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Swedish National Seismic Network (SNSN)

A short report on recorded earthquakes during the fourth quarter of the year 2009

Reynir Böðvarsson
Uppsala University, Department of Earth Sciences

January 2010

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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Keywords: Seismic network, Earthquakes.

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 observations of seismic events at seismic stations within the Swedish National Seismic Network (SNSN). This short report gives brief information about the recorded seismicity during October through December 2009.

The Swedish National Seismic Network consists of 61 stations. During October through December, 1,510 events were located whereof 127 are estimated as real earthquakes, 1,065 are estimated as explosions, 145 are induced earthquakes in the vicinity of the mines in Kiruna and Malmberget and 173 events are still considered as uncertain but these are most likely explosions and are mainly located outside the network.

The three largest earthquakes during the period occurred in November. One earthquake with magnitude M_L=2.0 was located 27 km NE of Kalix, one earthquake with magnitude M_L=1.9 was located 20 km NW of Åmål and one with magnitude M_L=1.8 was located 25 km south of Örnsköldsvik.

Sammanfattning

Enligt avtal mellan Svensk Kärnbränslehantering AB (SKB) och Uppsala Universitet, Institutionen för Geovetenskaper, fortsätter Uppsala Universitet att driva seismiska mätstationer i det Svenska Nationella Seismiska Nätet (SNSN). Denna rapport ger information om registrerade händelser under tidsperioden oktober till december 2009.

Det seismiska nätet består av 61 stationer. Under perioden oktober till december, 2009 var det 1 510 registrerade händelser varav 127 bedömdes som äkta jordskalv, 1 065 bedömdes vara förorsakade av explosioner eller sprängningar, 145 var inducerade skalv i närheten av gruvorna i Kiruna och Malmberget och 173 var osäkra händelser, men dessa var i huvudsak lokaliserade utanför det seismiska nätet och är sannolikt förorsakade av explosioner.

De tre största skalven under perioden inträffade i november. Ett skalv med magnitud M_L=2,0 lokaliserades 27 km nordost om Kalix, ett skalv med magnitud M_L=1,9 lokaliserades 20 km nordväst om Åmål och ett skalv med magnitud M_L=1,8 lokaliserades 25 km syd om Örnsköldsvik.

Contents

1 Introduction

This document reports the seismic events recorded by the Swedish National Seismic Network (SNSN) for the fourth quarter of the year 2009. 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 61 stations are in operation in the network, Figure 1-1.

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 i Sverige	AP PU 400-06-004	1.0

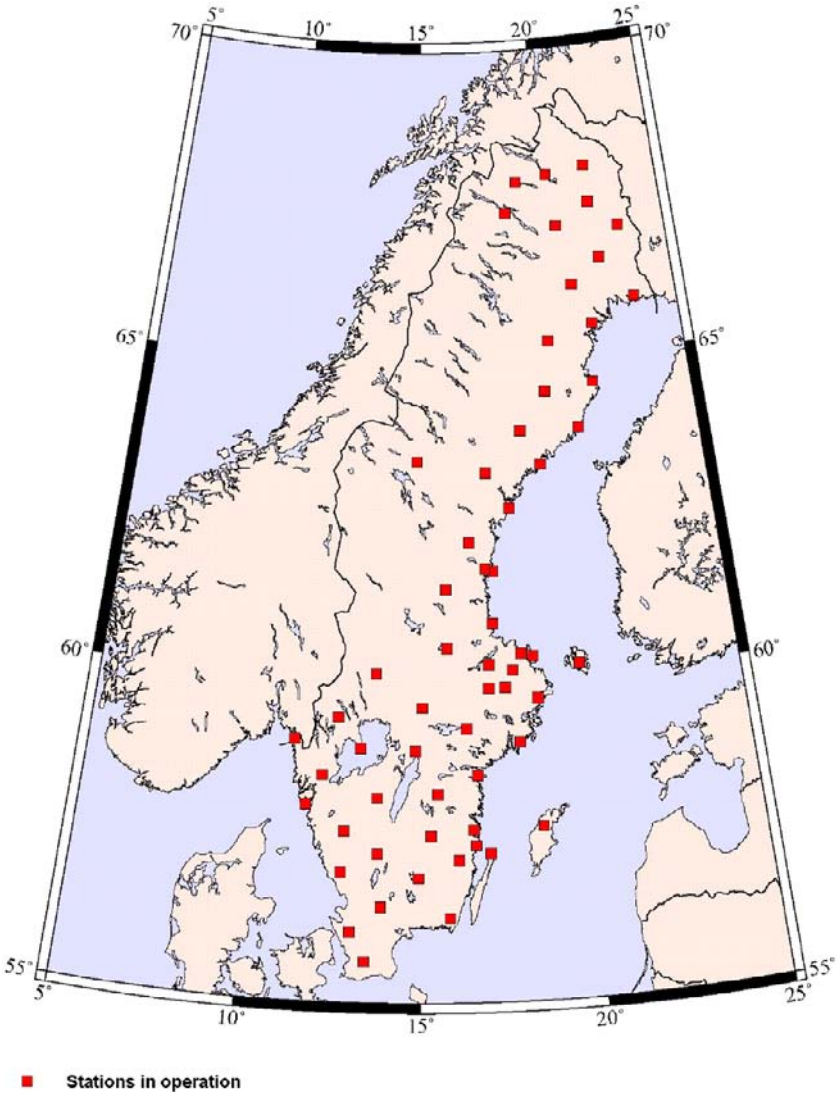

Figure 1-1. *The present Swedish National Seismic Network (SNSN).*

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 of seismic events at 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 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 site in Forsmark.

3 Recorded earthquakes during the fourth quarter of 2009

Figure 3-1 shows the recorded events in Sweden during October through December. During the period 1,510 events were located whereof 127 are estimated as real earthquakes (which are shown in Figure 3-2). 1,065 are estimated as explosions and 173 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 145 events in the very vicinity of the mines have been excluded in the report.

Event lists for October through December 2009 are given in sections 3.1 through 3.3.

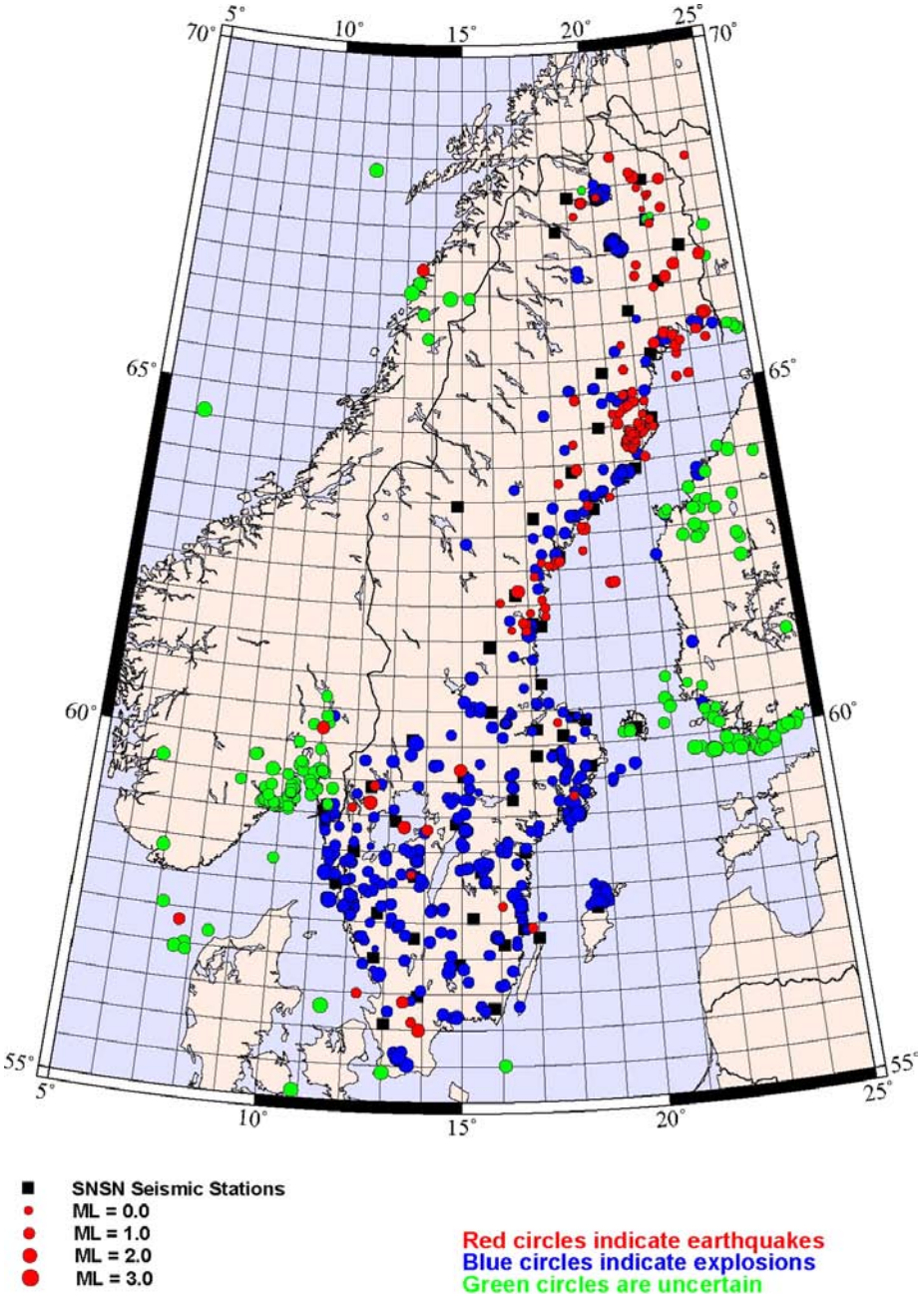

Figure 3-1. *Recorded events including explosions in the SNSN network during the period October through December 2009.*

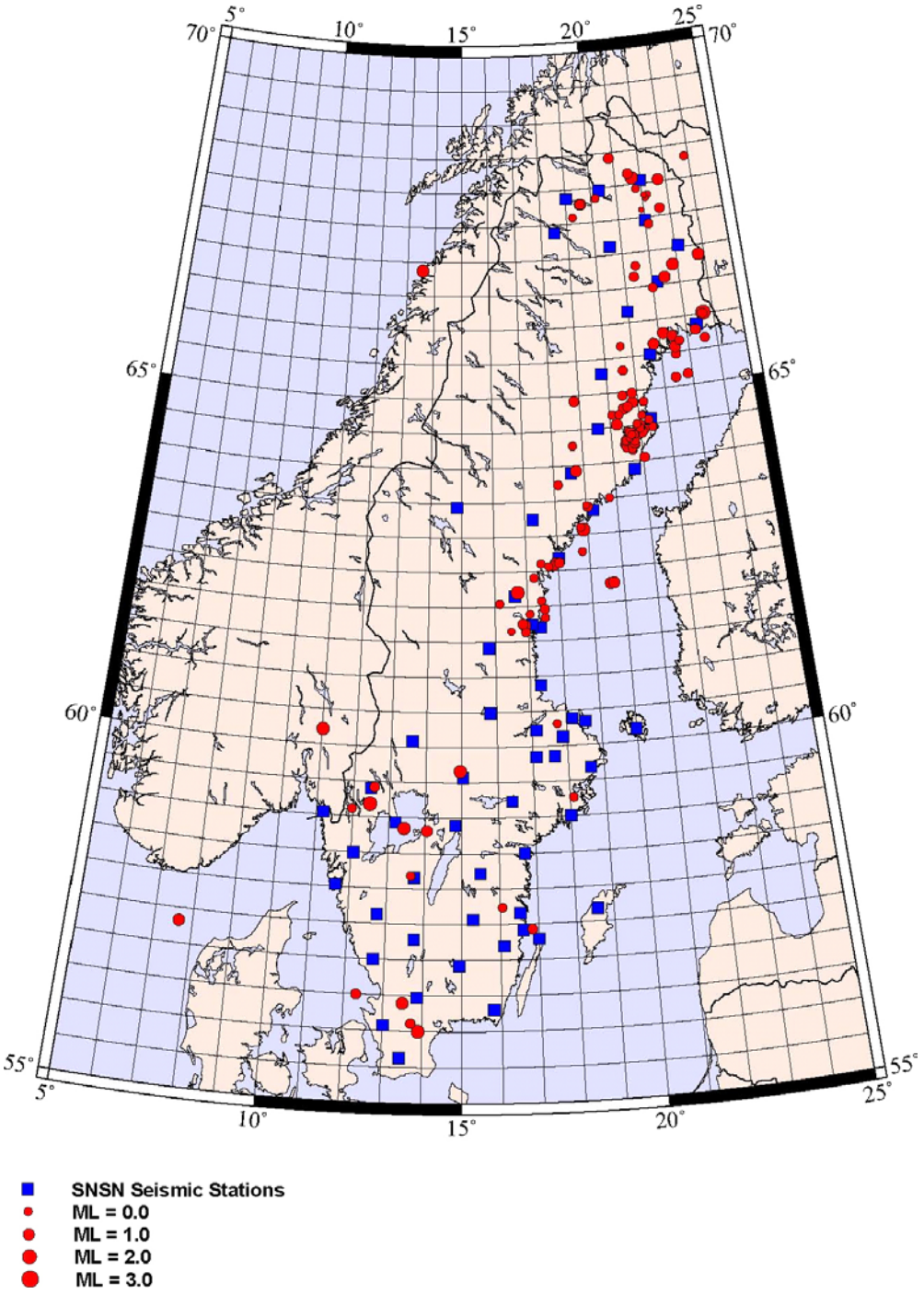

Figure 3-2. *Earthquake activity in Sweden during October through December 2009.*

3.1 October

An event 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 32 events were located whereof one had a magnitude of M_L=1.7 and was located 38 km SW of Sundsvall. One earthquake with a magnitude of M_L=1.6 was located 16 km west of Kristianstad. Additional 8 earthquakes had magnitudes between M_L=1.0 and M_L=1.5. The depth range of the events varies between 0.1 and 29.2 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
20091003	164534.8	62.206	16.703	6,899.5	1,546.5	2.3	1.7
20091004	170532.6	64.383	20.623	7,150.6	1,732.1	17.4	0.2
20091005	230920.6	56.001	13.902	6,209.7	1,381.1	20.8	1.6
20091006	201031.6	56.389	13.496	6,253.7	1,357.2	23.4	1.4
20091007	165404.1	64.275	18.676	7,132.9	1,638.9	29.1	0.1
20091008	164043.6	66.871	13.562	7,420.9	1,401.5	0.1	1.4
20091008	202803.4	58.813	14.050	6,522.5	1,398.4	4.6	1.1
20091009	063920.5	56.109	13.709	6,222.1	1,369.4	27.7	0.6
20091009	080423.1	63.394	19.037	7,035.6	1,661.3	1.6	0.5
20091010	031844.4	67.397	22.114	7,491.6	1,770.1	5.0	0.2
20091010	105722.6	64.356	20.926	7,148.8	1,747.0	17.7	0.1
20091011	054231.7	63.500	19.770	7,049.5	1,697.2	17.5	–0.2
20091011	232509.8	64.438	21.137	7,158.7	1,756.4	25.0	0.4
20091012	181958.5	62.753	18.784	6,963.6	1,652.0	18.0	0.1
20091016	231421.3	65.134	22.405	7,241.7	1,809.2	15.4	0.6
20091017	143259.8	64.455	21.416	7,161.7	1,769.6	12.6	0.0
20091017	163322.0	64.250	20.542	7,135.5	1,729.4	14.7	–0.3
20091018	113530.9	64.484	20.918	7,162.9	1,745.5	14.4	0.6
20091018	161250.3	64.427	20.584	7,155.3	1,729.9	1.1	0.1
20091019	094943.1	63.420	19.002	7,038.4	1,659.4	0.1	–0.4
20091019	153231.5	67.780	19.543	7,525.3	1,657.6	18.3	0.2
20091023	144636.0	64.402	21.030	7,154.3	1,751.6	22.0	1.3
20091024	033556.4	59.261	18.092	6,573.3	1,630.3	14.0	0.3
20091025	060522.2	64.237	20.414	7,133.6	1,723.3	15.1	–0.1
20091025	120607.3	68.315	23.845	7,601.8	1,830.7	29.2	–0.0
20091025	213656.1	67.779	19.565	7,525.2	1,658.5	3.7	1.3
20091026	081203.0	57.740	16.063	6,401.7	1,515.1	19.8	0.3
20091027	120141.1	65.791	22.154	7,313.4	1,790.1	8.9	1.0
20091029	063958.0	66.865	23.803	7,441.0	1,849.8	8.5	1.1
20091029	093251.7	64.152	20.670	7,125.0	1,736.4	18.0	0.1
20091030	005813.8	60.210	11.025	6,686.4	1,235.0	13.6	1.5
20091031	091409.4	64.208	20.489	7,130.7	1,727.1	1.8	0.7

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 45 events were located whereof one with a magnitude of M_L=2.0 was located 27 km NE of Kalix. One earthquake with a magnitude of M_L=1.9 was located 20 km NW of Åmål and one earthquake with a magnitude of M_L=1.8 was located 25 km south of Örnsköldsvik. Additional seven earthquakes had magnitudes equal to or above M_L=1.0. The depth range of the events varies between 0.1 and 31.0 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
20091103	194016.6	59.179	12.465	6,566.7	1,308.9	5.4	1.9
20091104	055314.2	64.292	20.493	7,140.1	1,726.6	4.0	0.9
20091104	113528.1	64.294	20.495	7,140.2	1,726.8	3.0	0.1
20091104	175132.8	65.312	20.589	7,253.8	1,722.7	1.1	0.4
20091105	035716.8	64.290	20.675	7,140.5	1,735.5	18.4	–0.2
20091105	232918.8	64.364	20.705	7,148.8	1,736.3	16.2	0.0
20091106	084855.1	64.921	18.827	7,205.2	1,642.8	23.4	0.7
20091106	160953.7	67.824	22.196	7,539.4	1,768.7	26.0	–0.5
20091106	223937.7	65.652	23.572	7,305.3	1,856.5	23.5	0.4
20091107	082346.8	65.466	22.512	7,279.1	1,810.2	6.0	0.4
20091109	092031.7	66.014	23.648	7,345.9	1,855.0	4.7	2.0
20091110	045859.9	64.638	21.089	7,180.7	1,752.2	18.1	–0.1
20091111	123549.3	59.105	11.971	6,560.0	1,280.2	8.1	0.3
20091111	173518.0	61.729	16.903	6,846.5	1,557.9	3.0	1.1
20091113	082529.3	66.604	22.461	7,405.1	1,794.4	5.2	1.2
20091113	094051.9	57.428	16.837	6,367.4	1,561.8	16.3	0.5
20091114	062756.9	68.027	22.688	7,564.1	1,786.8	2.9	1.0
20091114	172846.1	59.421	12.572	6,593.3	1,316.4	10.1	0.5
20091115	060406.4	62.045	16.147	6,881.2	1,517.7	9.5	0.1
20091115	195015.7	64.538	20.222	7,166.4	1,711.7	2.9	1.0
20091116	035536.6	57.323	7.640	6,384.8	1,008.7	0.1	1.2
20091117	115015.8	63.070	18.859	6,999.1	1,654.2	0.2	1.8
20091118	061929.7	64.564	21.308	7,173.4	1,763.4	21.6	0.1
20091120	084220.1	63.732	18.130	7,071.3	1,614.6	31.0	0.2
20091120	110148.6	65.578	22.513	7,291.4	1,809.0	0.1	1.0
20091120	180512.8	62.609	17.870	6,945.8	1,605.9	27.5	0.1
20091121	003555.1	65.788	23.301	7,318.9	1,842.3	5.1	0.7
20091121	061114.6	62.408	17.220	6,922.5	1,572.9	21.6	0.1
20091121	131537.9	64.467	21.024	7,161.4	1,750.7	13.7	–0.1
20091121	225631.6	65.665	20.596	7,293.1	1,720.0	16.3	–0.2
20091122	000525.5	61.648	16.483	6,837.2	1,535.8	4.0	–0.3
20091125	191535.1	63.920	18.744	7,093.6	1,644.0	6.4	1.0
20091126	070211.9	64.227	20.790	7,133.8	1,741.6	19.1	0.3
20091126	232616.7	64.948	20.496	7,213.0	1,721.4	17.4	0.4
20091127	185443.1	64.187	20.682	7,129.0	1,736.7	6.2	0.4
20091128	131046.2	64.043	21.040	7,114.4	1,755.4	17.8	0.5
20091128	201602.4	58.185	13.638	6,453.2	1,372.4	13.8	0.2
20091129	125005.6	64.239	20.774	7,135.2	1,740.7	24.9	0.5
20091129	155358.8	67.931	21.781	7,549.4	1,750.2	0.1	–0.1
20091129	190023.6	64.468	20.939	7,161.3	1,746.6	21.3	–0.0
20091130	055401.1	64.368	20.788	7,149.6	1,740.2	25.1	0.2
20091130	095914.4	64.398	20.662	7,152.4	1,733.9	9.2	0.9
20091130	103128.2	68.415	20.838	7,599.8	1,706.3	4.3	0.8
20091130	174942.1	65.166	22.839	7,247.5	1,829.0	20.0	0.6
20091130	203225.6	62.619	17.926	6,947.0	1,608.7	13.4	0.4

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 50 events were located whereof one had a magnitude of M_L=1.6 and was located 67 km NE of Kiruna. One earthquake with a magnitude of M_L=1.5 was located 44 km north of Örebro. Additional 5 earthquakes had magnitudes equal to or above M_L=1.0. The depth range of the events varies between 0.1 and 41.1 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
20091201	065538.3	64.278	20.780	7,139.5	1,740.7	7.8	0.0
20091201	115907.0	59.666	14.961	6,616.5	1,452.2	5.6	1.5
20091201	122055.9	67.775	19.510	7,524.6	1,656.2	0.1	–0.4
20091202	044927.2	64.509	21.017	7,166.2	1,750.0	20.4	0.3
20091203	215630.8	67.592	19.241	7,503.7	1,646.0	2.2	–0.2
20091204	164234.9	65.739	22.461	7,309.1	1,804.6	1.1	0.8
20091205	080620.5	61.629	16.922	6,835.4	1,559.1	16.9	0.3
20091205	142310.5	68.097	21.670	7,567.4	1,743.8	0.1	1.6
20091205	142715.3	68.165	21.527	7,574.4	1,737.1	2.7	0.5
20091206	043912.9	64.319	20.611	7,143.4	1,732.1	19.5	–0.4
20091206	130201.8	67.610	22.620	7,517.5	1,789.1	11.6	0.6
20091206	143244.6	64.839	20.818	7,202.0	1,737.5	24.8	0.9
20091207	015833.0	62.607	17.458	6,944.9	1,584.7	25.7	–0.0
20091208	143120.1	64.367	20.786	7,149.5	1,740.2	19.2	–0.1
20091209	051014.4	67.614	21.906	7,514.7	1,758.9	0.1	–0.9
20091209	075020.0	61.888	17.062	6,864.4	1,565.9	17.2	–0.2
20091209	154747.8	64.368	20.685	7,149.2	1,735.3	17.3	–0.1
20091211	133654.7	66.659	21.335	7,406.3	1,744.2	5.3	0.4
20091212	005540.1	64.681	20.083	7,181.9	1,703.9	3.0	0.1
20091212	191028.2	66.003	23.610	7,344.4	1,853.4	8.0	0.4
20091213	015938.2	64.757	20.490	7,191.7	1,722.7	19.8	0.7
20091213	075053.6	58.846	13.419	6,527.3	1,362.1	1.2	1.6
20091213	095504.6	67.783	22.110	7,534.4	1,765.6	26.0	–0.8
20091213	144854.0	67.824	22.065	7,538.8	1,763.2	25.6	–0.9
20091213	224159.8	66.775	22.821	7,425.9	1,808.1	1.5	1.4
20091214	062010.7	62.572	17.865	6,941.6	1,605.7	10.3	0.6
20091215	204830.9	62.071	17.432	6,885.1	1,584.9	19.2	0.0
20091216	164944.0	61.958	17.519	6,872.7	1,589.8	18.4	0.4
20091217	074907.3	64.836	21.202	7,203.2	1,755.7	5.2	0.2
20091217	165508.8	64.677	20.319	7,182.2	1,715.2	16.2	0.1
20091218	002022.5	65.653	21.770	7,296.4	1,774.0	41.1	1.1
20091218	125914.0	64.457	20.984	7,160.2	1,748.9	21.0	0.0
20091218	130951.0	63.107	18.779	7,003.1	1,649.9	20.8	0.0
20091218	165319.7	64.779	20.636	7,194.6	1,729.4	22.2	0.6
20091219	103909.1	62.612	18.042	6,946.4	1,614.7	12.1	0.5
20091220	091504.1	60.317	17.738	6,690.2	1,606.6	12.1	0.1
20091220	141244.6	62.272	19.591	6,912.3	1,696.4	4.2	1.1
20091220	145000.1	67.846	20.169	7,534.4	1,683.4	2.1	–0.2
20091220	152115.5	62.277	19.701	6,913.1	1,702.0	2.7	1.0
20091220	165510.6	64.973	20.824	7,216.9	1,736.6	3.0	0.5
20091221	092816.6	61.747	16.838	6,848.4	1,554.4	27.1	0.6
20091223	034701.5	61.828	17.521	6,858.3	1,590.2	17.1	0.1
20091224	010717.3	66.471	21.986	7,388.2	1,774.9	6.1	0.3
20091224	193021.3	62.562	17.697	6,940.2	1,597.1	15.7	0.1
20091225	043241.4	65.657	22.687	7,301.2	1,816.0	2.4	0.3
20091225	204113.8	56.499	12.312	6,269.0	1,284.8	18.2	0.8
20091230	025517.3	67.768	19.562	7,524.0	1,658.5	4.5	–0.2
20091230	110834.9	66.814	21.444	7,424.1	1,747.4	19.8	0.3
20091231	101621.8	67.777	19.557	7,525.0	1,658.2	1.1	0.6
20091231	141231.0	64.523	20.902	7,167.2	1,744.4	22.0	–0.1

4 Recorded earthquakes during the year 2009

Figure 4-1 shows the earthquake activity in Sweden during the year 2009. During 2009 there were 5,101 located events, Figure 4-2. Out of these 3,454 are explosions, 425 are true earthquakes and 622 events, mainly located outside the network, are still uncertain. Additionally 600 induced earthquakes in the vicinity of the mines in Kiruna and Malmberget were located. These are not shown in the figure.

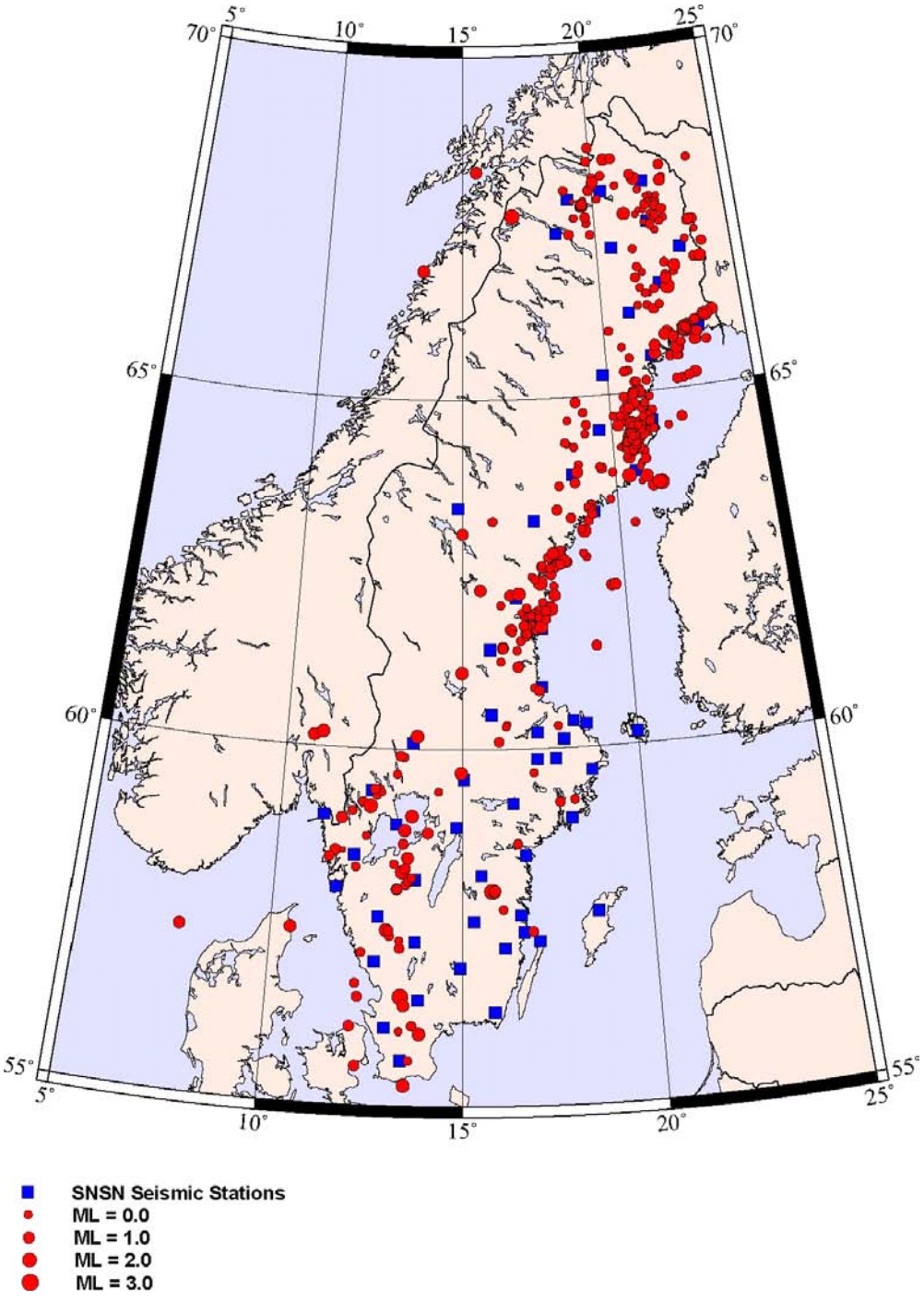

Figure 4-1. *Recorded earthquakes during the year 2009.*

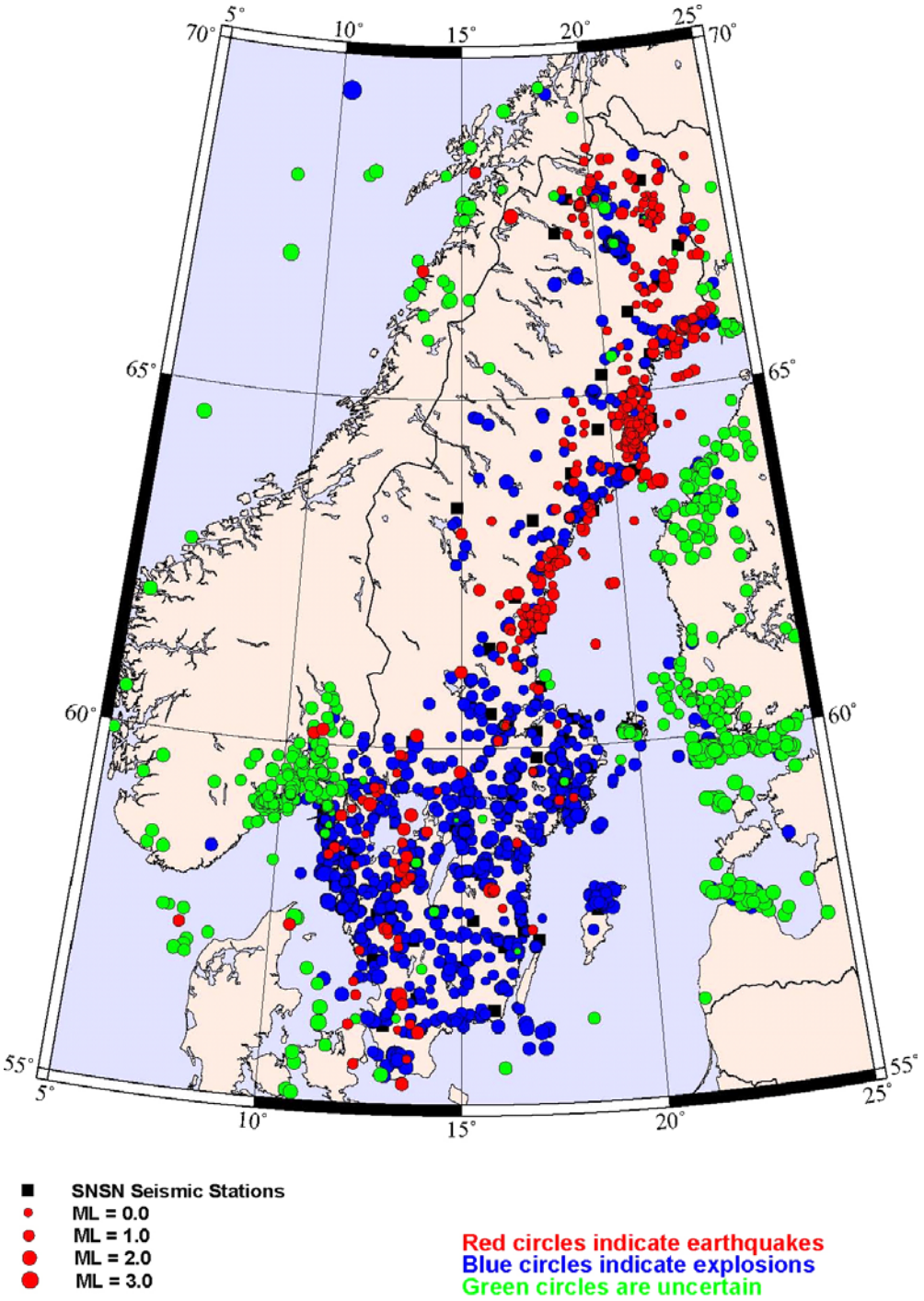

Figure 4-2. *Recorded events including explosions in the SNSN during the year 2009.*

The largest earthquake located in 2009 was the M_L=3.1earthquake that occurred on July 22, located 13 km west of Kalix. This earthquake was followed by additional 7 aftershocks, the largest one with a magnitude of M_L=2.0. In 2009 additionally 11 earthquakes had magnitudes of M_L=>2.0, the largest with a magnitude of M_L=2.8 was located 13 km NW of Markaryd. In June an earthquake with a magnitude of M_L=2.4 was located 46 km east of Tranås and in January an earthquake with a magnitude of M_L=2.2 was located 6.5 km west of Härnösand. In May two earthquakes with magnitudes of M_L=2.2 and M_L=1.9 were located 63 km east of Umeå.