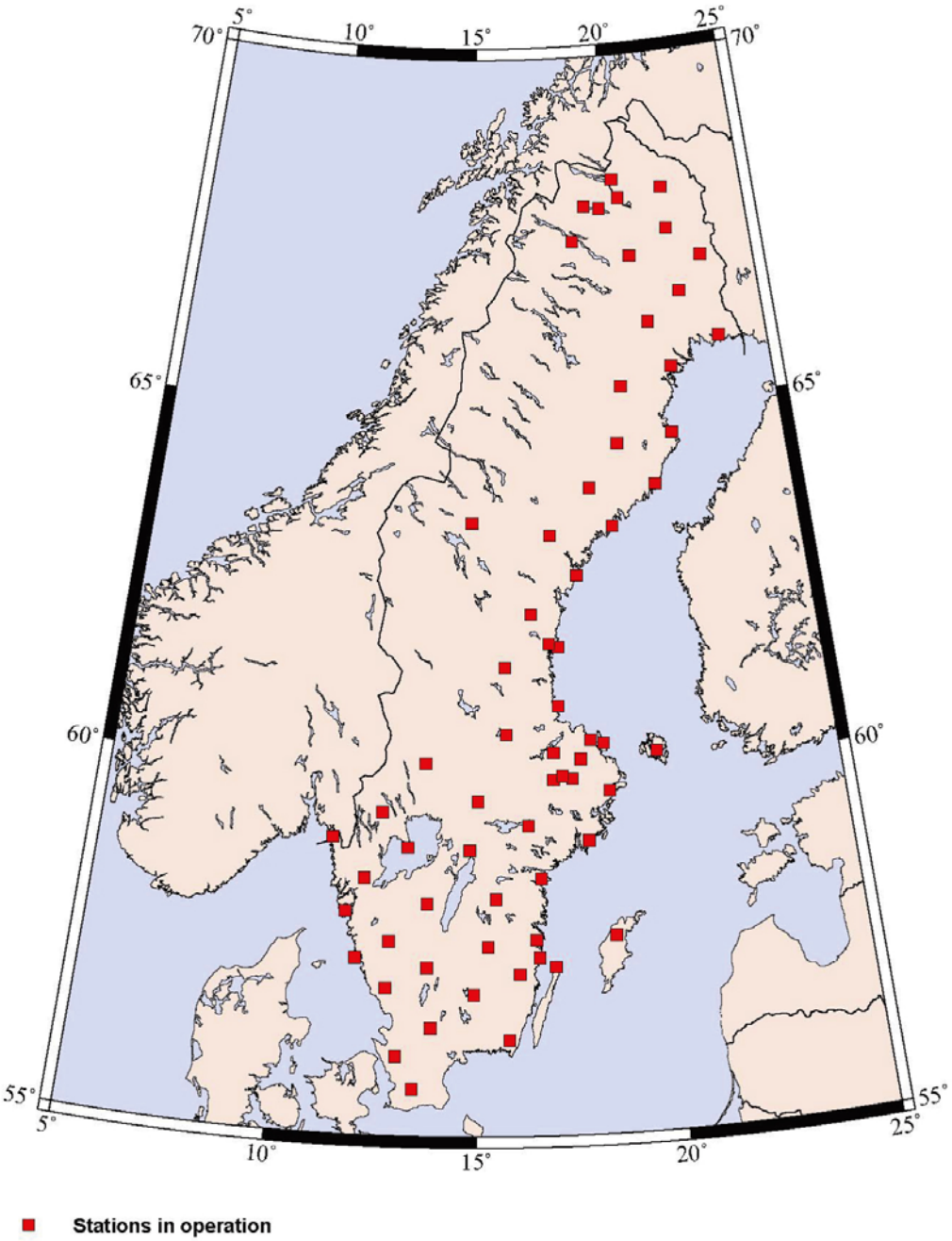

Figure 1-1. *The present Swedish National Seismic Network (SNSN).*

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 area.

Fundamental information about the seismic events, including origin time, hypocenter location and information about the source parameters are 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 repository site in Forsmark.

3 Recorded earthquakes during the fourth quarter of 2011

Figure 3-1 shows the recorded events in Sweden during October through December. During the period 2,682 events were located whereof 165 are estimated as real earthquakes (which are shown in Figure 3-2). 1,628 are estimated as explosions and 229 are still considered as uncertain but are most probably explosions and are mainly located outside the network. Large amounts of induced seismicity around the mines in Kirunavaara, Malmberget and Aitik are observed and 660 events in the very vicinity of the mines have been excluded in the report.

Earthquake lists for October through December 2011 are given in Sections 3.1 through 3.3.

3.1 October

An earthquake list for October is given in Table 3-1 with date, time (UTC), latitude, longitude, X (RT90 km), Y (RT90 km), depth and local magnitude (M_L). In October 65 earthquakes were located whereof one had a magnitude of $M_L = 2.2$ located 24 km SE of Nikkaluokta and one earthquake with a magnitude of $M_L = 2.1$ was located 28 km SW of Ludvika. Additional 10 earthquakes had magnitudes between $M_L = 1.0$ and $M_L = 1.8$. The depth range of the earthquakes varies between 0.8 and 38.5 km.

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	M_L Local Magnitude
20111001	213548.7	64.352	20.651	7,147.3	1,733.8	12.7	0.9
20111001	231517.1	61.781	17.242	6,852.7	1,575.6	17.0	0.3
20111002	034328.8	64.447	20.672	7,157.9	1,734.0	19.5	0.0
20111002	162755.1	65.517	22.763	7,285.9	1,821.2	14.9	0.7
20111002	181714.2	63.547	17.651	7,049.9	1,591.6	27.6	0.7
20111002	213344.1	66.416	21.519	7,380.1	1,754.7	6.9	–0.2
20111003	214046.0	67.918	19.628	7,540.9	1,660.2	0.9	–0.1
20111004	132503.9	60.912	17.701	6,756.5	1,602.7	16.1	1.1
20111004	144833.4	56.352	11.882	6,254.0	1,257.4	15.4	1.4
20111005	053021.4	59.938	14.910	6,646.8	1,449.8	18.7	2.1
20111006	001444.0	67.642	19.367	7,509.5	1,651.0	4.0	0.5
20111006	072914.9	63.366	19.037	7,032.5	1,661.5	3.8	0.7
20111006	193056.2	66.384	21.954	7,378.4	1,774.5	2.4	0.3
20111007	025518.6	61.898	17.334	6,865.8	1,580.2	19.2	0.7
20111007	032331.7	63.836	17.908	7,082.5	1,603.3	12.3	0.2
20111007	141459.9	64.436	20.851	7,157.3	1,742.7	23.5	0.4
20111007	193730.7	63.298	19.377	7,025.9	1,678.9	20.4	0.4
20111008	014253.1	64.522	21.534	7,169.7	1,774.6	21.9	0.0
20111009	032722.6	66.282	20.361	7,360.9	1,704.3	10.9	0.1
20111009	094430.0	66.935	22.802	7,443.5	1,805.3	4.0	–1.0
20111009	125918.6	64.265	20.348	7,136.5	1,719.8	2.3	0.6
20111009	171550.3	67.494	21.007	7,497.9	1,721.9	25.7	0.3
20111009	212055.8	64.473	21.333	7,163.4	1,765.5	0.8	0.4
20111010	131320.6	63.774	20.982	7,084.3	1,755.0	14.4	0.5
20111011	000154.5	61.665	16.494	6,839.1	1,536.3	19.0	0.0
20111011	005252.0	59.353	13.878	6,582.9	1,390.2	9.9	0.4
20111012	224234.4	56.568	12.015	6,277.6	1,266.9	24.2	0.6

Date	Time (UTC)	Latitude	Longitude	X RT90 Km	Y RT90 Km	Depth Km	M_L Local Magnitude
20111013	044557.8	57.145	12.003	6,341.8	1,269.7	19.3	0.5
20111014	021536.9	62.902	18.421	6,979.4	1,632.8	3.4	0.6
20111014	073646.9	58.882	12.784	6,532.7	1,325.7	15.0	–0.3
20111015	001819.2	66.551	22.432	7,399.1	1,793.8	9.1	–0.6
20111015	191749.7	64.343	20.584	7,146.0	1,730.6	16.2	0.6
20111016	012826.9	67.381	22.281	7,490.6	1,777.4	6.0	–0.2
20111016	043814.3	63.883	18.611	7,089.0	1,637.6	25.2	0.2
20111017	125345.6	67.557	18.216	7,497.7	1,602.6	2.7	0.1
20111017	192238.7	67.739	19.484	7,520.5	1,655.4	5.3	–0.3
20111018	002213.7	64.442	21.142	7,159.1	1,756.6	28.0	0.1
20111018	061913.3	57.623	12.438	6,393.6	1,298.7	20.0	0.8
20111018	081844.0	67.674	19.273	7,512.8	1,646.8	9.3	2.2
20111018	164810.4	64.667	21.315	7,184.8	1,762.7	6.9	0.3
20111019	164803.4	67.571	22.277	7,511.7	1,775.1	18.3	0.1
20111019	185101.9	64.332	20.714	7,145.3	1,737.0	19.2	0.3
20111020	153412.0	56.167	12.389	6,231.8	1,287.7	17.5	1.3
20111020	215329.0	63.997	20.858	7,108.6	1,746.9	16.6	0.3
20111020	231507.1	59.274	13.370	6,575.1	1,361.0	19.0	0.5
20111023	083451.2	65.320	19.201	7,250.6	1,658.1	24.3	1.5
20111023	223141.3	67.885	19.562	7,537.1	1,657.7	5.4	–0.3
20111025	090958.8	64.048	20.747	7,113.7	1,741.0	11.9	1.2
20111026	071042.5	67.148	18.701	7,453.0	1,625.3	10.2	0.1
20111026	210925.1	67.924	19.760	7,541.9	1,665.7	11.0	0.9
20111027	050725.4	61.752	17.055	6,849.2	1,565.8	12.4	1.1
20111027	141421.0	68.189	20.644	7,574.0	1,700.4	29.3	1.5
20111027	234356.0	66.880	22.889	7,437.8	1,809.8	16.8	0.2
20111028	041159.3	64.315	20.698	7,143.4	1,736.4	14.4	–0.0
20111029	002503.3	58.969	15.100	6,538.7	1,459.3	9.6	–0.3
20111029	003755.1	65.686	22.410	7,303.0	1,803.0	16.2	–0.3
20111029	014957.2	66.221	23.079	7,365.7	1,826.6	24.3	0.4
20111029	082527.3	66.006	23.221	7,342.7	1,835.8	6.9	0.3
20111029	181557.7	67.926	19.741	7,542.1	1,664.9	10.4	1.1
20111030	061343.1	59.938	15.204	6,646.7	1,466.2	22.8	1.0
20111030	065833.1	57.567	7.157	6,415.4	983.1	38.5	1.8
20111030	073615.8	64.153	20.746	7,125.5	1,740.1	3.0	0.2
20111030	135639.3	64.209	20.631	7,131.3	1,734.0	17.3	–0.2
20111031	131839.6	61.431	16.410	6,813.0	1,532.1	19.6	0.3
20111031	231750.0	68.261	20.117	7,580.4	1,678.0	18.7	0.3

3.2 November

An earthquake 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 37 earthquakes were located whereof one with a magnitude of M_L = 2.2, located 55 km north of Övertorneå and one earthquake with a magnitude of M_L = 2.0 was located 6 km east of Granträsk and 101 km NW of Umeå. Additional 5 earthquakes had magnitudes above M_L = 1.0. The depth range of the earthquakes varies between 0.7 and 45.8 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	M_L Local Magnitude
20111103	004926.1	64.316	18.464	7,137.0	1,628.4	25.3	2.0
20111103	220206.1	63.890	20.824	7,096.6	1,746.2	14.0	0.4
20111105	031029.8	57.681	7.744	6,423.7	1,019.7	34.0	1.5
20111105	102622.3	65.729	23.285	7,312.3	1,842.4	2.3	0.1
20111106	055715.2	67.576	19.211	7,501.8	1,644.8	9.1	–0.1
20111106	082259.3	66.716	22.610	7,418.2	1,799.6	19.9	–0.3
20111107	160314.8	67.750	19.471	7,521.8	1,654.7	8.8	0.3
20111108	012654.9	66.195	21.873	7,357.1	1,772.9	15.0	0.3
20111111	152042.1	61.722	16.927	6,845.8	1,559.1	4.9	–0.2
20111112	034122.9	61.535	16.488	6,824.6	1,536.1	19.1	–0.6
20111112	203312.7	67.785	19.553	7,525.9	1,658.0	7.6	–0.2
20111113	021604.6	61.658	16.940	6,838.6	1,559.9	4.3	–0.2
20111113	025059.9	65.420	20.630	7,265.9	1,723.7	26.6	0.2
20111113	084735.6	64.837	20.627	7,201.1	1,728.5	23.4	–0.3
20111114	034655.1	56.722	13.282	6,291.1	1,345.4	17.2	0.9
20111114	081822.8	64.501	21.225	7,166.1	1,760.0	17.7	1.2
20111115	122615.1	66.923	23.306	7,444.7	1,827.4	19.7	0.5
20111115	231414.1	58.872	15.805	6,527.7	1,499.8	20.7	0.2
20111117	071433.9	67.892	19.681	7,538.2	1,662.6	1.9	0.3
20111119	182549.1	56.955	13.656	6,316.3	1,369.1	16.6	0.1
20111120	212120.8	64.477	20.497	7,160.6	1,725.3	22.0	0.2
20111121	041136.4	66.791	24.019	7,434.1	1,860.3	1.9	2.2
20111121	072917.7	61.389	16.464	6,808.3	1,535.0	9.8	1.1
20111123	133937.8	65.702	22.883	7,307.2	1,824.4	1.1	–0.1
20111124	051446.4	64.488	21.114	7,164.1	1,754.8	19.1	0.3
20111125	032932.1	63.939	20.541	7,100.9	1,731.9	13.2	0.4
20111125	042942.2	60.622	17.603	6,724.0	1,598.2	18.2	0.9
20111125	132253.5	67.313	22.130	7,482.3	1,771.8	11.2	1.5
20111126	081018.8	64.662	22.463	7,189.6	1,817.4	3.8	1.2
20111126	181649.7	59.694	16.101	6,619.3	1,516.5	16.5	0.3
20111126	194032.5	61.580	18.881	6,833.3	1,663.2	2.8	0.5
20111126	202958.8	65.707	22.381	7,305.2	1,801.4	3.9	0.5
20111127	034652.2	67.735	19.489	7,520.2	1,655.6	5.3	–0.0
20111128	085555.6	66.255	22.648	7,367.3	1,806.9	0.7	0.5
20111128	142120.9	68.155	19.740	7,567.6	1,663.2	10.8	0.4
20111129	184928.5	62.985	18.403	6,988.6	1,631.5	9.9	0.7
20111130	171111.9	64.108	19.812	7,117.3	1,695.0	45.8	0.8

3.3 December

An earthquake 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 63 earthquakes were located whereof one had a magnitude of M_L = 2.8 located 22 km NW of Robertsfors and one earthquake with a magnitude of M_L = 2.4 was located 25 km north of Robertsfors. One earthquake with a magnitude of M_L = 2.2 was located 8 km west of Hudiksvall. Additional 9 earthquakes had magnitudes equal to or above M_L = 1.0. The depth range of the events varies between 0.1 and 33.4 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
20111202	001009.8	67.787	22.540	7,536.8	1,783.6	3.0	0.3
20111202	180047.2	64.288	20.712	7,140.3	1,737.3	23.3	0.4
20111203	090632.3	61.704	16.973	6,843.8	1,561.6	3.0	2.2
20111203	112733.9	64.441	20.822	7,157.8	1,741.2	22.6	1.7
20111203	143909.9	59.879	12.917	6,643.4	1,338.1	30.1	1.1
20111205	171013.1	65.924	17.588	7,314.7	1,581.0	0.1	1.2
20111206	172017.1	61.876	17.274	6,863.2	1,577.1	7.2	–0.1
20111206	222603.3	58.965	10.176	6,551.7	1,176.2	12.1	0.9
20111208	144711.4	67.629	21.459	7,514.6	1,739.8	20.9	–0.0
20111209	073529.9	68.012	19.927	7,552.2	1,672.0	10.6	0.5
20111209	180339.0	59.275	12.145	6,578.4	1,291.2	20.5	1.0
20111210	070537.4	67.883	19.406	7,536.5	1,651.1	0.1	–0.8
20111210	183056.7	64.521	21.012	7,167.4	1,749.6	14.8	1.0
20111211	043144.3	64.192	20.403	7,128.6	1,723.1	3.2	0.9
20111211	135147.5	64.397	20.928	7,153.4	1,746.7	24.1	–0.1
20111212	040531.6	57.363	13.303	6,362.5	1,349.3	19.6	0.3
20111213	053955.6	68.258	20.373	7,580.9	1,688.6	9.2	0.4
20111213	183309.3	67.781	19.546	7,525.5	1,657.7	10.8	–0.3
20111214	063525.1	67.964	22.711	7,557.2	1,788.6	11.9	0.1
20111214	114340.6	67.717	16.695	7,513.7	1,537.5	1.5	1.1
20111214	152422.3	58.428	13.910	6,479.9	1,389.1	14.6	0.9
20111216	080019.6	64.399	20.992	7,153.8	1,749.8	20.6	2.4
20111216	131854.3	67.906	19.450	7,539.1	1,652.8	3.8	–0.4
20111216	232835.8	62.613	17.475	6,945.6	1,585.6	24.5	0.0
20111217	113440.2	64.520	18.960	7,160.9	1,651.3	8.0	1.6
20111217	143657.5	67.796	19.594	7,527.2	1,659.6	10.1	–0.4
20111217	185405.0	63.178	18.843	7,011.1	1,652.8	3.0	0.4
20111218	001346.8	65.362	18.378	7,253.4	1,619.6	25.1	0.4
20111218	034834.3	65.113	21.667	7,235.9	1,774.9	18.9	0.5
20111218	131421.8	64.545	21.406	7,171.7	1,768.3	17.0	–0.1
20111218	161252.9	67.200	23.140	7,474.6	1,816.5	9.3	0.3
20111219	131544.6	59.616	15.512	6,610.6	1,483.3	19.5	0.0
20111219	195314.9	65.314	22.610	7,262.7	1,816.6	10.4	0.6
20111220	082514.5	64.426	20.781	7,156.0	1,739.4	4.1	0.5
20111220	145436.1	59.361	12.826	6,586.0	1,330.4	24.5	0.2
20111221	041246.9	67.639	19.859	7,510.4	1,671.9	3.7	0.0
20111221	140633.4	61.875	16.977	6,862.8	1,561.5	13.5	0.3
20111221	141010.7	61.862	17.011	6,861.4	1,563.3	19.3	0.1
20111221	144757.8	66.360	22.229	7,376.9	1,787.0	13.6	0.1
20111222	025538.1	64.256	19.295	7,132.3	1,669.0	33.4	–0.2
20111222	090109.2	61.571	16.334	6,828.5	1,527.9	3.5	0.6
20111222	164900.3	67.833	20.199	7,533.0	1,684.8	0.1	0.1
20111223	013758.6	62.339	17.585	6,915.3	1,592.0	11.5	0.5
20111223	073339.7	68.080	19.908	7,559.6	1,670.8	10.2	0.3
20111223	225804.8	64.349	20.648	7,146.9	1,733.7	19.9	0.1
20111224	024800.0	67.488	22.412	7,503.0	1,781.8	3.0	0.3
20111224	114850.5	62.519	17.636	6,935.4	1,594.1	1.1	0.3
20111224	170350.3	60.340	16.915	6,691.8	1,561.1	18.1	–0.2
20111225	111605.7	59.139	13.675	6,559.4	1,377.9	21.8	0.3
20111225	111636.2	59.145	13.686	6,560.1	1,378.6	19.2	1.9
20111226	184538.7	68.262	20.311	7,581.1	1,686.0	9.8	0.3
20111227	161101.0	64.346	20.572	7,146.3	1,730.0	6.6	2.8

Date	Time (UTC)	Latitude	Longitude	X RT90 Km	Y RT90 Km	Depth Km	M_L Local Magnitude
20111228	030551.9	64.880	20.793	7,206.5	1,736.0	2.2	0.5
20111228	084251.7	61.464	17.039	6,817.1	1,565.6	27.8	0.1
20111229	071435.0	67.876	19.418	7,535.7	1,651.7	3.0	–0.0
20111229	144130.3	68.122	19.731	7,563.8	1,663.1	5.2	0.8
20111229	163246.0	63.569	21.074	7,061.8	1,761.4	13.6	1.3
20111230	003052.2	62.637	18.050	6,949.2	1,615.0	7.1	0.4
20111230	005911.5	62.627	18.053	6,948.1	1,615.2	7.5	0.4
20111230	233651.6	65.041	20.785	7,224.4	1,734.2	12.2	–0.1
20111231	024315.2	68.337	20.604	7,590.3	1,697.4	4.6	0.5
20111231	091213.3	62.785	17.522	6,964.8	1,587.5	3.0	0.3
20111231	190759.4	63.912	21.044	7,099.8	1,756.7	19.0	0.2

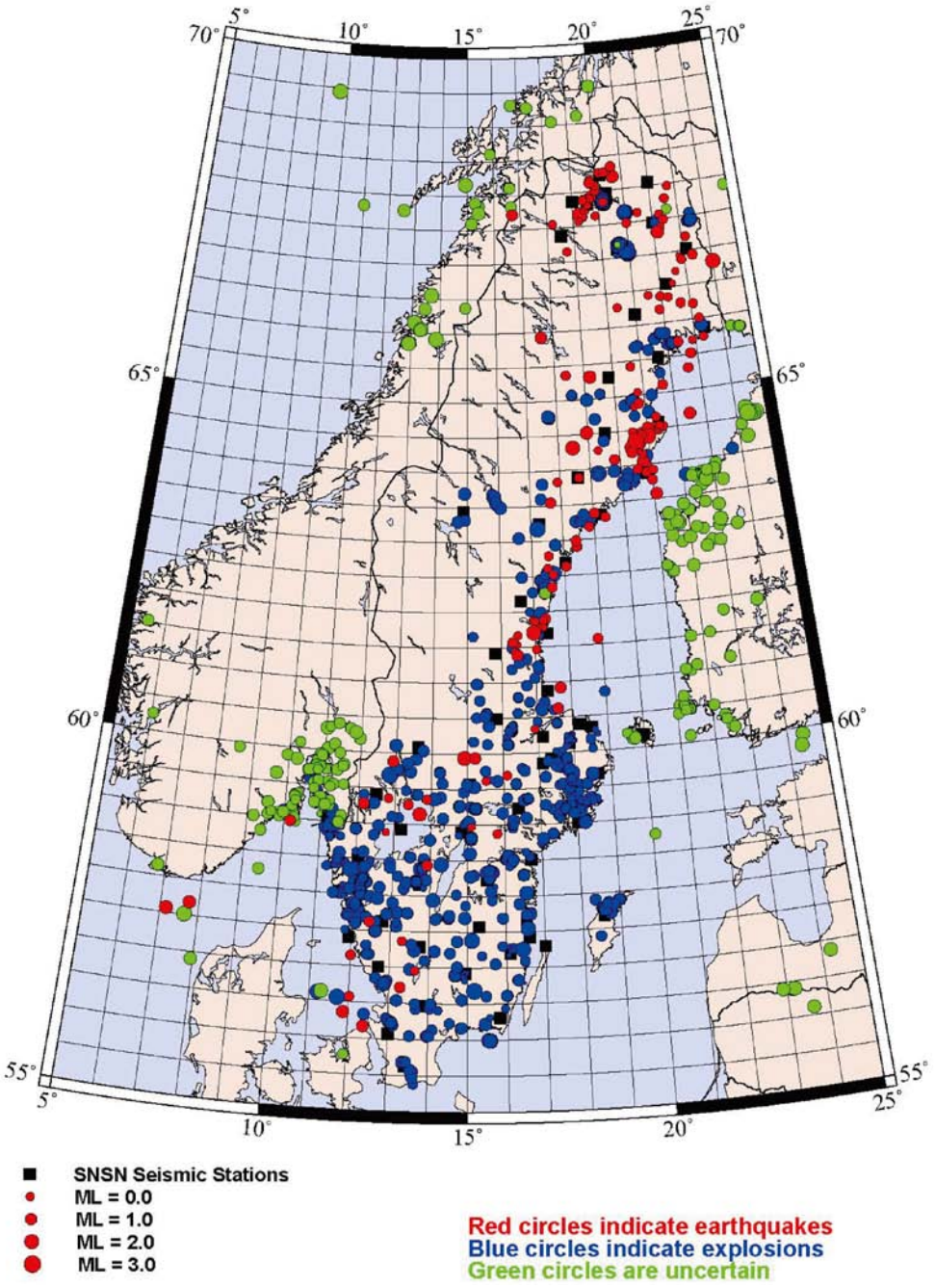

Figure 3-1. *Recorded events including explosions in the SNSN network during the period October through December 2011.*

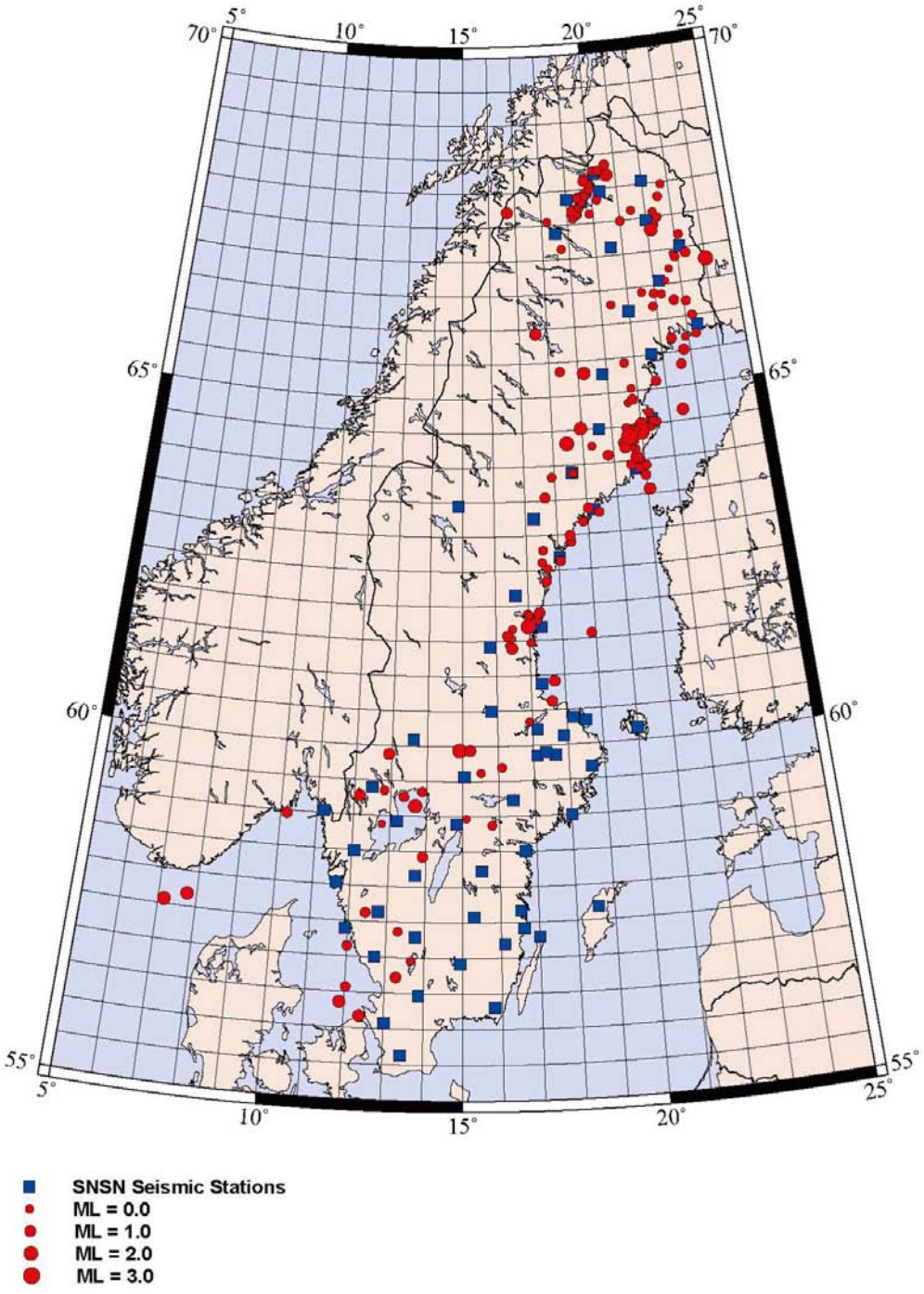

Figure 3-2. *Earthquake activity in Sweden during October through December 2011.*

4 Recorded earthquakes during the year 2011

During 2011 there were 9,083 located events, Figure 4-1. Out of these 5,901 are explosions, 547 are true earthquakes and 869 events, mainly located outside the network, are still uncertain. Additionally 1,766 induced earthquakes in the vicinity of the mines in Kiruna and Malmberget were located. These are not shown in the figure.

Figure 4-2 shows the earthquake activity in Sweden during the year 2011. The three largest earthquakes located by the network during 2011 were the $M_L = 2.9$ earthquake, located in Oppland-Hedmark in Norway on July 21, the $M_L = 2.8$ earthquake in May 12, located in Kattegatt and the $M_L = 2.8$ earthquake in December 27 located 22 km NW of Robertsfors. Three earthquakes with a magnitude of $M_L = 2.4$ occurred, one on January 31 located in Gulf of Bothnia, 74 km east of Umeå, one on August 3 located 66 km north of Kiruna and one on December 16 located 25 km north of Robertsfors. Additional 11 earthquakes had magnitudes equal or larger than $M_L = 2.0$.

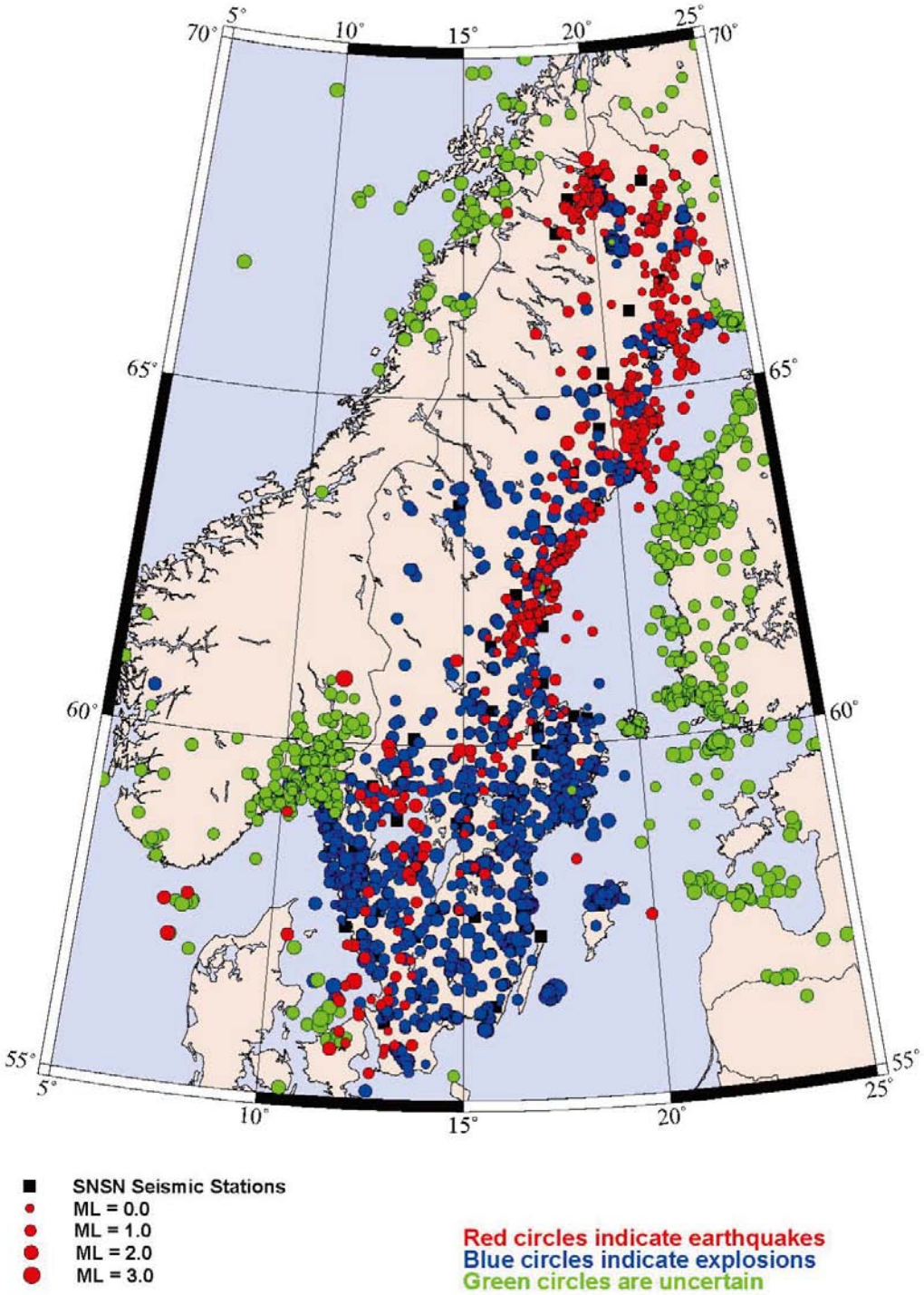

Figure 4-1. *Recorded events including explosions in the SNSN network during the year 2011.*

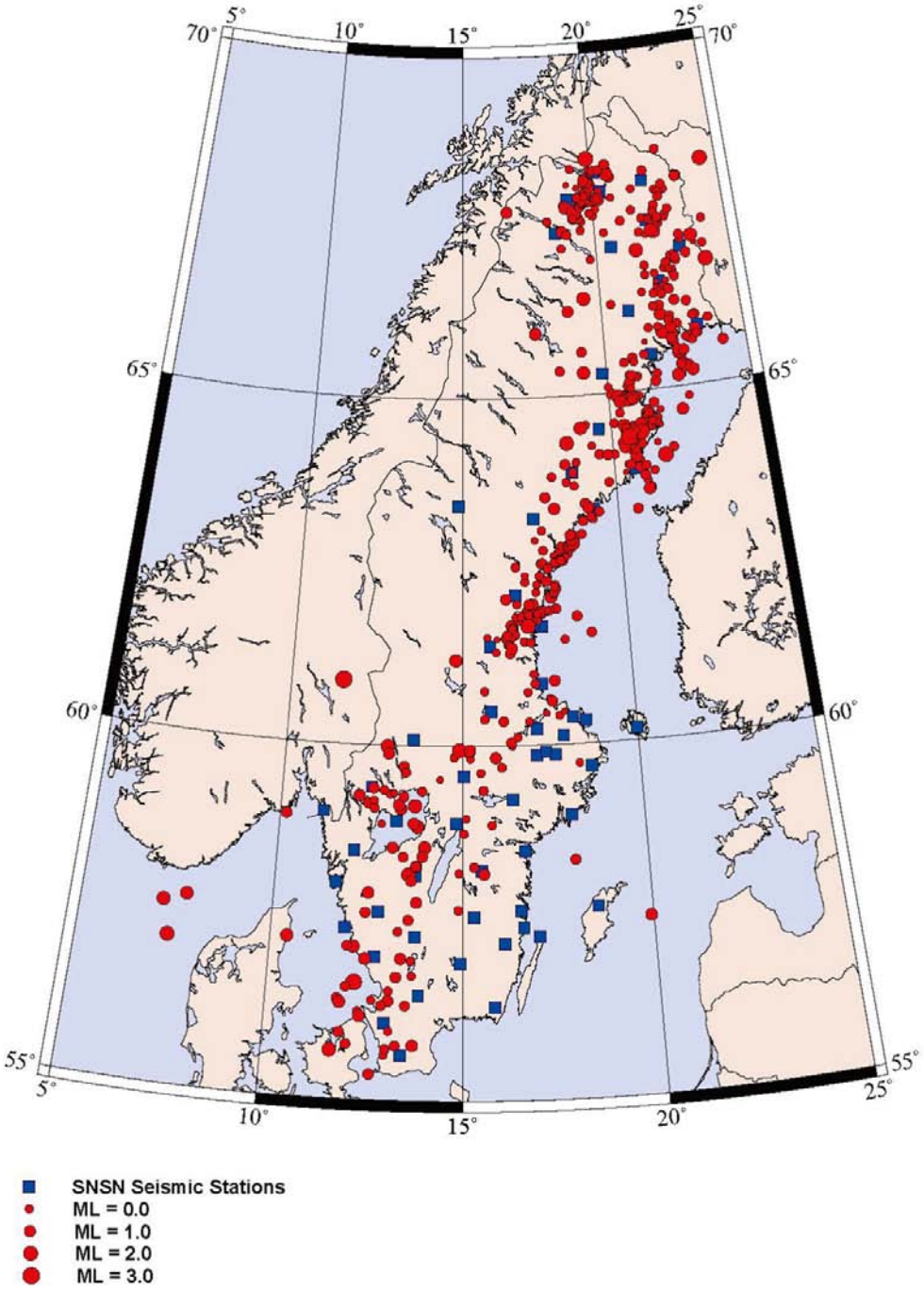

Figure 4-2. *Earthquake activity in Sweden during the year 2011.*