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Swedish National Seismic Network (SNSN)

A short report on recorded earthquakes during the fourth quarter of the year 2010

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January 2011

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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 2010. The Swedish National Seismic Network consists of 62 stations.

During October through December, 2,241 events were located whereof 158 are estimated as real earthquakes, 1,457 are estimated as explosions, 444 are induced earthquakes in the vicinity of the mines in Kiruna and Malmberget and 182 events are still considered as uncertain but these are most likely explosions and are mainly located outside the network.

One earthquake had a magnitude above $M_L = 2.0$ during the period. In November one earthquake was located 13 km SW of Härnösand with a magnitude of $M_L = 2.1$. The largest earthquake in October had a magnitude of $M_L = 1.7$ and was located 12 km NE of Eksjö and in December an earthquake with a magnitude of $M_L = 1.8$ was located 19 km north of Motala.

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 2010.

Det seismiska nätet består av 62 stationer. Under perioden oktober till december 2010 var det 2 241 registrerade händelser varav 158 bedömdes som äkta jordskalv, 1 457 bedömdes vara förorsakade av explosioner eller sprängningar, 444 var inducerade skalv i närheten av gruvorna i Kiruna och Malmberget och 182 var osäkra händelser, men dessa var i huvudsak lokaliserade utanför det seismiska nätet och är sannolikt förorsakade av explosioner.

Ett jordskalv hade magnitud över M_L = 2.0 under perioden. I november inträffade ett skalv med magnitud M_L = 2,1 som lokaliserades 13 km sydväst om Härnösand. Största skalvet i oktober lokaliserades 12 km nordost om Eksjö med magnitud M_L = 1,7 och i december inträffade ett skalv med magnitud M_L = 1,8, 19 km norr om Motala.

Contents

1 Introduction

This document reports the seismic events recorded by the Swedish National Seismic Network (SNSN) for the fourth quarter of the year 2010. 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 62 stations 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

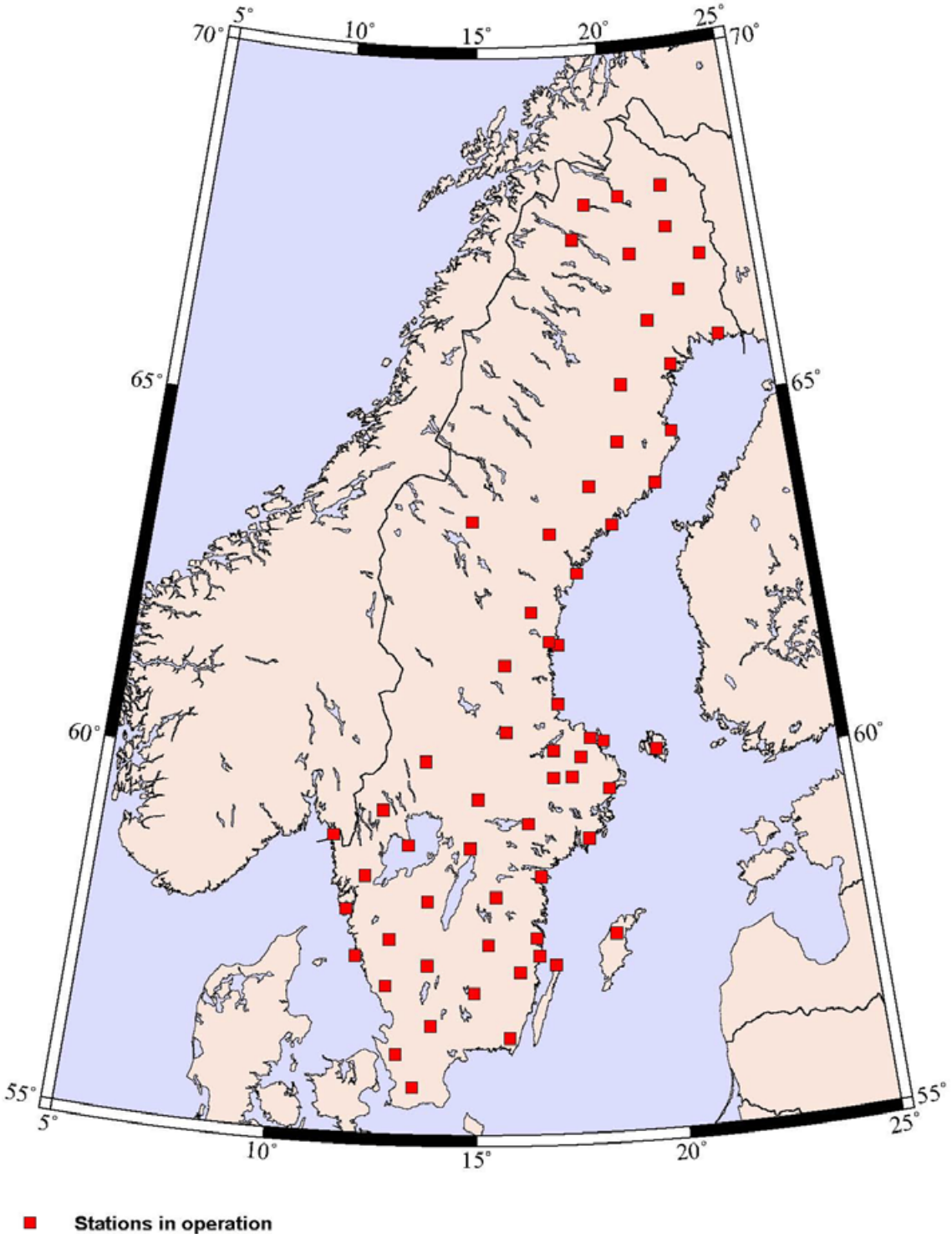

Figure 1-1. *The present Swedish National Seismic Network (SNSN).*

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 a magnitude of 0.0 near the proposed nuclear waste repository site in Forsmark.

3 Recorded earthquakes during the fourth quarter of 2010

Figure 3-1 shows the recorded events in Sweden during October through December. During the period 2,241 events were located whereof 158 are estimated as real earthquakes (which are shown in Figure 3-2). 1,457 are estimated as explosions and 182 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 444 events in the very vicinity of the mines have been excluded in the report.

Event lists for October through December 2010 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 (UTC), latitude, longitude, X (RT90 km), Y (RT90 km), depth and local magnitude (M_L). In October 50 events were located whereof one had a magnitude of M_L = 1.7 located 8.6 km south of Rydsnäs and 12 km NE of Eksjö. One earthquake with a magnitude of M_L = 1.6 was located 17 km south of Kramfors and one with a magnitude of M_L = 1.5 was located 64 km north of Boden. Additional 5 earthquakes had magnitudes between M_L = 1.0 and M_L = 1.4. The depth range of the events varies between 0.6 and 28.9 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)	ML Local Magnitude
20101001	075408.1	65.320	20.870	7,255.7	1,735.7	22.8	0.2
20101002	012512.0	67.602	21.692	7,512.6	1,749.9	14.8	0.5
20101003	011644.9	67.711	19.399	7,517.3	1,652.0	3.0	0.1
20101003	015855.4	67.922	22.483	7,551.4	1,779.6	5.5	0.4
20101003	141639.2	64.344	20.624	7,146.3	1,732.6	18.8	0.1
20101003	154216.4	67.078	22.528	7,458.1	1,791.6	9.6	1.0
20101003	222813.8	60.081	17.518	6,663.7	1,595.1	3.5	–0.6
20101004	210713.4	62.771	17.778	6,963.7	1,600.6	3.0	0.4
20101008	154239.5	64.540	20.886	7,169.0	1,743.4	3.0	0.1
20101009	005415.5	63.986	20.883	7,107.4	1,748.2	1.5	–0.0
20101009	204826.3	66.405	22.265	7,382.1	1,788.1	9.1	0.2
20101009	205111.9	62.765	17.768	6,963.0	1,600.1	6.1	–0.1
20101010	193252.5	61.980	16.926	6,874.5	1,558.6	17.4	0.1
20101011	002458.3	61.851	17.242	6,860.4	1,575.5	3.0	–0.2
20101011	100300.1	65.466	22.608	7,279.6	1,814.7	0.9	0.4
20101013	081947.0	62.775	17.795	6,964.1	1,601.4	11.0	1.6
20101013	204301.2	64.446	21.371	7,160.6	1,767.5	21.2	–0.1
20101013	224152.8	61.706	16.942	6,844.0	1,560.0	6.1	0.2
20101014	094537.5	66.396	22.116	7,380.4	1,781.5	5.1	1.5
20101014	210235.4	64.484	21.019	7,163.4	1,750.3	9.4	–0.2
20101015	202505.3	67.437	22.109	7,496.0	1,769.5	3.7	0.8
20101016	012335.8	64.346	20.549	7,146.3	1,728.9	22.0	–0.0
20101017	004856.0	67.441	18.931	7,486.1	1,633.7	6.6	0.6
20101017	072155.6	62.507	17.818	6,934.4	1,603.5	4.8	–0.0
20101018	144802.9	62.278	17.915	6,909.0	1,609.4	17.0	0.7
20101019	040754.6	67.373	18.958	7,478.6	1,635.2	0.6	–0.6
20101019	135918.8	67.109	21.523	7,457.1	1,747.9	0.9	0.5
20101020	171856.6	64.088	20.605	7,117.7	1,733.8	3.0	1.4

Date	Time (UTC)	Latitude	Longitude	X RT90 (km)	Y RT90 (km)	Depth (km)	ML Local Magnitude
20101021	214642.5	67.719	22.119	7,527.3	1,766.7	3.6	1.4
20101022	005329.5	65.042	21.052	7,225.5	1,746.7	3.0	0.6
20101022	225856.1	68.023	20.550	7,555.2	1,697.9	2.4	0.3
20101023	023738.7	58.555	11.907	6,499.1	1,273.0	22.2	0.8
20101023	102441.8	67.441	18.772	7,485.7	1,626.9	4.7	–0.0
20101024	143205.4	66.706	22.796	7,418.0	1,807.9	2.5	0.1
20101025	003556.5	62.850	17.713	6,972.4	1,597.0	11.0	0.3
20101025	092838.5	61.679	16.722	6,840.7	1,548.4	9.2	–0.1
20101025	094640.7	67.672	18.943	7,511.9	1,632.9	20.7	–0.9
20101026	173341.9	67.815	22.453	7,539.5	1,779.6	1.5	–0.0
20101026	210858.9	64.489	21.216	7,164.7	1,759.7	20.3	–0.1
20101027	152714.8	67.605	22.565	7,516.7	1,786.9	3.0	–0.2
20101027	185618.9	66.075	22.460	7,346.4	1,800.6	28.9	0.5
20101027	222337.2	64.548	21.375	7,171.9	1,766.8	20.2	0.0
20101028	111818.9	61.387	16.235	6,808.0	1,522.8	18.1	1.4
20101029	003328.8	64.379	21.399	7,153.2	1,769.5	20.9	0.3
20101029	101412.3	57.717	15.170	6,399.3	1,462.0	19.1	1.7
20101029	101640.9	57.713	15.208	6,398.8	1,464.2	20.2	0.4
20101029	101946.1	57.724	15.153	6,400.0	1,461.0	18.1	0.3
20101029	220913.3	65.855	23.158	7,325.5	1,835.0	4.0	–0.2
20101029	230710.7	64.766	17.809	7,186.0	1,595.2	13.4	0.6
20101030	123137.8	68.407	18.789	7,593.5	1,622.4	12.1	1.0

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 = 2.1, located 13 km SW of Härnösand. One earthquake with a magnitude of M_L = 1.7 was located 21 km south of Skellefteå. Additional 5 events had magnitudes equal to or above M_L = 1.0. The depth range of the events varies between 0.9 and 28.8 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
20101101	100759.3	68.049	16.831	7,550.9	1,542.7	0.9	1.3
20101102	002908.8	63.305	18.981	7,025.5	1,659.0	5.1	0.2
20101102	151709.5	68.012	19.125	7,550.2	1,638.6	22.3	0.6
20101103	025233.5	64.423	21.127	7,157.0	1,756.1	18.5	0.3
20101103	145910.7	64.736	20.654	7,190.0	1,730.6	6.8	0.5
20101105	040304.7	64.762	22.144	7,199.1	1,801.1	25.2	0.4
20101105	150607.8	64.973	20.874	7,217.1	1,739.0	28.1	0.5
20101106	044133.8	64.762	20.342	7,191.8	1,715.6	19.2	0.6
20101106	230803.5	65.948	22.232	7,331.2	1,791.8	24.0	0.5
20101108	030221.3	67.965	19.573	7,546.0	1,657.6	12.0	–1.2
20101109	003752.3	61.768	16.635	6,850.7	1,543.7	7.8	0.3
20101109	205451.7	64.370	20.940	7,150.4	1,747.5	18.1	0.0
20101109	213717.1	64.585	20.721	7,173.4	1,735.1	23.0	–0.1
20101110	104507.3	61.613	17.708	6,834.5	1,600.8	11.1	0.9
20101111	114814.7	63.254	19.085	7,020.2	1,664.5	6.0	0.4
20101111	182651.3	63.186	18.958	7,012.3	1,658.5	7.8	0.2
20101112	074806.8	64.036	21.094	7,113.8	1,758.0	19.4	–0.1

Date	Time (UTC)	Latitude	Longitude	X RT90 (km)	Y RT90 (km)	Depth (km)	ML Local Magnitude
20101113	073118.2	64.546	21.343	7,171.6	1,765.2	20.2	1.4
20101113	075107.3	64.394	20.732	7,152.3	1,737.3	1.5	–0.1
20101115	012046.1	67.740	19.478	7,520.7	1,655.1	10.1	–0.5
20101115	023041.8	64.448	20.902	7,158.8	1,745.0	19.3	1.7
20101116	091920.1	64.648	21.191	7,182.3	1,757.0	4.5	–0.7
20101119	183841.4	67.463	22.107	7,498.9	1,769.1	7.3	–0.2
20101119	210504.5	64.196	20.597	7,129.7	1,732.5	17.2	0.1
20101120	140330.1	60.043	14.835	6,658.6	1,445.7	23.3	0.1
20101121	050915.9	61.565	16.346	6,827.8	1,528.6	16.8	0.2
20101122	063240.6	64.850	20.754	7,203.0	1,734.4	14.0	1.1
20101123	002526.6	67.370	19.803	7,480.3	1,671.5	16.2	0.2
20101123	005710.4	64.940	21.027	7,214.0	1,746.5	16.2	0.2
20101123	023613.6	58.609	14.067	6,499.7	1,398.8	28.8	0.1
20101123	131532.6	64.599	21.658	7,178.8	1,779.7	21.7	0.5
20101123	195806.9	58.744	13.157	6,516.5	1,346.5	21.8	0.4
20101123	235123.1	65.240	21.638	7,249.9	1,772.2	15.3	0.2
20101124	062945.0	61.546	17.069	6,826.3	1,567.0	10.5	0.3
20101126	100624.1	64.320	20.697	7,143.8	1,736.3	19.7	–0.0
20101126	210329.4	61.946	17.636	6,871.6	1,595.9	14.9	1.5
20101128	102911.2	65.114	22.612	7,240.5	1,819.1	9.0	1.5
20101128	145317.3	67.444	22.117	7,496.8	1,769.7	8.8	–0.2
20101128	145407.5	67.437	22.163	7,496.3	1,771.8	7.3	–0.1
20101128	160239.4	67.446	22.121	7,497.1	1,769.9	9.9	0.5
20101129	052607.3	68.243	23.397	7,591.5	1,813.3	14.2	0.9
20101129	165800.4	62.565	17.799	6,940.7	1,602.4	9.3	2.1
20101129	175409.5	61.824	17.035	6,857.2	1,564.6	13.4	–0.5
20101130	210249.7	64.424	20.547	7,154.9	1,728.1	24.2	–0.4
20101130	225930.8	59.692	14.031	6,620.4	1,399.9	17.7	0.0

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 63 events were located whereof one had a magnitude of M_L = 1.8 located 19 km north of Motala and one with the same magnitude was located 31 km NW of Kiruna. One earthquake with a magnitude of M_L = 1.6 was located 26 km SE of Luleå. Additional 4 earthquakes had magnitudes equal to or above M_L = 1.0. The depth range of the events varies between 0.5 and 26.7 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)	ML Local Magnitude
20101201	203551.6	64.704	19.252	7,182.0	1,664.2	21.7	0.3
20101203	021409.2	56.918	13.599	6,312.3	1,365.5	11.1	0.4
20101203	025944.4	64.420	20.991	7,156.1	1,749.6	8.2	0.2
20101203	051925.5	67.227	21.193	7,469.0	1,732.4	24.2	0.1
20101203	150940.8	65.420	22.488	7,273.8	1,809.7	14.5	1.6
20101204	041716.3	64.151	20.987	7,126.2	1,751.8	23.1	0.4
20101205	033457.1	61.573	17.703	6,830.1	1,600.6	4.2	0.2
20101205	034943.5	59.197	12.376	6,569.0	1,303.9	8.1	0.8
20101206	005942.8	64.501	20.976	7,165.0	1,748.1	4.0	0.2
20101206	112832.7	64.560	21.288	7,172.9	1,762.5	7.3	0.3

Date	Time (UTC)	Latitude	Longitude	X RT90 (km)	Y RT90 (km)	Depth (km)	ML Local Magnitude
20101206	201145.1	57.220	13.127	6,346.9	1,338.1	12.4	1.3
20101207	143754.1	67.426	22.071	7,494.6	1,768.0	11.0	0.1
20101208	162327.1	66.988	22.113	7,446.1	1,774.7	2.5	0.9
20101208	162555.5	66.988	22.115	7,446.2	1,774.8	8.8	1.2
20101208	202947.4	64.321	21.085	7,145.5	1,755.0	19.1	0.1
20101209	005307.9	64.922	20.590	7,210.4	1,726.0	19.2	0.6
20101209	041508.0	66.660	22.386	7,411.0	1,790.4	0.5	–0.2
20101210	123719.1	61.941	17.643	6,871.0	1,596.3	16.7	0.3
20101210	152746.5	63.998	20.943	7,109.0	1,751.0	9.4	0.2
20101210	235853.1	61.521	16.436	6,823.0	1,533.4	16.4	0.7
20101211	124806.1	67.499	21.863	7,501.8	1,758.3	25.5	0.7
20101211	194933.2	66.290	20.863	7,363.6	1,726.7	8.0	–0.1
20101212	214859.5	64.634	21.635	7,182.6	1,778.3	23.8	–0.3
20101213	023757.9	67.257	21.455	7,473.3	1,743.4	21.1	0.0
20101213	105659.5	66.489	22.193	7,391.1	1,783.9	1.1	0.7
20101213	113511.4	64.693	21.093	7,186.9	1,751.9	2.9	0.2
20101214	213930.1	64.570	20.634	7,171.4	1,731.1	13.9	1.3
20101214	214413.3	64.574	20.596	7,171.8	1,729.3	21.7	0.3
20101214	230645.2	64.930	21.313	7,214.1	1,760.1	7.2	–0.5
20101214	231519.9	66.884	22.892	7,438.3	1,809.9	1.7	–0.4
20101215	203816.2	64.688	21.408	7,187.5	1,767.0	6.4	0.2
20101216	212411.6	66.777	22.756	7,425.7	1,805.3	3.6	0.6
20101216	233804.5	57.896	14.791	6,419.5	1,439.7	20.9	0.6
20101217	053037.3	58.270	13.626	6,462.7	1,372.0	14.9	0.8
20101217	150507.3	66.692	22.359	7,414.4	1,788.9	8.4	0.3
20101217	191135.1	58.720	15.040	6,511.1	1,455.5	13.2	1.8
20101217	222234.1	58.729	15.071	6,512.1	1,457.3	4.3	0.1
20101218	105140.3	65.001	20.955	7,220.6	1,742.5	20.2	0.7
20101219	013612.2	62.557	17.789	6,939.8	1,601.9	2.3	0.1
20101219	023001.6	61.814	17.055	6,856.2	1,565.7	8.1	–0.4
20101219	095111.6	62.634	17.782	6,948.4	1,601.2	12.7	1.2
20101220	165023.6	62.778	17.614	6,964.2	1,592.2	8.6	–0.3
20101220	192614.2	64.584	21.261	7,175.4	1,760.9	5.9	0.4
20101222	065156.2	64.587	20.589	7,173.2	1,728.8	19.0	0.7
20101223	125128.5	64.376	21.486	7,153.3	1,773.8	9.4	–0.6
20101224	032428.0	56.349	12.882	6,250.7	1,319.1	20.9	0.3
20101224	093356.7	60.032	13.862	6,658.5	1,391.5	9.0	0.6
20101224	123613.9	64.146	20.628	7,124.3	1,734.4	3.0	0.6
20101224	181659.6	67.533	22.185	7,506.9	1,771.6	0.7	–0.3
20101224	182504.7	67.642	22.469	7,520.4	1,782.4	12.1	0.3
20101225	142544.6	64.659	21.229	7,183.6	1,758.7	0.6	0.5
20101225	183346.3	65.826	23.075	7,321.9	1,831.5	2.9	0.2
20101226	030200.4	68.096	19.813	7,561.2	1,666.7	4.6	1.8
20101226	045840.3	64.712	21.408	7,190.3	1,766.7	10.5	–0.1
20101227	054344.8	67.308	24.244	7,492.5	1,862.3	20.6	0.2
20101227	235813.0	64.308	21.399	7,145.3	1,770.2	22.0	–0.1
20101228	041110.1	64.186	20.876	7,129.7	1,746.1	1.4	–0.1
20101228	050933.7	61.667	16.172	6,839.2	1,519.3	19.9	0.2
20101228	121255.9	67.559	22.062	7,509.3	1,766.1	16.8	0.6
20101229	150637.9	64.652	20.608	7,180.5	1,729.2	16.4	0.2
20101230	092426.6	59.198	13.700	6,565.9	1,379.6	21.3	0.3
20101230	152134.6	61.982	17.729	6,875.6	1,600.7	26.7	0.4
20101231	212037.3	57.613	15.255	6,387.7	1,466.9	2.3	–0.5

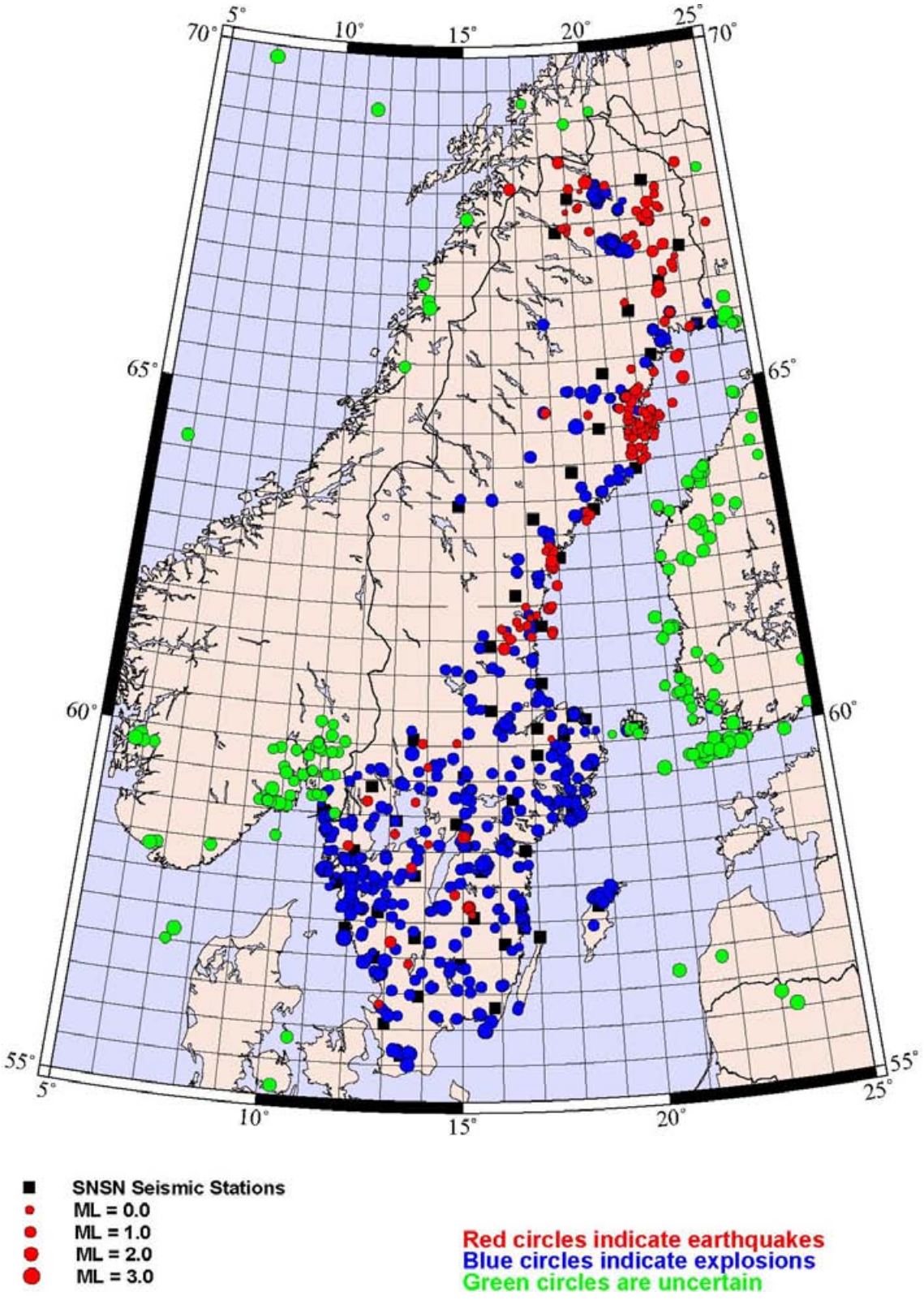

Figure 3-1. *Recorded events including explosions in the SNSN network during the period October through December 2010.*

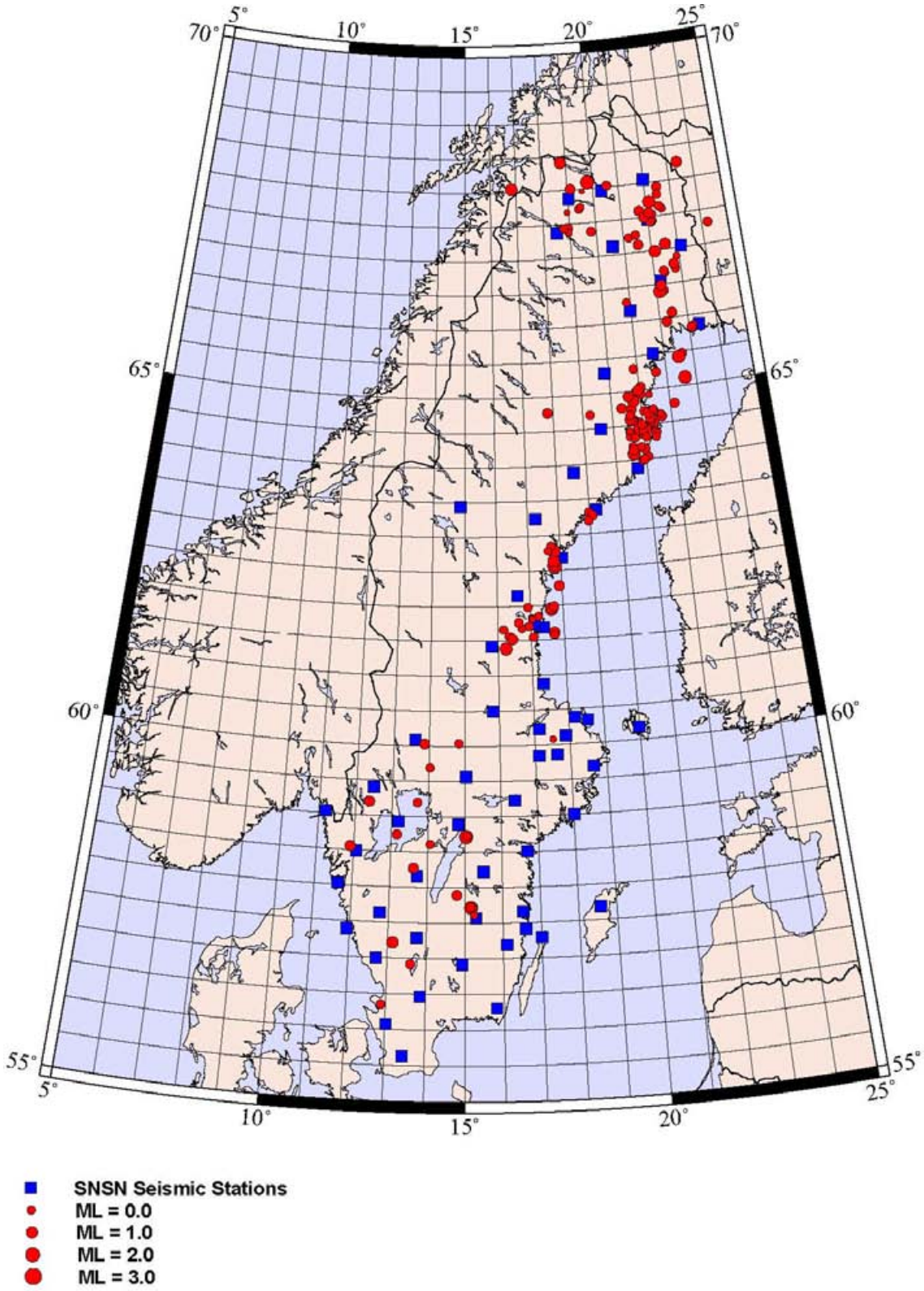

Figure 3-2. *Earthquake activity in Sweden during October through December 2010.*

4 Recorded earthquakes during the year 2010

Figure 4-1 shows the earthquake activity in Sweden during the year 2010. During 2010 there were 7,910 located events, Figure 4-2. Out of these 5,240 are explosions, 583 are true earthquakes and 696 events, mainly located outside the network, are still uncertain. Additionally 1,391 induced earthquakes in the vicinity of the mines in Kiruna and Malmberget were located. These are not shown in the figure.

The largest earthquake located during 2010 was the $M_L = 3.5$ earthquake that occurred in June 15, located 31 km SE of Skellefteå. One foreshock with a magnitude of $M_L = 0.3$ and 10 aftershocks with magnitudes between $M_L = -0.1$ and $M_L = 0.7$ were located during this earthquake sequence. In January an earthquake with a magnitude of $M_L = 2.3$ was located 18 km SE of Kramfors, one with a magnitude of $M_L = 2.2$ was located 10 km SE of Falköping and one with a magnitude of $M_L = 2.1$ was located in the Norwegian Sea. In February an earthquake with a magnitude of $M_L = 2.0$ was located 12 km east of Härnösand. In September an earthquake was located 23 km NW of Härnösand with a magnitude of $M_L = 2.1$.

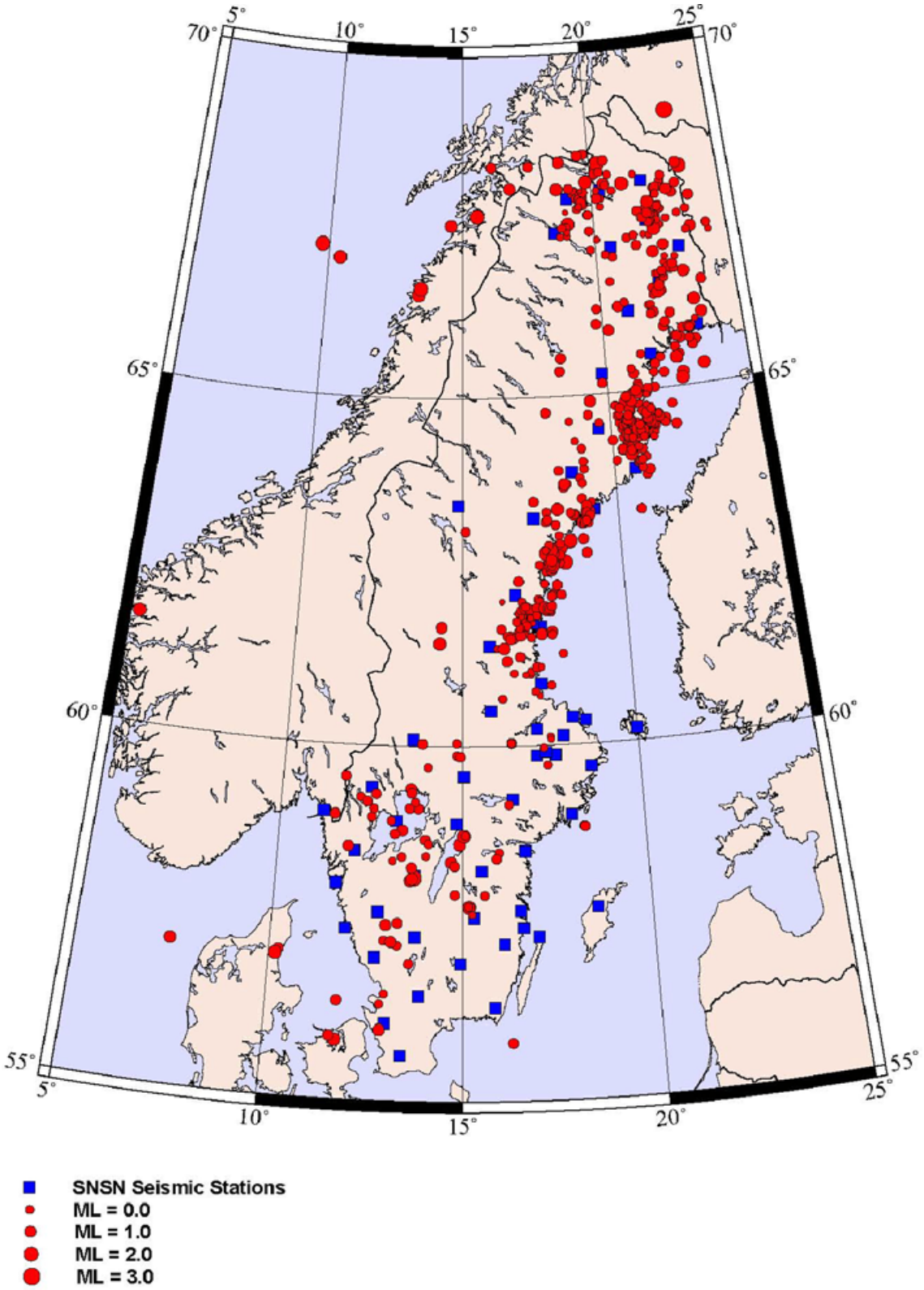

Figure 4-1. *Recorded earthquakes during the year 2010.*

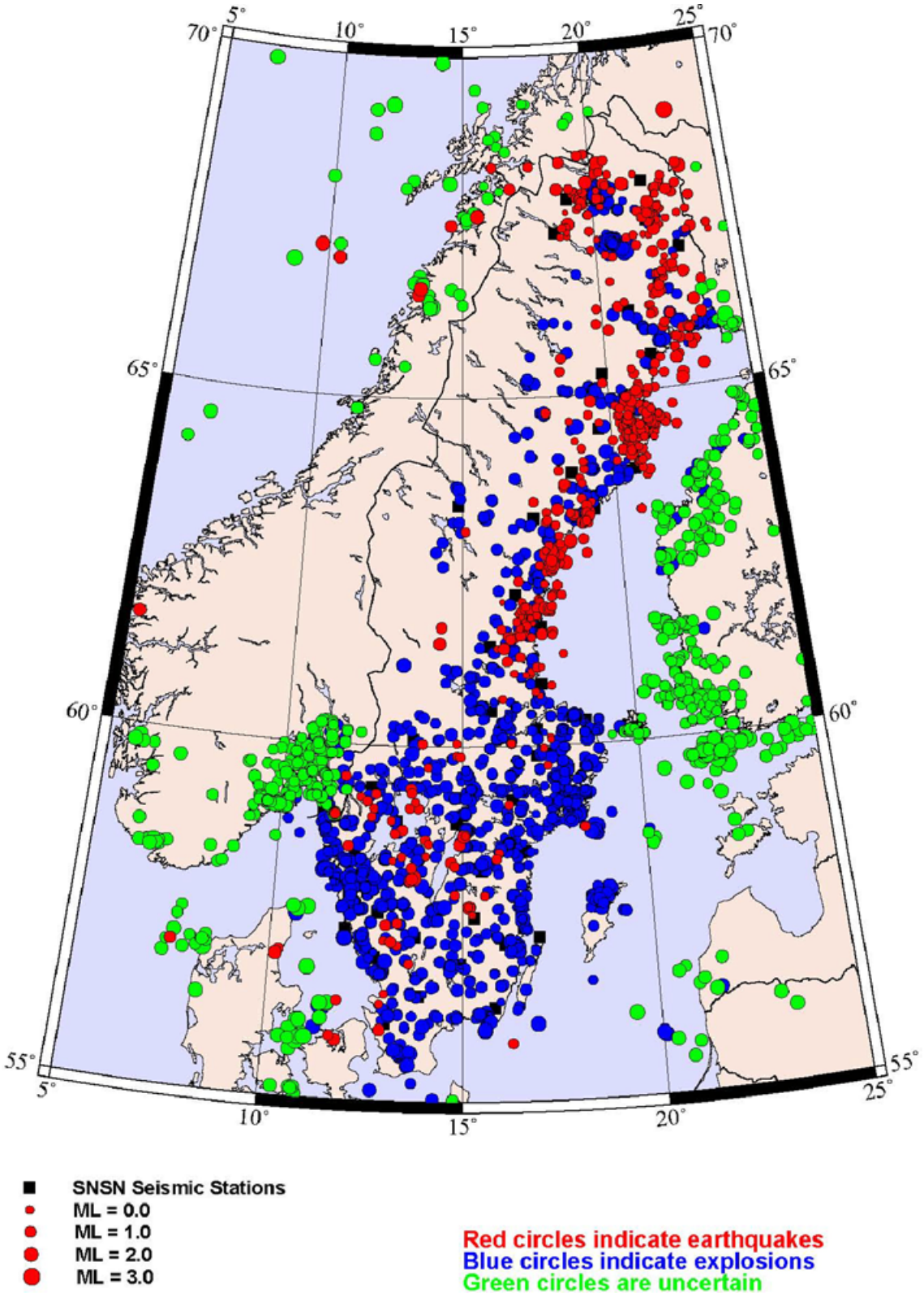

Figure 4-2. *Recorded events including explosions in the SNSN during the year 2010.*