

# **Swedish National Seismic Network (SNSN)**

## **A short report on recorded earthquakes during the third quarter of the year 2009**

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October 2009

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*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. SKB may draw modified conclusions, based on additional literature sources and/or expert opinions.

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## 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 61 seismic stations within the Swedish National Seismic Network (SNSN). This short report gives brief information about the recorded seismicity during July through September 2009.

The Swedish National Seismic Network consists of 61 stations. During July through September, 692 events were located whereof 66 are estimated as real earthquakes, 463 are estimated as explosions, 30 are induced earthquakes in the vicinity of the mines in Kiruna and Malmberget and 133 events are still considered as uncertain but these are most likely explosions and are mainly located outside the network.

In July during a period of less than 22 hours, 8 earthquakes were located in a small area 13 km west of Kalix. The first and largest one had a magnitude of  $M_L=3.1$  and the second had a magnitude of  $M_L=2.0$ . Additional two earthquakes had magnitudes above  $M_L=2.0$  during the period. In August one earthquake was located 5 km SE of Sundsvall with a magnitude of  $M_L=2.1$  and in September an earthquake, also with a magnitude of  $M_L=2.1$ , was located 41 km NE of Hudiksvall.

# 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 juli till september 2009.

Det seismiska nätet består av 61 stationer. Under perioden juli till september, 2009 var det 692 registrerade händelser varav 66 bedömdes som äkta jordskalv, 463 bedömdes vara förorsakade av explosioner eller sprängningar, 30 var inducerade skalv i närheten av gruvorna i Kiruna och Malmberget och 133 var osäkra händelser, men dessa var i huvudsak lokaliserade utanför det seismiska nätet och är sannolikt förorsakade av explosioner.

I juli månad inträffade 8 skalv, under en period av mindre än 22 timmar, i ett litet område 13 km väst om Kalix. Det första och största av dessa skalv hade en magnitud på  $M_L=3,1$  och det närmast följande skalvet hade en magnitud på  $M_L=2,0$ . Ytterligare två skalv hade magnitud över  $M_L=2,0$  under perioden. I augusti lokaliserades ett jordskalv 5 km sydost om Sundsvall med magnitud  $M_L=2,1$  och i september lokaliserades ett skalv med samma magnitud 41 km nordost om Hudiksvall.

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# 1 Introduction

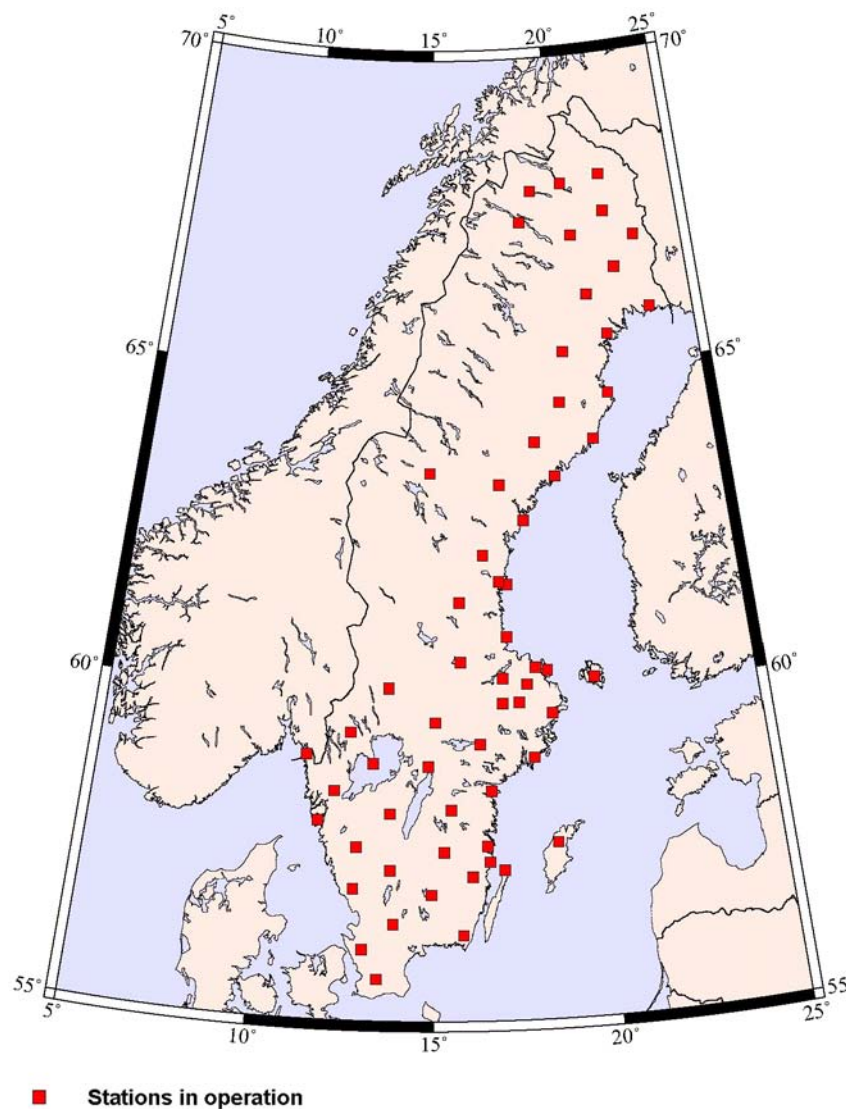
This document reports the seismic events recorded by the Swedish National Seismic Network (SNSN) for the second quarter of the year 2009. The work was carried out in accordance with activity plan AP PU 400-06-004. In Table 1-1 controlling document for performing this activity is listed. The activity 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 areas.

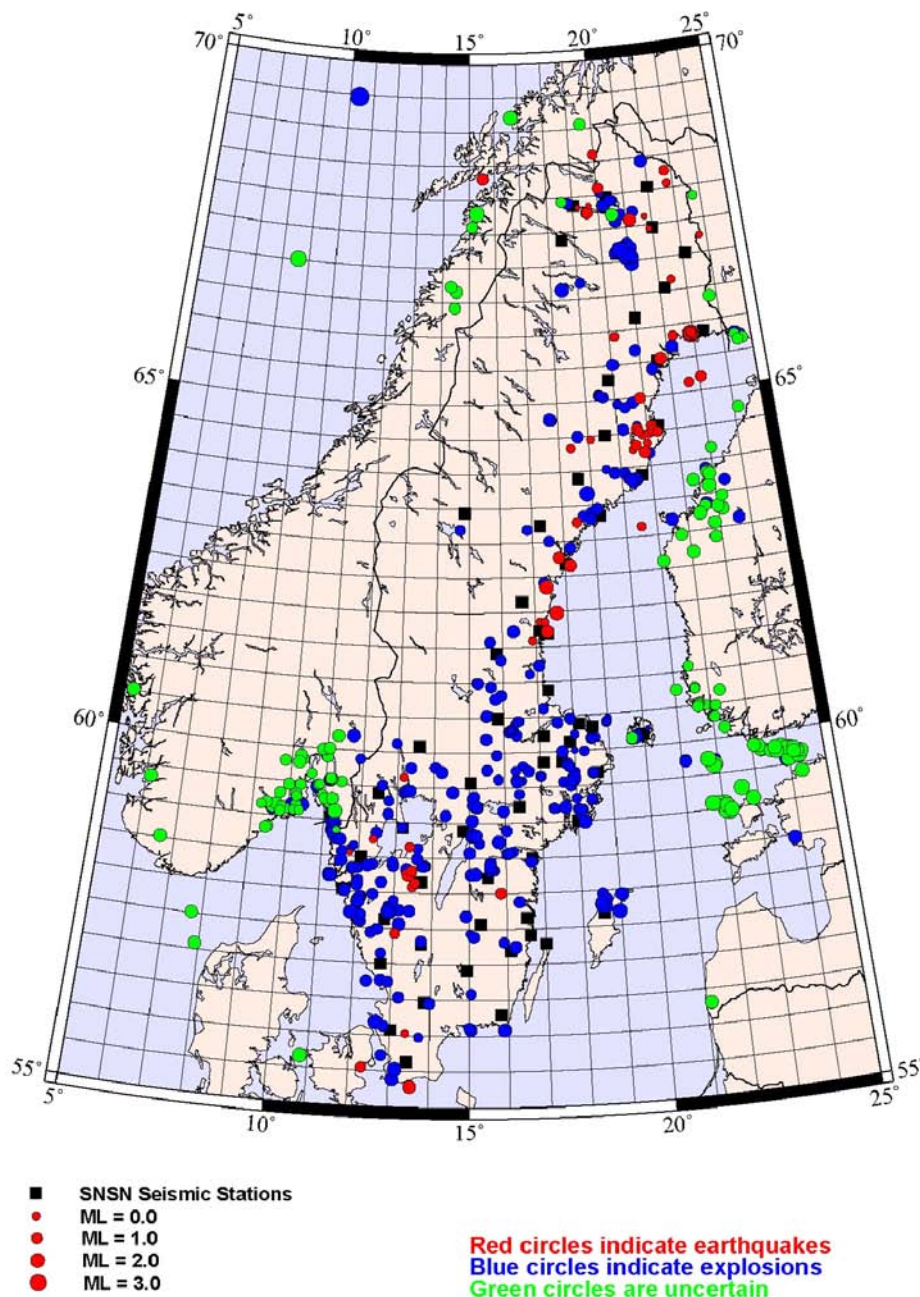
Fundamental information about the seismic events, including origin time, hypocenter location and information about the source parameters will be given after every three month period.

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 third quarter of 2009

Figure 3-1 shows the recorded events in Sweden during July through September. During the period 692 events were located whereof 66 are estimated as real earthquakes (which are shown in Figure 3-2). 463 are estimated as explosions and 133 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 30 events in the very vicinity of the mines have been excluded in the report.

Event lists for July through September 2009 are given in sections 3.1 through 3.3.



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



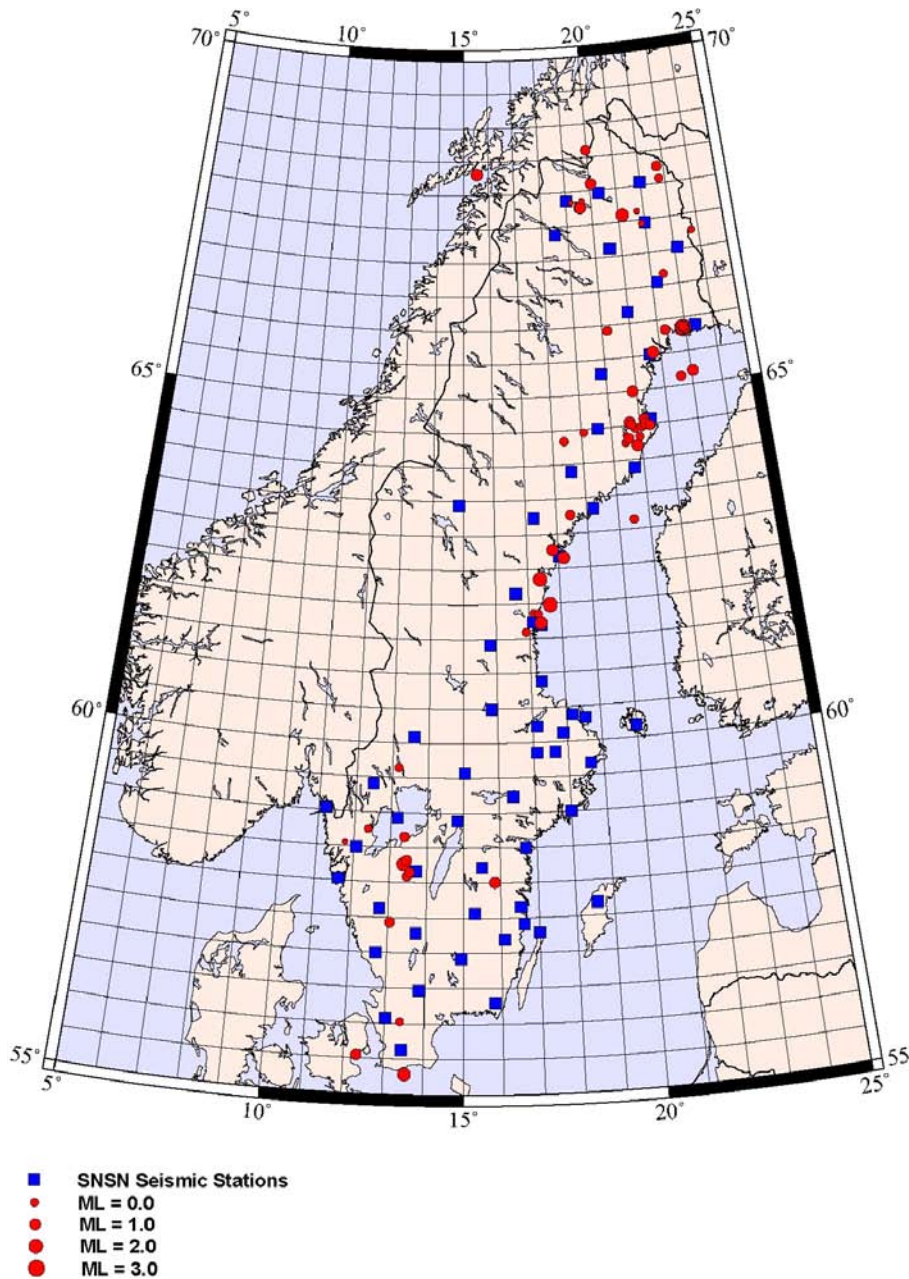


Figure 3-2. Earthquake activity in Sweden during July through September 2009.

### 3.1 July

An event list for July 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 July 28 events were located whereof one had a magnitude of  $M_L=3.1$  and another had a magnitude of  $M_L=2.0$ , both located 13 km west of Kalix. Additional 6 earthquakes, all with magnitudes below  $M_L=1.0$ , were located in the same area within 24 hours from the main event. One earthquake with magnitude  $M_L=1.9$  was located 14 km south of Skara. Additional 6 earthquakes had magnitudes between  $M_L=1.0$  and  $M_L=1.4$ . The depth range of the events varies between 2.5 and 26.2 km.

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

Date	Time (UTC)	Latitude	Longitude	X RT90 Km	Y RT90 Km	Depth Km	$M_L$ Local Magnitude
20090702	162838.7	64.534	21.204	7,169.7	1,758.7	20.0	0.8
20090704	030713.8	64.548	20.655	7,169.1	1,732.3	18.7	1.2
20090704	235850.8	67.753	19.530	7,522.3	1,657.2	7.2	1.0
20090704	235850.8	67.753	19.558	7,522.4	1,658.4	2.5	1.0
20090705	155717.8	66.668	22.452	7,412.2	1,793.3	10.0	-0.2
20090709	085834.6	58.755	12.381	6,519.8	1,301.7	26.2	-0.2
20090710	010100.9	68.604	19.964	7,618.1	1,669.1	12.1	0.6
20090710	182642.0	64.459	20.830	7,159.8	1,741.4	8.6	0.2
20090710	183052.6	65.201	23.056	7,252.5	1,838.7	12.0	1.0
20090711	093213.2	59.639	13.178	6,616.1	1,351.7	6.4	-0.0
20090711	192634.0	64.333	20.959	7,146.3	1,748.8	24.3	-0.2
20090713	130827.6	58.263	13.379	6,462.5	1,357.5	6.9	1.9
20090714	102937.1	62.772	17.819	6,963.9	1,602.7	2.7	1.3
20090714	162235.6	64.580	21.157	7,174.6	1,756.0	3.3	0.9
20090715	012356.5	64.472	21.045	7,162.1	1,751.7	16.6	0.2
20090715	084128.5	63.269	18.455	7,020.4	1,632.9	19.5	0.6
20090722	081506.5	65.841	22.911	7,322.6	1,823.9	11.0	3.1
20090722	082054.6	65.842	22.908	7,322.7	1,823.8	8.3	2.0
20090722	083240.2	65.841	22.920	7,322.7	1,824.3	9.9	0.1
20090722	083254.6	65.840	22.913	7,322.6	1,824.0	9.8	-0.5
20090722	084312.1	65.840	22.916	7,322.6	1,824.1	16.1	0.5
20090722	085545.3	65.828	22.974	7,321.6	1,826.9	9.4	0.9
20090722	182607.1	65.832	22.968	7,322.0	1,826.6	10.2	0.2
20090723	054026.4	65.857	22.924	7,324.6	1,824.3	3.4	0.4
20090723	081708.2	68.256	22.729	7,589.7	1,785.7	16.8	0.6
20090724	024526.3	67.259	23.743	7,484.3	1,841.6	21.4	-0.4
20090729	122442.8	65.534	21.731	7,283.0	1,773.5	20.1	1.4
20090731	092039.3	68.099	20.062	7,562.2	1,677.0	9.1	0.9

### 3.2 August

An event list for August 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 August 24 events were located whereof one with a magnitude of  $M_L=2.1$  was located 5 km SE of Sundsvall. One earthquake with a magnitude of  $M_L=1.7$  was located 24 km SW of Ystad and one with a magnitude of  $M_L=1.6$  was located 50 km SE of Kiruna. Additional five events had magnitudes equal to or above  $M_L=1.0$ . The depth range of the events varies between 0.1 and 41.5 km.

### 3.3 September

An event list for September 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 September 14 events were located whereof one had a magnitude of  $M_L=2.1$ , which was located 41 km NE of Hudiksvall. Additional two earthquakes had magnitudes equal to or above  $M_L=1.0$ . The depth range of the events varies between 1.1 and 35.3 km.

**Table 3-2. Date, time (UTC), latitude, longitude, X (RT90), Y (RT90), depth and local magnitude (M<sub>L</sub>) of recorded earthquakes in August.**

Date	Time (UTC)	Latitude	Longitude	X RT90 Km	Y RT90 Km	Depth Km	M <sub>L</sub> Local Magnitude
20090802	010734.9	61.866	17.138	6,862.0	1,570.0	17.3	-0.3
20090805	171846.1	67.597	21.156	7,510.0	1,727.3	16.6	1.6
20090805	181548.5	61.722	17.363	6,846.2	1,582.2	0.1	1.5
20090805	225233.3	58.006	15.846	6,431.3	1,502.2	17.4	1.1
20090806	022921.6	67.626	21.727	7,515.4	1,751.2	24.4	-0.8
20090806	164359.8	68.073	22.763	7,569.5	1,789.4	13.4	-0.0
20090811	000704.8	64.205	20.846	7,131.7	1,744.5	9.8	1.3
20090811	070800.5	67.840	19.207	7,531.2	1,643.0	1.1	-1.1
20090811	085309.5	63.143	20.496	7,012.2	1,736.2	25.0	0.3
20090813	122702.6	67.447	21.866	7,496.1	1,759.0	18.5	-0.8
20090814	205116.4	55.285	13.543	6,130.7	1,356.1	41.5	1.7
20090815	083127.7	57.436	13.058	6,371.1	1,334.8	2.5	0.8
20090815	135627.7	58.553	11.756	6,499.3	1,264.2	9.7	-0.9
20090817	012440.7	65.846	22.262	7,320.0	1,794.3	18.2	0.5
20090818	090245.5	64.513	20.699	7,165.3	1,734.7	19.0	0.4
20090821	124931.5	64.513	21.208	7,167.4	1,759.1	13.5	1.1
20090822	035354.6	61.858	17.293	6,861.3	1,578.2	18.5	-0.2
20090822	155022.5	62.349	17.381	6,916.1	1,581.5	15.9	2.1
20090826	033520.7	64.364	20.483	7,148.0	1,725.6	13.0	-0.8
20090826	063601.1	64.487	21.342	7,165.0	1,765.7	18.5	0.6
20090827	060231.8	58.658	13.388	6,506.4	1,359.6	17.5	0.5
20090827	142644.3	64.257	20.453	7,136.0	1,725.0	18.3	-0.1
20090830	201334.3	64.314	20.578	7,142.8	1,730.6	20.8	0.7
20090831	195026.8	62.652	18.169	6,951.1	1,621.0	0.8	1.4

**Table 3-3. Date, time (UTC), latitude, longitude, X (RT90), Y (RT90), depth and local magnitude (M<sub>L</sub>) of recorded earthquakes in September.**

Date	Time (UTC)	Latitude	Longitude	X RT90 Km	Y RT90 Km	Depth Km	M <sub>L</sub> Local Magnitude
20090901	054224.5	64.345	18.391	7,140.1	1,624.8	28.6	0.3
20090901	085223.5	55.543	12.321	6,162.6	1,279.9	35.3	0.9
20090902	142124.0	68.312	15.543	7,579.9	1,489.1	6.2	1.3
20090906	091012.4	61.595	16.896	6,831.6	1,557.7	19.8	0.0
20090907	094860.0	64.988	20.863	7,218.7	1,738.3	28.7	1.1
20090908	042514.6	65.916	20.180	7,319.7	1,699.0	1.1	0.3
20090916	030742.6	58.088	13.481	6,442.7	1,362.8	12.9	0.4
20090917	082522.7	56.032	13.398	6,214.1	1,349.8	19.0	-0.1
20090919	163743.2	65.140	22.612	7,243.4	1,818.8	17.4	0.6
20090921	113440.3	64.452	19.082	7,153.6	1,657.5	21.7	-0.2
20090921	183534.0	61.980	17.673	6,875.4	1,597.8	2.4	2.1
20090922	053914.8	58.143	13.549	6,448.8	1,367.0	16.7	0.5
20090929	051218.9	58.313	13.459	6,467.9	1,362.3	14.1	0.9
20090930	093154.2	67.853	19.636	7,533.6	1,661.0	3.7	-1.0