Seismicity of Norway and surrounding areas

for

2008

Prepared by

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CONTENTS

1. Introduction

This annual report on the seismicity of Norway and adjacent areas encompasses the time period January 1st - December 31st, 2008. The earthquake locations have been compiled from all available seismic stations operating on the Norwegian territory including the Arctic islands of Spitsbergen, Bjørnøya, Hopen and Jan Mayen. In addition, stations from neighbouring countries have been included for large or well-recorded events.

In Norway, the University of Bergen (UiB) operates the Norwegian National Seismic Network (NNSN) consisting of 33 seismic stations where 12 have broad band sensors. NORSAR operates 3 seismic arrays and one seismic station (Figure 1). Data from temporarily installed local networks are also included whenever data are made available. In addition to NNSN stations waveform data from other selected stations in Norway (operated by NORSAR), Finland, Denmark and Great Britain are transferred in real time and included in the NNSN database.

Phase data from arrays in Russia (Apatity), Finland (Finess), Sweden (Hagfors) and from stations operated by the British Geological Survey (BGS) are also included when available. All phase data are collected by UiB, and a monthly bulletin is prepared and distributed. All earthquakes with magnitude ≥ 2.0 on mainland Norway and M ≥ 3.0 around Jan Mayen and the Mid Atlantic ridge, are presented on the web pages and also e-mailed to European-Mediterranean Seismological Centre (EMSC). A brief overview of the events published in the monthly bulletins is given in this annual report. Macroseismic data for the largest felt earthquakes in Norway are collected, and macroseismic maps are presented.

Local, regional and teleseismic events that are detected by the UiB network are included. The merging of data between NORSAR and UiB is based on the following principles:

> **i)** All local and regional events recorded by NORSAR that are also detected by the NNSN network are included.
> **ii)** All local and regional events with local magnitude larger than 2.0 detected by NORSAR and not recorded by the NNSN are included.
> **iii)** All teleseismic events recorded by NORSAR and also detected by the NNSN are included.
> **iv)** All teleseismic events with NORSAR magnitude $M_b \geq 5.0$ are included.

Data from British Geological Survey (BGS) are included in the database in Bergen following similar criteria as mentioned above, however only events located in the prime area of interest, shown in Figure 1, are included.

Starting from 2008 the NNSN stations were upgraded to provide continuous data in real time. This has resulted in more effective monitoring of earthquake activity in the region.

Data availability to the public

All the data stored in the NNSN database is also available to the public via Internet, e-mail or manual request. The main web-portal for earthquake information is www.skjelv.no. It is possible to search interactively for specific data, display the data locally (waveforms and hypocenters) and then download the data. Data are processed daily and updated lists of events recorded by Norwegian stations are available soon after recording. All events with an estimated local magnitude ≥ 2.0 are processed daily and plotted on individual maps shown on the web pages. These pages are automatically updated with regular intervals.

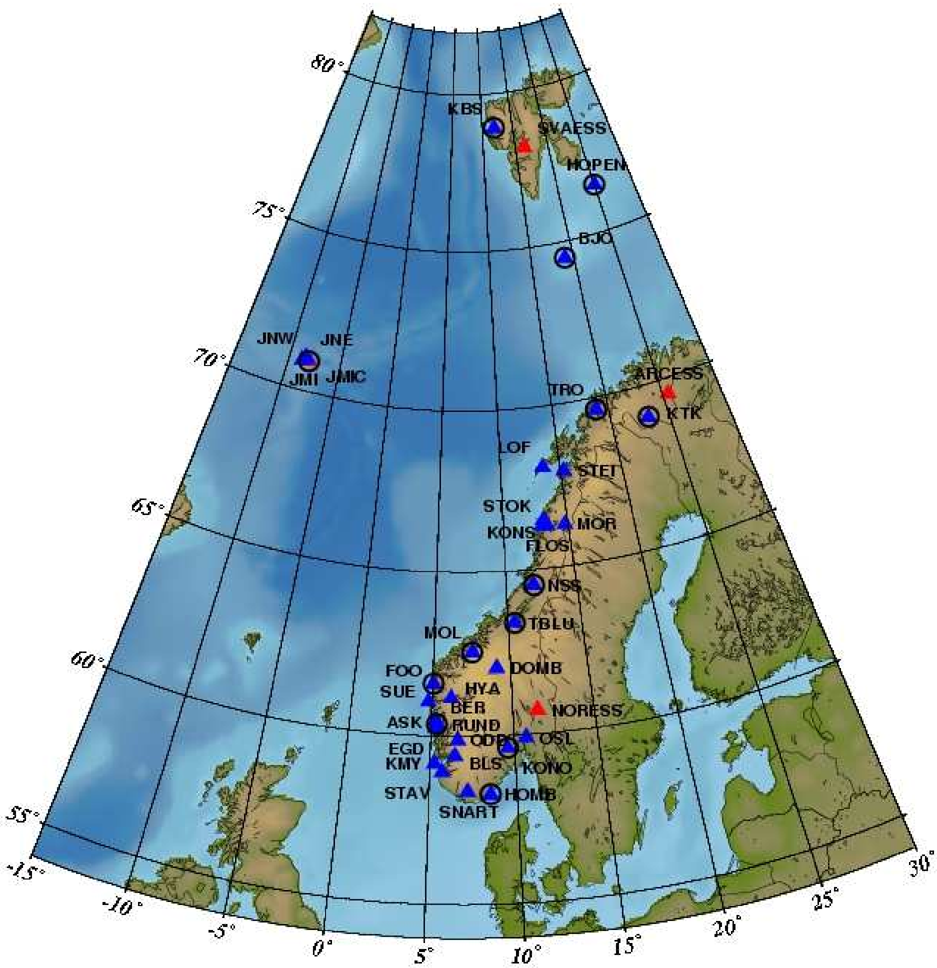

Figure 1: Norwegian seismic stations. UiB operates the 33 stations (blue triangles) in the National Seismic Network (NNSN) and NORSAR operates the 3 arrays and the station JMIC (red triangles). Circles identify broad band stations.

2. Velocity models and magnitude relations

The velocity model used for locating all local and regional events, except for the local Jan Mayen events, is shown in Table 1 (Havskov and Bungum, 1987). Event locations are performed using the HYPOCENTER program (Lienert and Havskov, 1995) and all processing is performed using the SEISAN data analysis software (Havskov and Ottemöller, 1999).

Table 1: Velocity model used for locating all local and regional events, except for the local Jan Mayen events, (from Havskov and Bungum, 1987).

P-wave velocity (km/sec)	Depth to layer interface (km)
6.2	0.0
6.6	12.0
7.1	23.0
8.05	31.0
8.25	50.0
8.5	80.0

Magnitudes are calculated from coda duration, amplitudes or seismic spectra. The coda magnitude relation was revised in 2006 (Havskov & Sørensen 2006). The coda wave magnitude scale (M_C) is estimated through the relation

$$M_C = -4.28 + 3.16 \cdot \log10(T) + 0.0003 \cdot D$$

where T is the coda length in seconds and D is the epicentral distance in km. The new scale made M_C more consistent with M_L since M_C in general is reduced. For this report all data are updated using the new magnitude scale. When instrument corrected ground amplitudes A (nm) are available, local magnitude M_L is calculated using the equation given by Alsaker et al. (1991):

$$M_L = 1.0 \cdot \log(A) + 0.91 \cdot \log(D) + 0.00087 \cdot D - 1.67$$

where D is the hypocentral distance in km.

The moment magnitude M_w is calculated from the seismic moment M_0 using the relation (Kanamori, 1977)

$$M_w = 0.67 \cdot \log(M_0) – 6.06$$

The unit of M_0 is Nm. The seismic moment is calculated from standard spectral analysis assuming the Brune model (Brune, 1970) and using the following parameters:

Density: 3.0 g/cm^2
$Q = 440 \cdot f^{0.7}$
P-velocity = 6.2 km/s
S velocity = 3.6 km/s

For more computational details, see Havskov and Ottemöller, (2003).

For the Jan Mayen area, a local velocity model (see Table 2) and coda magnitude scale is used (Andersen, 1987).

Table 2: Velocity model used for locating local Jan Mayen events.

P-wave velocity (km/sec)	Depth to layer interface (km)
6.33	18
8.25	50

The coda magnitude scale for Jan Mayen which is used in this report is given by Havskov & Sørensen (2006). This scale was implemented in 2006 but all events used in this report are updated during April/May 2006.

$$M_C = 3.27 \cdot \log(T) 2.74 + 0.001 \cdot D$$

where T is the coda duration and D is the epicentral distance in km.

The regional and teleseismic events recorded by the network are located using the global velocity model IASPEI91 (Kennett and Engdahl, 1991).

Body wave magnitude is calculated using the equation by Veith and Clawson (1972):

$$Mb = \log(A/T) + Q(D,h)$$

Here h is the hypocentre depth (km), A is the amplitude (microns), T is period in seconds and Q(D,h) is a correction for distance and depth.

Surface wave magnitude Ms is calculated using the equation (Karnik et al., 1962):

$$Ms = \log(A/T) + 1.66 \cdot \log(D) + 3.3$$

where A is the amplitude (microns), T is period in seconds and D is the hypocentral distance in degrees.

Starting from January 2001, the European Macroseismic Scale, EMS98, (Grünthal, 1998) has been used. All macroseismic intensities mentioned in the text will refer to the EMS98 instead of the previously used Modified Mercalli Intensity scale. The two scales are very similar at the lower end of the scale for intensities less than VII.

3. Events recorded by the Norwegian stations

Based on the criteria mentioned in section 1 and above, a total of 4256 local and regional events, were detected by the Norwegian seismic stations during 2008. Of these local and regional events, 54% were large enough to be recorded by several stations and hence could be located reliably. The number of local/regional and teleseismic events, recorded per month in 2008 is shown in Figure 2. The average number of local and regional events recorded per month is 348.
The number of recorded local/regional events is higher than in 2007 which can be explained by the Storfjorden earthquake (21st February) and its many aftershocks. This effect is clearly seen in Figure 2 were the number of recorded local/regional events in February through May is clearly above average for the rest of the year.

A total of 909 teleseismic events were recorded between January and December 2008, of which 95% were located. In addition to the locations determined at UiB, also preliminary locations published by the USGS (United States Geological Survey) based on the worldwide network are included in the UiB database whenever the earthquake is recorded with Norwegian stations. The monthly average of teleseismic earthquakes recorded by NNSN is 75.

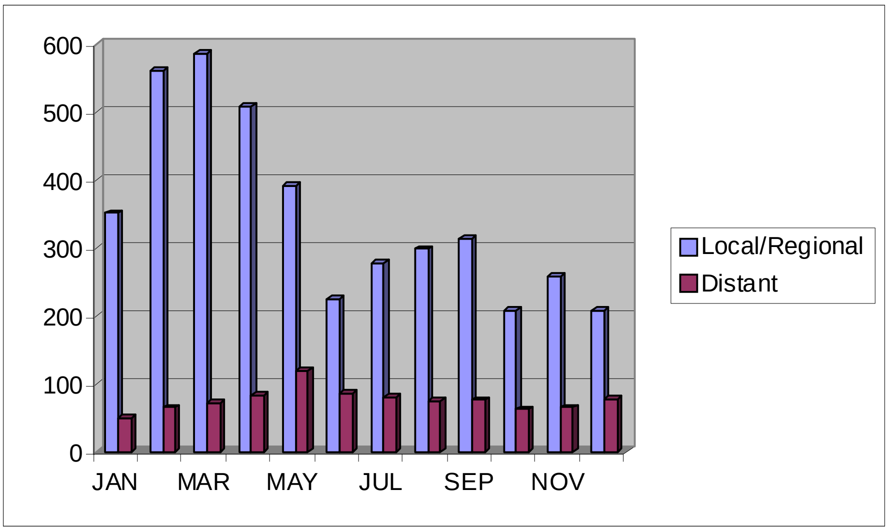

Figure 2: Monthly distribution of local/regional and distant events, recorded during 2008. The apparent increase in the number of local events during the period Jan – May is probably due to aftershocks of the Svalbard earthquake.

UiB, as an observatory in the global network of seismological observatories, reports as many secondary phases as possible from the teleseismic recordings.
All events (teleseismic, regional and local) recorded from January to December 2008 with $M \geq 3$ are plotted on Figure 3.

Monthly station recording statistics from January to December 2008 are given in Table 3. This table shows, for each station, the number of local events that were recorded only at one station, local events recorded on more than one station and recorded teleseismic events. It must be observed that Table 3 shows both earthquakes and explosions, and that the large number of detections at KTK mainly

is due to explosions at the Kirruna/Malmberget mines in Sweden. The MOR station also records the Kirruna/Malmberget explosions but in addition the station also records a large number of local earthquakes. Since 2003 a new seismic station, STOK, was located close to the existing MOR station and in 2006 this is further extended by two more stations (FLOS and KONS). Therefore the number of recorded local earthquakes in this region is increased.
During 2008 two new stations (HOMB and TBLU), both Broad Band stations, started operation and were added to the Norwegian National Seismic Network. Their location can be seen in Figure 1.

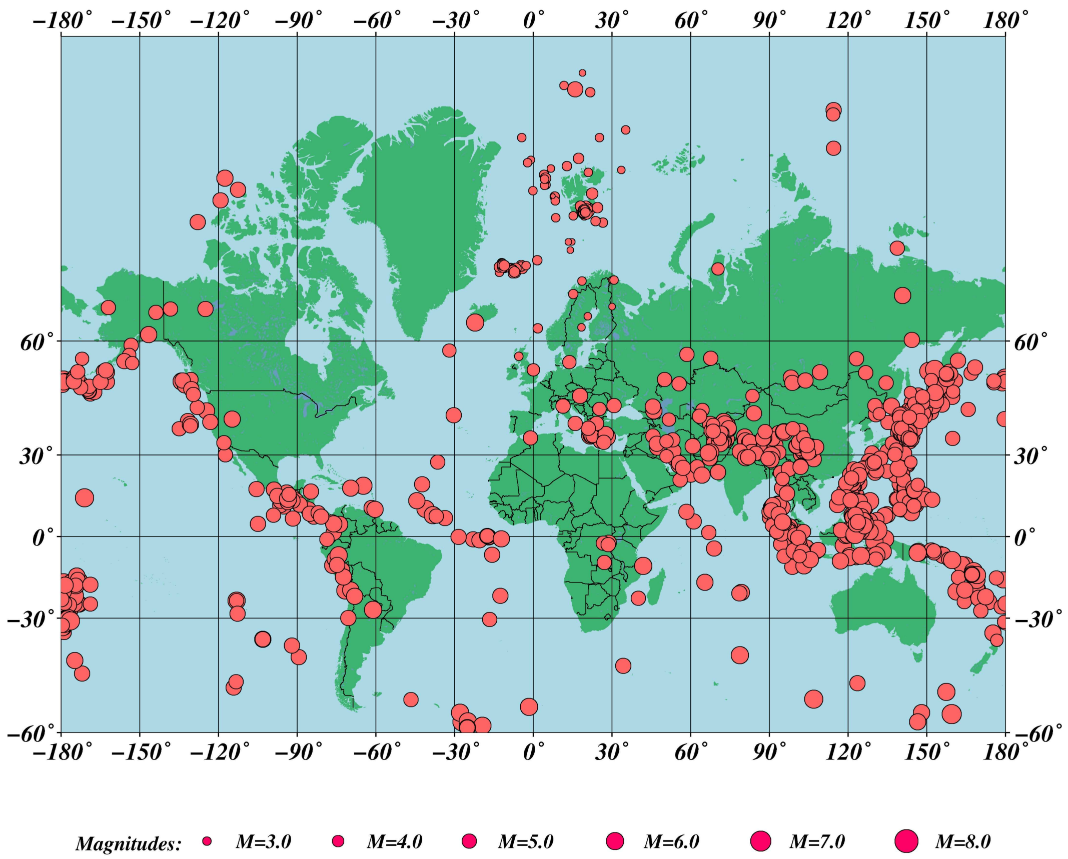

Figure 3: Epicentre distribution of earthquakes with M≥3.0, located by the Norwegian Seismic Network from January to December 2008. Teleseismic events recorded only by NORSAR have M≥5.0.

4. The seismicity of Norway and adjacent areas

A total of 2082 of the recorded events are located inside the NNSN prime area, 54°N-82°N and 15°W-32°E. During analysis and using the explosion filter (Ottemöller, 1995), 33% of these events were identified as probable explosions. Figure 4 shows all local/regional events in the prime area, analyzed and located during 2008.

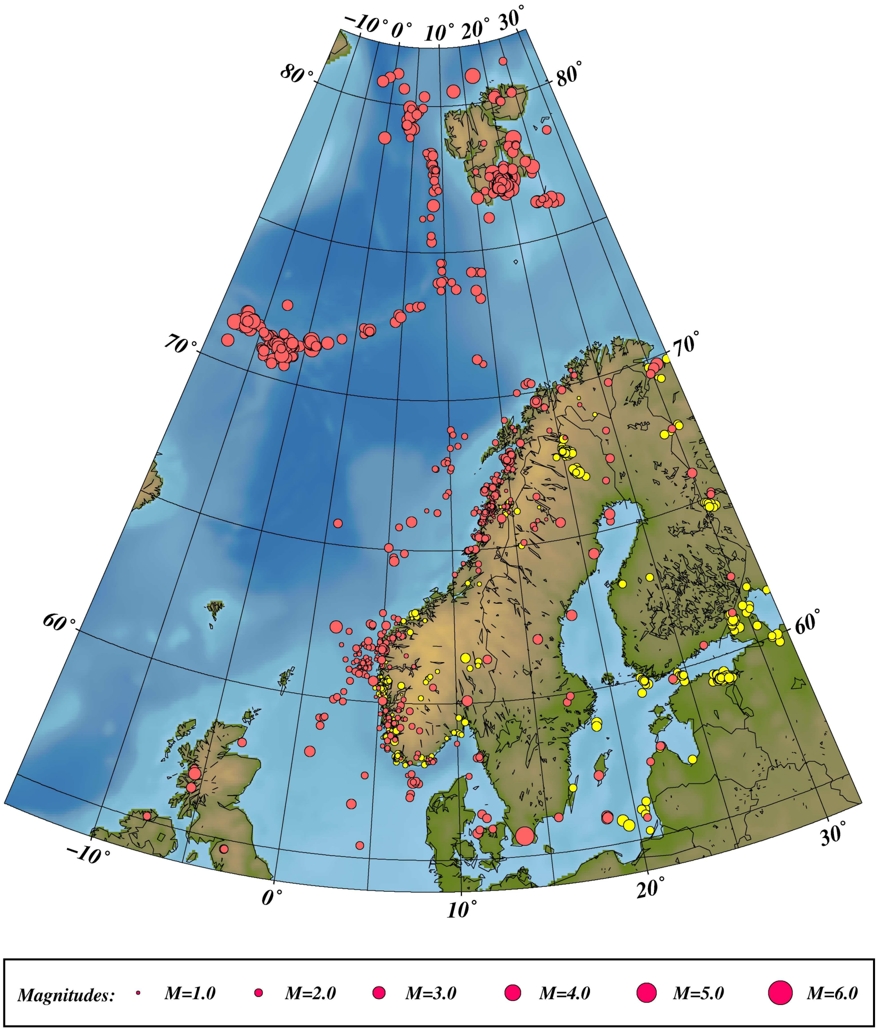

Figure 4: Epicentre distribution of events analyzed and located from January through December 2008. Earthquakes are plotted in red and probable and known explosions in yellow. For station locations, see Figure 1.

Table 3a: Monthly statistics of events recorded at each station for January-June 2008. Abbreviations are: **LM** = Number of local events recorded at more than one station, **LS** = Number of local events recorded at only one station and **D** = Number of teleseismic events. The stations TBLU and HOMB was installed in December 2008.

	JANUARY			**FEBRUARY**			**MARCH**			**APRIL**			**MAY**			**JUNE**		
STATION	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**
ASK	16	0	5	43	0	6	31	0	5	48	0	4	14	0	3	28	0	10
BER	7	0	14	4	0	16	9	0	20	9	0	14	10	0	30	8	0	35
BJO1	3	0	10	106	0	15	45	1	11	28	0	10	20	0	18	20	0	11
BLS5	20	0	6	31	0	14	26	0	9	50	0	11	40	0	4	30	1	13
DOMB	3	0	6	7	0	10	5	0	11	5	0	13	5	0	12	0	0	2
EGD	11	0	3	19	0	4	19	0	4	25	0	2	9	0	3	8	0	4
FLOS	53	0	3	44	0	2	56	0	2	91	0	4	35	0	5	35	0	7
FOO	0	0	0	21	1	11	26	0	14	33	0	19	16	0	32	18	0	27
HOMB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOPEN	15	7	0	234	80	1	161	34	1	41	0	0	62	11	1	28	4	4
HYA	20	4	1	38	1	8	44	2	6	59	1	9	25	0	7	21	0	10
JMI	11	0	0	9	0	0	9	0	0	17	0	0	23	0	0	18	0	0
JMIC	2	0	8	6	0	9	2	0	11	3	0	11	7	0	22	1	0	19
JNE	13	0	0	13	0	0	9	0	0	18	0	0	18	0	0	19	0	0
JNW	13	0	0	15	0	3	11	0	0	19	0	0	24	0	1	20	1	2
KBS	17	3	17	192	5	17	138	1	24	50	3	28	64	11	30	40	3	41
KMY	20	0	1	34	0	1	27	0	0	51	0	2	40	0	3	32	0	7
KONO	1	0	15	7	0	21	1	0	22	6	0	28	9	0	33	6	1	38
KONS	62	0	3	49	0	5	64	0	1	97	0	4	43	1	3	37	0	10
KTK1	33	3	11	26	1	14	24	5	17	38	2	12	18	0	20	4	0	21
LOF	39	1	6	33	2	10	26	2	11	118	2	12	45	2	20	19	1	12
MOL	3	0	4	9	0	14	7	0	19	7	0	14	11	0	17	4	0	15
MOR8	70	2	10	60	7	19	57	3	20	120	6	17	43	2	29	33	2	19
NSS	22	2	15	20	3	19	11	1	22	27	2	20	15	3	25	12	2	22
ODD1	21	0	7	40	0	12	31	0	11	47	0	10	10	0	0	19	0	7
OSL	0	0	5	1	0	9	0	0	16	2	0	18	4	0	23	0	0	15
RUND	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	5	0	1
SNART	15	0	6	27	1	5	17	0	4	30	0	5	24	0	9	9	0	10
STAV	3	0	2	8	0	3	2	0	2	3	0	0	5	0	3	1	0	5
STEI	42	3	4	24	0	5	18	0	9	107	0	3	34	0	5	14	0	7
STOK	70	0	7	52	0	14	66	1	14	96	0	16	42	0	15	30	0	11
SUE	9	0	1	11	0	0	15	0	3	19	0	2	11	0	5	15	0	5
TBLU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRO	25	0	17	21	0	22	16	0	28	32	0	29	11	0	44	3	0	41
NORSAR	19	0	47	19	0	64	14	0	70	23	0	77	35	0	108	18	0	82
ARCES	44	0	0	165	0	0	78	3	0	89	0	0	76	0	0	63	0	0
SPITS	16	0	0	139	0	0	50	0	0	47	0	0	34	0	0	26	0	0

Table 3b: Monthly statistics of events recorded at each station for July-December 2007. Abbreviations are: **LM** = Number of local events recorded at more than one station, **LS** = Number of local events recorded at only one station and **D** = Number of teleseismic events.

	JULY			**AUGUST**			**SEPTEMBER**			**OCTOBER**			**NOVEMBER**			**DECEMBER**		
STATION	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**	**LM**	**LS**	**D**
ASK	25	0	17	22	0	2	60	0	13	40	0	8	30	0	13	27	0	13
BER	9	0	25	5	0	38	1	0	19	2	0	12	8	0	14	9	0	17
BJO1	11	0	15	8	0	23	8	0	10	7	1	13	7	0	8	4	0	9
BLS5	28	0	17	30	0	3	62	0	14	39	0	4	32	0	3	20	0	5
DOMB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2
EGD	8	0	3	9	0	0	10	0	4	21	0	4	12	0	3	0	0	0
FOO	21	0	23	18	0	37	24	0	22	30	0	13	12	0	15	17	0	16
FLOS	55	0	15	34	0	3	48	0	11	29	0	10	42	0	7	25	0	10
HOMB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	3
HOPEN	1	0	1	1	0	0	8	0	0	6	0	3	0	0	1	4	0	6
HYA	23	0	17	18	0	3	40	0	3	47	0	2	26	0	3	20	0	3
JMI	13	0	1	12	0	0	14	0	0	14	0	0	10	0	0	11	0	0
JMIC	11	0	20	8	0	34	17	0	15	5	0	11	9	0	9	8	0	2
JNE	24	0	1	18	0	0	19	0	0	18	0	0	15	0	0	14	0	0
JNW	24	0	3	18	0	0	23	2	0	18	0	1	18	0	0	16	0	0
KBS	24	3	31	23	4	47	24	5	20	24	1	21	29	0	18	22	4	24
KMY	29	0	13	22	0	0	54	0	1	30	0	0	31	0	1	22	0	3
KONO	1	0	26	4	0	44	3	0	15	4	0	18	10	0	22	5	0	26
KONS	62	0	16	42	0	6	51	0	10	31	0	4	32	0	3	4	0	3
KTK1	17	1	23	18	0	39	31	5	40	20	2	29	22	4	35	35	3	42
LOF	55	5	19	16	1	14	23	1	16	6	0	7	4	0	5	6	0	7
MOL	4	0	13	4	0	17	5	0	9	5	0	13	2	0	12	2	0	11
MOR8	71	3	29	45	0	27	50	6	31	34	1	23	43	4	16	35	1	29
NSS	16	2	24	19	0	37	22	0	23	14	0	17	17	0	16	9	0	21
ODD1	20	0	15	20	0	0	50	0	11	19	0	2	27	0	7	18	0	18
OSL	0	0	18	1	0	23	1	0	22	0	0	6	0	0	12	1	0	8
RUND	5	0	3	15	0	2	51	0	14	33	0	9	28	0	13	21	0	11
SNART	5	0	4	20	0	9	41	0	7	20	0	8	26	0	14	19	0	18
STAV	0	0	13	1	0	0	1	0	1	2	0	1	2	0	3	0	0	1
STEI	49	1	12	11	0	1	21	0	11	6	0	11	7	0	23	11	0	19
STOK	52	0	11	34	0	4	43	0	13	32	0	17	42	0	22	24	0	17
SUE	16	0	9	12	0	0	13	0	6	16	0	1	12	0	2	7	0	0
TBLU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	3
TRO	16	1	34	16	0	51	24	0	41	7	0	26	8	0	30	13	0	44
NORSAR	31	0	79	21	0	70	32	0	67	23	0	62	22	0	63	17	0	79
ARCES	74	0	0	63	1	0	49	0	0	76	0	0	69	1	0	47	0	0
SPITS	21	0	0	17	0	0	8	0	0	28	0	5	37	0	24	28	0	34

Figure 5 and Table 4 show the 141 local and regional events, located in the prime area, with one of the calculated magnitudes greater than or equal to 3.0. Among these, 40 are located in the vicinity of the Jan Mayen Island. Depth is checked for the earthquakes with magnitude equal or above 3.0.

It should be emphasized that it is often difficult to get a good magnitude estimate for the earthquakes located on the oceanic ridge in the Norwegian sea, since distances are too large to compute a proper M_L, too short for M_b and coda magnitudes for these locations are often unreliable. Most of the recorded earthquakes in this area have magnitudes above 3.0 if they are recorded on Norwegian mainland stations.

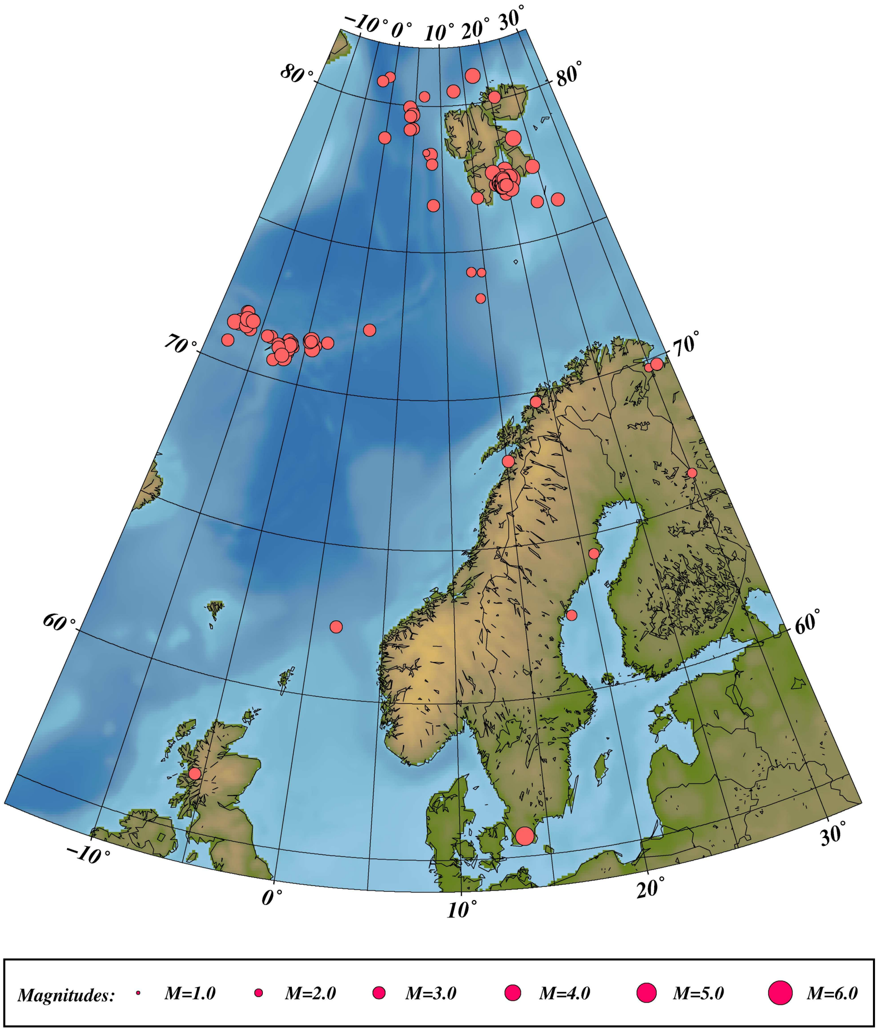

Figure 5: Epicentre distribution of located events with one of the calculated magnitudes above or equal to 3.0. All earthquakes are listed in Table 2. For station location, see Figure 1.

Table 4: Local and regional events in prime area with any magnitude above or equal to 3.0 for the time period January through December 2008. Only magnitudes reported by the University of Bergen are included. In cases where all BER magnitudes are below 3 but the event still is included in the list, NORSAR has reported a magnitude of 3.0 or larger. Abbreviations are: **HR** = hour (UTC), **MM** = minutes, **Sec** = seconds, **L** = distance identification (L=local, R=regional, D=teleseismic), **Latitud** = latitude, **Longitud** = longitude, **Depth** = focal depth (km), **F** = fixed depth, **AGA** = agency (BER=Bergen), **NST** = number of stations, **RMS** = root mean square of the travel-time residuals, **Mc** = coda magnitude, **Ml** = local magnitude and **Mw** = moment magnitude.

Year	Date	HRMM	Sec	L	Latitud	Longitud	Depth	FF	AGA	NST	RMS	Mc	Ml	Mw	Mb	Ms
2008	1 3	0050	26.2	L	78.355	8.112	10.0	F	BER	3	0.7	2.1	3.3			
2008	115	0029	1.7	L	71.390	-6.933	10.0	F	BER	3	0.3	2.3	3.1	2.9		
2008	118	1902	10.8	L	71.003	-7.410	10.0	F	BER	5	0.4	2.7	3.5	3.2		
2008	122	0510	56.5	L	74.266	14.461	10.0	F	BER	11	1.2	2.7	2.3			
2008	2 4	0930	16.0	L	76.143	26.527	15.0	F	BER	4	0.9	2.8	3.3			
2008	2 4	2158	47.7	L	76.277	23.668	15.0	F	BER	9	1.5	2.4	3.2	3.4		
2008	212	1321	55.6	L	78.019	8.332	15.0	F	BER	2	0.5	2.5	2.9			
2008	221	0246	19.3	L	77.243	20.261	15.0	F	BER	31	2.9		5.7	6.0	5.7	5.9
2008	221	0253	57.5	L	77.135	18.265	15.0	F	BER	5	0.6		3.4	3.4		
2008	221	0306	32.7	L	77.062	19.530	15.0	F	BER	5	0.8		3.1	3.2		
2008	221	0308	54.0	L	77.037	18.928	15.0	F	BER	4	0.7		3.0	3.0		
2008	221	0324	8.0	L	77.100	19.977	15.0	F	BER	4	1.1		3.4			
2008	221	0326	3.1	L	77.033	19.242	15.0	F	BER	5	0.9	2.1	3.0			
2008	221	0332	51.3	L	77.113	18.932	15.0	F	BER	7	0.7	2.2	3.3	3.2		
2008	221	0350	59.8	L	77.074	19.149	15.0	F	BER	5	1.1	2.1	3.0	2.8		
2008	221	0356	26.4	L	77.586	19.988	15.0	F	BER	8	0.9	3.1	3.7	3.3		
2008	221	0409	26.6	L	77.333	19.545	15.0	F	BER	10	1.1	2.8	3.6	3.6	4.2	
2008	221	0413	13.6	L	76.777	19.374	15.0	F	BER	5	0.8	2.3	3.0	2.8		
2008	221	0427	19.0	L	77.431	19.419	15.0	F	BER	5	0.7	2.0	3.2	3.2		
2008	221	0515	12.9	L	77.039	19.131	15.0	F	BER	11	1.1	2.6	3.7	3.7	4.4	
2008	221	0745	24.6	L	77.121	18.943	15.0	F	BER	5	1.0	2.4	3.0	3.0		
2008	221	1155	49.9	L	77.086	18.755	15.0	F	BER	5	0.8	2.6	3.3	3.4		
2008	221	1220	12.0	L	77.047	19.031	15.0	F	BER	6	0.7	2.1	3.3	3.2		
2008	221	2135	29.3	L	77.085	18.826	15.0	F	BER	5	0.8		3.0	3.0		
2008	221	2228	48.9	L	77.148	19.394	15.0	F	BER	5	1.1	2.3	3.1	3.0		
2008	221	2252	40.9	L	77.035	19.403	15.0	F	BER	13	1.1	2.5	3.8	4.0	4.1	
2008	222	0021	24.5	L	77.074	19.240	15.0	F	BER	9	0.7	2.5	4.2	4.1		
2008	222	0219	30.0	L	77.194	18.785	15.0	F	BER	8	0.8	2.1	3.7	3.6		
2008	222	0451	56.4	L	77.093	19.225	15.0	F	BER	6	0.7	2.3	3.6	3.6		
2008	222	0630	30.4	L	77.068	19.512	15.0	F	BER	4	0.5	3.1	3.3	3.3		
2008	222	0647	15.4	L	77.067	19.172	15.0	F	BER	5	0.8	2.2	3.2	3.0		
2008	223	0531	6.5	L	77.151	19.219	15.0	F	BER	5	0.6	2.6	3.4			
2008	223	0900	16.1	L	77.196	19.446	15.0	F	BER	7	1.1	3.6	3.9	4.1	4.2	
2008	224	0042	5.1	L	77.163	19.467	15.0	F	BER	5	0.5	2.7	3.0	3.0		
2008	224	0320	16.0	L	77.153	19.139	15.0	F	BER	5	0.9	2.0	3.4	3.5		
2008	224	0323	56.1	L	77.564	18.080	15.0	F	BER	9	1.1		3.8	3.6		
2008	224	0905	16.9	L	77.076	19.149	15.0	F	BER	8	0.9	2.4	3.5	3.3		
2008	224	0928	33.4	L	71.324	-6.513	10.0	F	BER	3	0.1	2.6	3.0	2.8		
2008	224	1048	45.0	L	77.032	19.199	15.0	F	BER	8	0.8	2.6	3.6	3.3		
2008	224	1417	6.0	L	77.030	19.121	15.0	F	BER	5	0.7	2.0	3.2	3.2		
2008	225	1502	16.0	L	77.147	19.369	15.0	F	BER	6	0.7	2.5	3.2	3.2		
2008	226	1102	20.3	L	77.181	19.458	15.0	F	BER	6	0.9	2.5	3.3	3.3		
2008	229	0816	6.6	L	77.315	20.413	15.0	F	BER	18	2.3		3.9	4.1	4.2	
2008	3 2	0657	47.9	L	77.024	19.237	15.0	F	BER	10	1.1	2.6	3.4	3.7		
2008	3 3	1859	35.5	L	79.210	4.866	10.0	F	BER	5	1.7	2.9	3.1	3.1		
2008	3 4	1255	24.6	L	77.034	19.169	15.0	F	BER	10	1.0	2.4	3.8	3.5		
2008	3 7	1007	52.1	L	77.089	19.430	15.0	F	BER	5	0.7	2.3	3.1	3.1		
2008	3 8	1656	30.2	L	77.116	19.047	15.0	F	BER	6	0.4	2.8	3.1	3.4		
2008	3 9	0948	44.7	L	79.171	4.283	10.0	F	BER	5	1.4	3.0	3.1			
2008	3 9	1953	13.8	L	77.131	18.998	15.0	F	BER	5	0.4	2.3	3.1	3.4		
2008	310	0317	20.7	L	77.275	18.852	15.0	F	BER	7	1.2	2.9	3.2	3.2		
2008	311	0605	15.0	L	77.188	19.268	15.0	F	BER	7	1.0	2.6	3.2	3.4		
2008	311	1407	26.2	L	77.083	19.026	15.0	F	BER	7	1.0	2.5	3.5	3.5		
2008	312	1314	49.1	L	77.255	18.747	15.0	F	BER	6	1.0	2.3	2.9	3.0		
2008	312	1833	43.4	L	77.207	18.600	15.0	F	BER	6	1.2	2.4	3.1	3.2		
2008	323	1229	38.1	L	77.183	19.307	15.0	F	BER	5	1.0	2.2	3.1	3.2		
2008	324	1828	20.0	L	80.895	17.527	15.0	F	BER	10	1.4	3.2	3.8			
2008	331	0148	4.9	L	71.336	-11.146	10.0	F	BER	10	2.3	3.9	3.4	3.6	4.3	
2008	331	1703	50.6	L	80.487	12.743	10.0	F	BER	3	0.6	3.1	3.3		4.3	
2008	4 7	2351	19.6	L	76.622	9.168	15.0	F	BER	9	1.2	2.5	3.1	2.8		
2008	4 8	0332	59.9	L	77.100	19.092	15.0	F	BER	7	1.1	2.5	3.7	3.6		
2008	4 9	0122	48.1	L	70.898	-7.472	10.0	F	BER	12	1.3	3.3	3.1	3.6		
2008	410	0620	3.6	L	77.118	19.636	15.0	F	BER	14	1.4	3.2	4.3	4.3		
2008	411	0602	56.5	L	67.848	15.154	5.0	F	BER	12	1.2		3.2	3.4		

2008	413	0346	9.3	L	77.103	18.737	15.0	F	BER	6	0.7	2.6	3.1	3.0		
2008	418	2239	38.2	L	77.130	18.909	15.0	F	BER	4	1.5		3.2	3.0		
2008	424	1714	56.6	L	69.685	18.466	15.0	F	BER	12	1.8	3.2	2.7	3.0		
2008	425	0453	18.7	L	69.669	18.455	15.0	F	BER	12	1.5	3.4	2.9	3.1		
2008	425	2228	8.2	L	77.063	18.984	15.0	F	BER	6	0.8	2.3	3.3	3.2		
2008	5 1	0805	54.2	L	71.319	-8.786	10.0	F	BER	3	0.2	2.7	3.4			
2008	5 5	0435	51.1	L	71.169	-7.702	15.0	F	BER	3	0.0	2.6	3.0	3.1		
2008	5 6	0450	14.3	L	71.772	-11.904	10.0	F	BER	3	0.1	3.5	3.4			
2008	5 6	0500	23.6	L	71.547	-12.579	10.0	F	BER	3	0.1	3.5	3.3	3.2		
2008	5 6	1951	12.6	L	71.408	-12.462	10.0	F	BER	10	2.9		3.6	3.6		
2008	5 6	2055	44.1	L	71.870	-12.005	10.0	F	BER	4	0.5	4.1	3.4	3.6		
2008	5 6	2338	4.8	L	70.743	-12.973	10.0	F	BER	3	0.6	2.7	3.0			
2008	5 6	2348	30.7	L	77.143	18.895	15.0	F	BER	6	0.8		3.2			
2008	5 7	1643	51.2	L	71.407	-12.937	10.0	F	BER	10	1.3		3.7		4.8	
2008	5 8	0820	44.1	L	71.912	-12.058	10.0	F	BER	3	0.3	2.9	3.0	2.8		
2008	5 8	2239	14.7	L	77.050	19.092	15.0	F	BER	8	1.4	2.6	3.4	3.5		
2008	516	0033	51.4	L	77.058	19.096	15.0	F	BER	4	0.4	2.2	3.0	3.1		
2008	518	0213	41.1	L	77.154	19.304	15.0	F	BER	7	1.0		3.1	3.3		
2008	521	1207	45.4	L	77.074	19.162	15.0	F	BER	5	1.1	2.6	3.3			
2008	524	0818	16.4	L	71.411	-3.955	10.0	F	BER	21	1.3	2.3	2.9	3.0		
2008	6 1	0624	37.7	L	79.792	4.472	10.0	F	BER	12	1.6	3.6	3.3			
2008	6 3	2359	6.0	L	80.884	-0.850	10.0	F	BER	3	1.1	3.1	2.6			
2008	6 4	2125	43.8	L	70.962	-6.834	10.0	F	BER	24	1.7	3.3	3.8			
2008	6 4	2329	24.9	L	71.000	-6.740	10.0	F	BER	3	0.1	2.6	3.0	3.0		
2008	611	1252	16.8	L	77.156	19.060	15.0	F	BER	5	1.0		3.1	3.1		
2008	617	0911	51.4	L	69.811	29.899	15.0	F	BER	20	1.2	3.4	2.3	2.6		
2008	7 6	1721	25.2	L	71.210	-6.238	10.0	F	BER	3	0.1	3.0	2.7	3.0		
2008	710	1036	13.1	L	71.290	-6.644	10.0	F	BER	3	0.1	3.0	2.6	2.7		
2008	716	1037	36.7	L	71.336	-9.222	10.0	F	BER	3	0.1	3.0	3.1	2.9		
2008	730	1406	26.7	L	78.564	22.498	15.0	F	BER	12	1.5	3.3	4.0			
2008	731	0128	1.0	L	74.286	13.264	10.0	F	BER	8	1.0	2.6	2.4			
2008	8 2	1625	42.0	L	76.902	20.360	15.0	F	BER	12	1.1	2.2	3.8	3.7		
2008	8 3	2014	34.8	L	70.765	-7.017	10.0	F	BER	9	1.2	3.4	3.9	3.7		
2008	8 8	0421	19.8	L	79.916	4.139	10.0	F	BER	3	0.7	2.9	3.3			
2008	8 9	0350	37.5	L	78.419	7.574	10.0	F	BER	2	0.1	1.7	1.8			
2008	8 9	0725	19.0	L	71.035	-7.360	10.0	F	BER	3	0.1	2.9	3.2	3.0		
2008	814	0718	21.8	L	79.609	4.766	10.0	F	BER	10	1.9	3.7	3.5			
2008	818	0100	8.0	L	70.970	-7.238	10.0	F	BER	3	0.2	2.7	3.2	3.0		
2008	824	1021	56.4	L	77.013	19.150	15.0	F	BER	5	0.7	2.8	3.4	3.4		
2008	831	0316	47.4	L	71.258	-6.498	10.0	F	BER	3	0.3	2.9	3.3	3.1		
2008	831	1153	42.6	L	70.609	-7.958	10.0	F	BER	3	0.5	2.6	3.1			
2008	9 8	2117	18.1	L	72.253	1.466	10.0	F	BER	20	1.4	3.1	3.2			
2008	9 9	0422	44.0	L	80.708	-2.187	10.0	F	BER	8	1.3	3.9	2.9			
2008	920	0440	38.5	L	78.804	-0.097	10.0	F	BER	5	1.8	3.1				
2008	925	1534	13.2	L	77.304	19.424	15.0	F	BER	5	0.9	2.7	3.5	3.6		
2008	927	0220	13.4	L	65.951	30.034	13.0	F	BER	17	1.3	3.4	2.4			
2008	928	1952	25.4	L	71.548	-4.724	10.0	F	BER	16	1.2	2.8	3.4		5.0	
2008	928	2220	18.6	L	71.277	-4.321	10.0	F	BER	26	0.9		3.7	3.7	5.3	5.1
2008	928	2313	6.6	L	71.515	-4.685	10.0	F	BER	11	0.8		3.1			
2008	929	0349	57.1	L	77.478	24.352	15.0	F	BER	4	0.8	2.5	3.5			
2008	929	1103	54.6	L	71.491	-4.702	10.0	F	BER	13	1.1	3.0	3.3		4.8	4.0
2008	929	1916	45.1	L	71.581	-4.594	10.0	F	BER	22	1.0	2.6	3.7	3.7	4.7	4.2
2008	929	1920	21.0	L	71.513	-4.572	10.0	F	BER	15	0.8	2.9	3.2		5.0	
2008	10 4	0212	37.5	L	80.095	20.887	15.0	F	BER	4	1.1	3.1	3.0			
2008	1010	0428	39.7	L	56.832	-5.494	10.0	F	BER	40	1.2	3.2	3.1			
2008	1014	0223	44.5	L	62.326	1.663	10.0	F	BER	39	1.3	3.0	3.2	3.0		
2008	1014	1647	42.1	L	69.762	30.725	10.0	F	BER	12	1.6	3.4	3.1	3.0		
2008	1016	1932	0.4	L	64.345	20.825	15.0	F	BER	10	1.5	3.5	2.7	3.0		
2008	1018	1938	44.9	L	71.021	-6.671	10.0	F	BER	3	0.1	2.6	3.1	3.0		
2008	1026	1044	39.9	L	79.577	4.748	10.0	F	BER	3	1.0	1.9	3.0			
2008	11 4	0019	44.7	L	77.292	19.518	15.0	F	BER	4	0.9		3.0			
2008	11 4	0213	3.1	L	73.367	14.155	10.0	F	BER	9	1.2	3.1	2.4	2.4		
2008	11 7	2017	39.7	L	71.339	-12.157	10.0	F	BER	13	1.4	4.1	3.7		4.1	
2008	11 7	2113	15.7	L	71.712	-11.588	10.0	F	BER	7	0.5	3.4	3.5	3.3		
2008	11 7	2140	54.6	L	71.621	-12.112	10.0	F	BER	18	1.6	4.9	4.0			
2008	11 8	2121	54.9	L	71.158	-6.575	10.0	F	BER	3	0.1	3.0	3.6	3.4		
2008	1117	0551	41.5	L	80.325	6.692	10.0	F	BER	3	1.1	2.1	2.7			
2008	1120	0118	42.9	L	62.521	18.065	15.0	F	BER	12	1.1	3.2	2.6	2.9		
2008	1120	2344	2.0	L	77.058	19.536	15.0	F	BER	3	0.9	2.6	3.1			
2008	1128	0329	6.1	L	77.056	19.883	15.0	F	BER	5	0.9	2.9	3.3			
2008	1216	0520	3.0	L	55.643	13.636	10.0	F	BER	32	1.8	4.1	4.6	4.3		
2008	1216	1032	0.4	L	71.179	-7.824	10.0	F	BER	3	0.1	2.1	3.1			
2008	1217	0632	36.4	L	71.058	-7.723	10.0	F	BER	13	1.2	3.7	3.6			
2008	1218	1253	20.2	L	71.692	-11.462	10.0	F	BER	11	0.7		3.7	3.5		
2008	1220	0006	52.8	L	70.833	-7.192	10.0	F	BER	24	1.7	2.9	3.5			
2008	1222	0749	40.7	L	76.807	15.441	15.0	F	BER	5	1.0	2.4	3.0			
2008	1225	0414	25.5	L	71.586	-2.819	10.0	F	BER	19	1.2		3.0			

The largest local or regional earthquake in 2008, recorded on Norwegian stations and within the prime area, occurred on February 21st at 02:46 (UTC) in Storfjorden southwest of Spitsbergen. The earthquake had a magnitude of M_W=6.0 (BER) and was strongly felt in Longyearbyen. Among the largest earthquakes in the vicinity of the Norwegian mainland is the earthquake located in Varangerfjorden, occurring on 14th October at 16:47 with a magnitude of M_L=3.4.

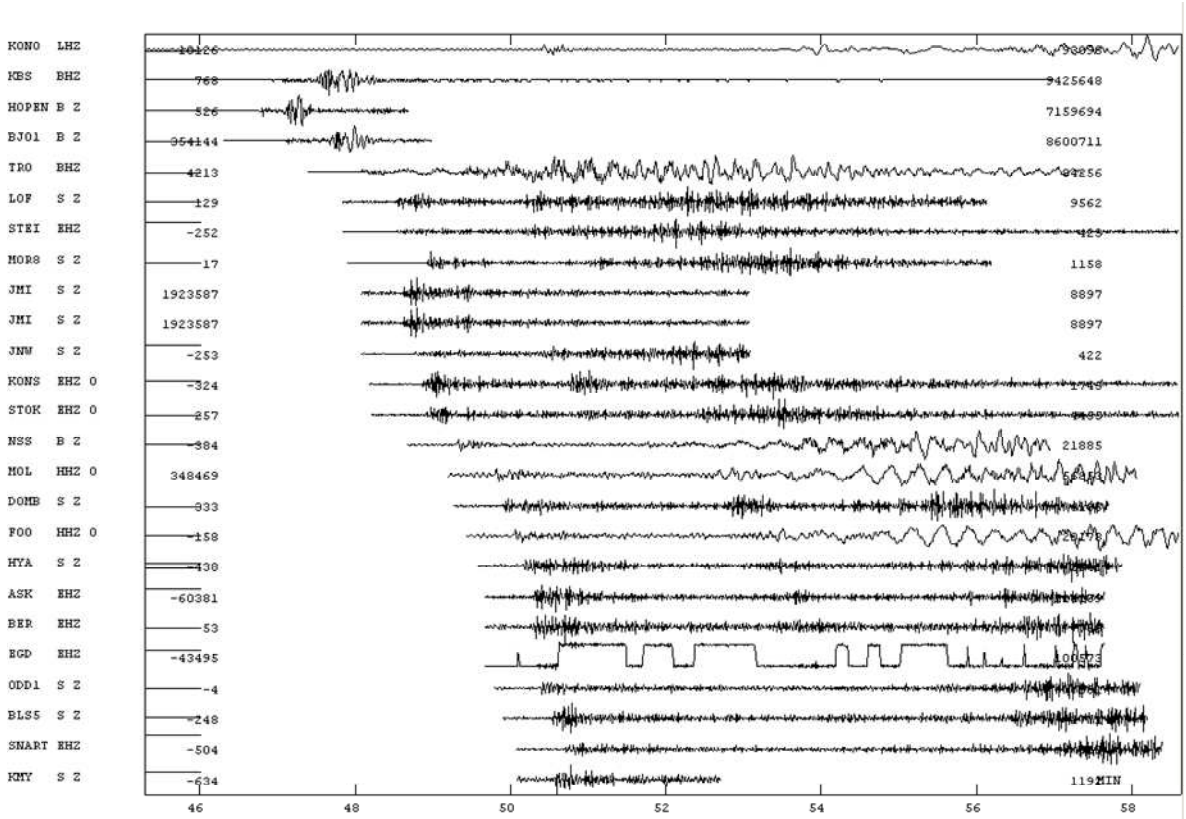

Figure 6: Seismograms for the earthquake on February 21st, 2008 at 02:46(UTC). This earthquake is located in Storfjorden, Svalbard. The seismograms are not filtered. The horizontal time scale is minutes, first marking at 02:46 (UTC). The station abbreviations are: KONO: Kongsberg, KBS: Kings bay, HOPEN: Hopen island, BJO: Bjørnøya, TRO: Tromsø, LOF: Lofoten, STEI: Steigen, MOR: Mo i Rana, JMI and JNW: Jan Mayen, KONS: Konsvik, STOK: Stokkvågen, NSS: Namsos, MOL: Molde, DOMB: Dombås, FOO: Florø, HYA: Hyanger, ASK: Askøy, BER: Bergen, EGD: Espegrend, ODD: Odda, BLS: Blåsjø, SNART: Snartemo and KMY: Karmøy.

The magnitude 6 earthquake in Storfjorden, Svalbard.

At 02:46 (UTC) on 21st February 2008 a magnitude 6.0 (M_W) earthquake occurred in Storfjorden, Svalbard, approximately 155 km south east of Longyearbyen. The earthquake was strongly felt in Longyearbyen and is the largest intraplate earthquake recorded on Norwegian territory. The mainshock was followed by a large number of aftershocks, which is still ongoing.

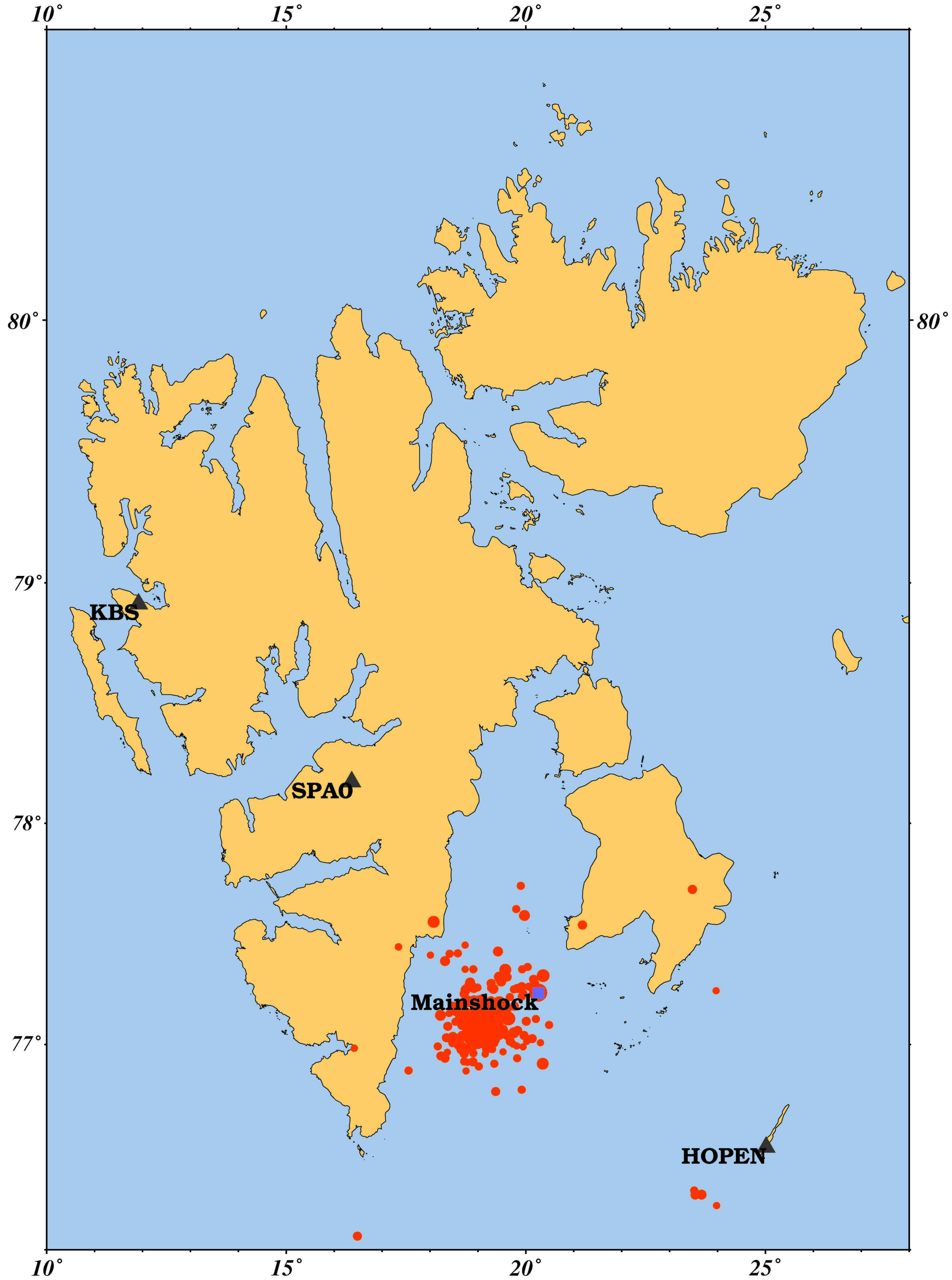

Figure 7. Aftershocks of the Svalbard earthquake (M_W=6.0) of February 21st, 2008. The mainshock is shown in blue quadrangle.

During 2008, 296 aftershocks were located to the Storfjorden area as seen in Figure 7. Due to the many aftershocks recorded on the Hopen and KBS stations, a high number of earthquakes are still not processed and located. The monthly distribution of the located earthquakes are presented in Figure 8.

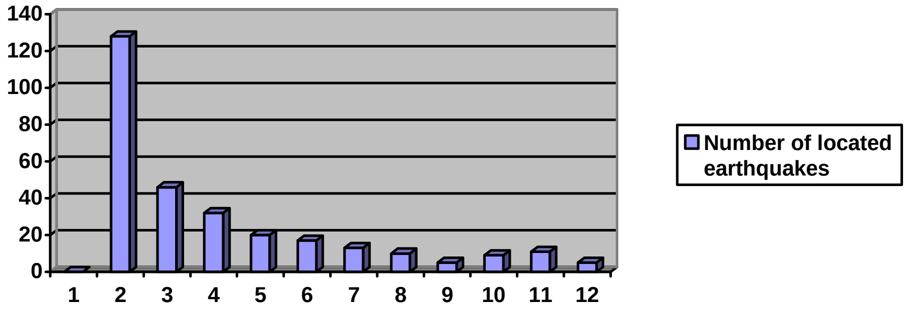

Figure 8. Monthly distribution of aftershocks of the Svalbard earthquake.

On 30th September, 2008, an internet connection via satellite was obtained at Hopen and data recorded at the seismic station on the island could from then on be transferred in real time. It is now possible to integrate phase readings from the HOPEN station with the data collected from other stations and the location of the earthquakes in the Storfjorden area are more accurate. Prior to the satellite communication, seismic data were received on memory sticks often with months delay.
A study of the Storfjorden earthquake is presented in Pirli et.al. (in prep).

Earthquake recordings in the Stokkvågen area

The network around Stokkvågen continued operation in 2008. The seismic activity is approximately the same as for 2007 but reduced compared to 2006. During 2008, 204 seismic events were located in the area shown on Figure 9. There is a renewed research interest in the area and independent funding might be needed for additional monitoring of seismicity and crustal motions.

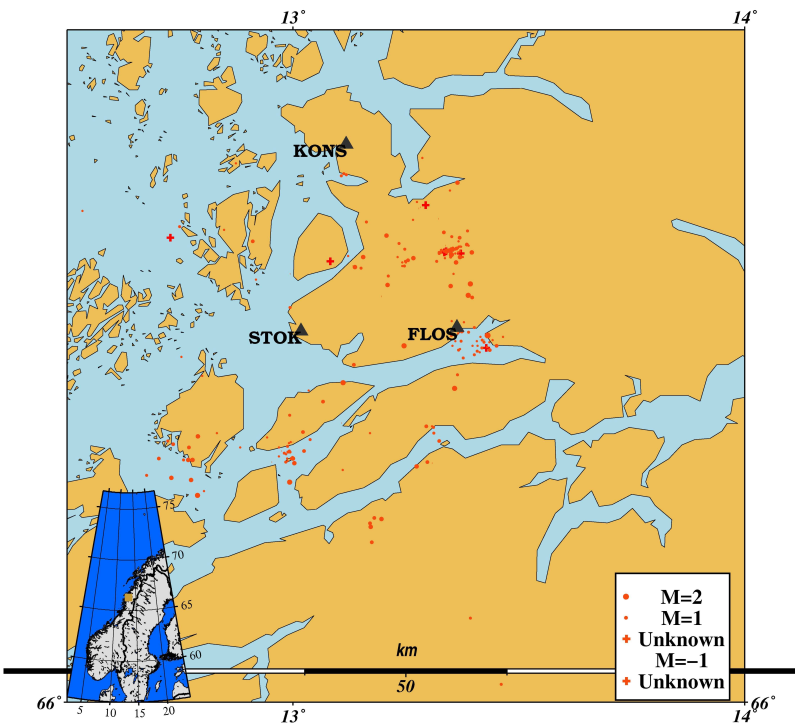

Figure 9: Events located in the Stokkvågen area during 2008.

Earthquake recordings in the Steigen area

A new seismic station (STEI) was installed in June 2007, in the Steigen area in Nordland. This seismic station is recording small local earthquakes and also the larger earthquakes occurring offshore Lofoten. During 2008 a total of 179 small local events was recorded by STEI and located to the area shown in Figure 10.

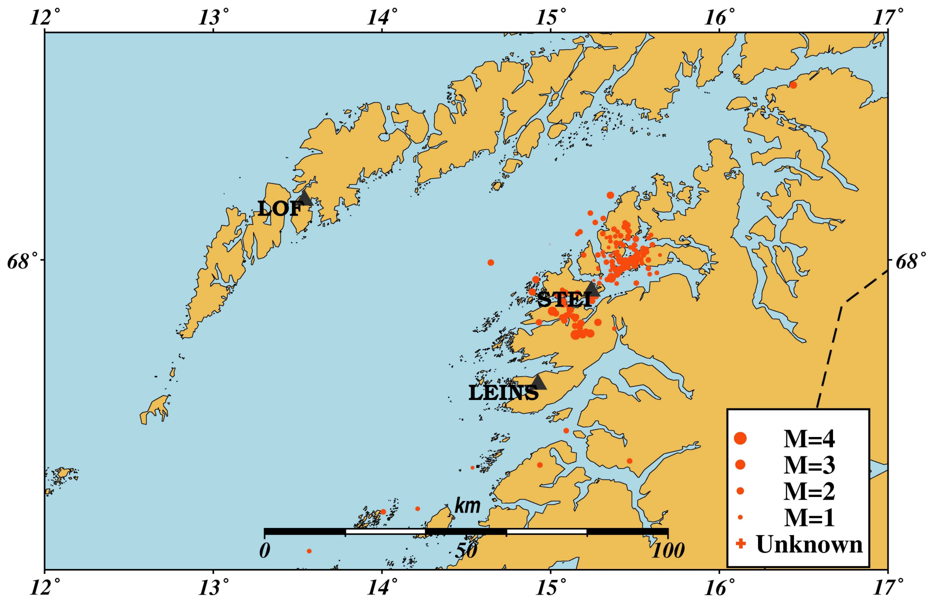

Figure 10. Events located in the Steigen area during 2008. LEINS is a portable station temporary used in autumn 2007.

It is evident that the distribution of epicentres follows a NE-trend, which is known to coincide with a previously known zone of weakness (Atakan et. al. 1994). However, the activity now seems to be more concentrated in the NE when compared to the 1993 earthquake swarm.

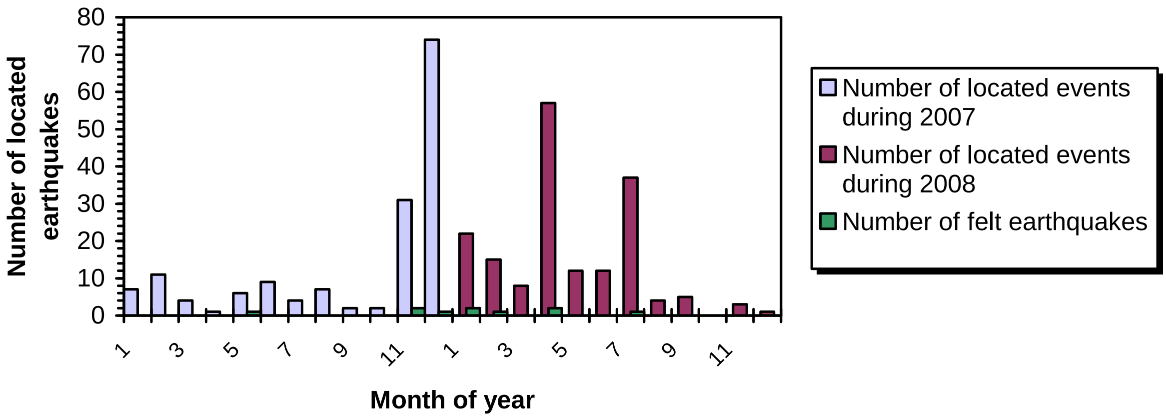

Figure 11. Events located in the Steigen area, during 2007 and 2008.

The monthly number of located earthquakes within the area defined in Figure 10, are presented in Figure 11. The number increases in November 2007 and reaches a maximum in December 2007. During the first 7 months of 2008 the number of events decreases with two local highs in April and July. Several of these earthquakes were reported felt by the local population, 4 in 2007 and 6 during 2008. The data presented are not filtered for explosions and some might be manmade events.

Jan Mayen

The Jan Mayen Island is located in an active tectonic area with two major structures, the Mid Atlantic ridge and the Jan Mayen fracture zone, interacting in the vicinity of the island. Due to both tectonic and magmatic activity in the area, the number of recorded earthquakes is higher than in other areas covered by Norwegian seismic stations. During 2008 a total of 197 earthquakes were located as seen on Figure 12 and of these, 40 were calculated to have a magnitude equal to or above 3.0.
The largest earthquake in the Jan Mayen region occurred August 3rd at 20:14 (UTC). This earthquake was located to 70.9N and 6.8W with magnitude 3.9.

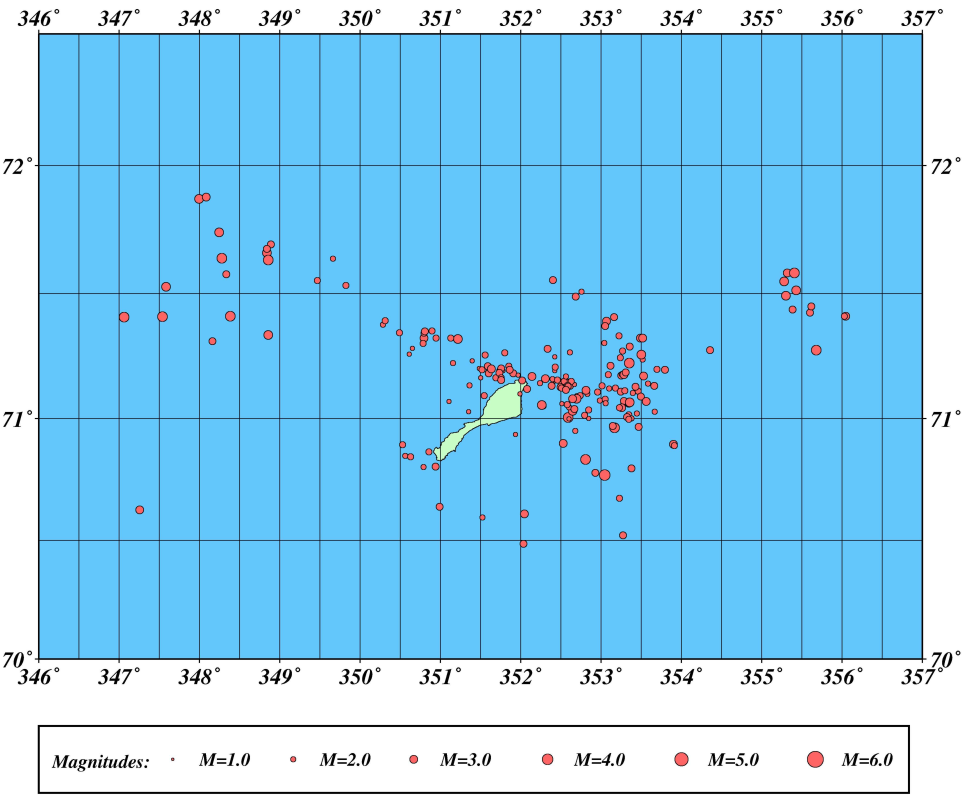

Figure 12: Earthquakes located in the vicinity of the Jan Mayen Island during 2008.

The number of recorded earthquakes in the Jan Mayen area has varied over the last years, see Figure 13. The number of relative strong earthquakes show smaller time variation than smaller earthquakes. The apparent increase in 2004 and 2005 is due to the M=6.0 earthquake in 2004 and its aftershocks (Sørensen et al., 2007).

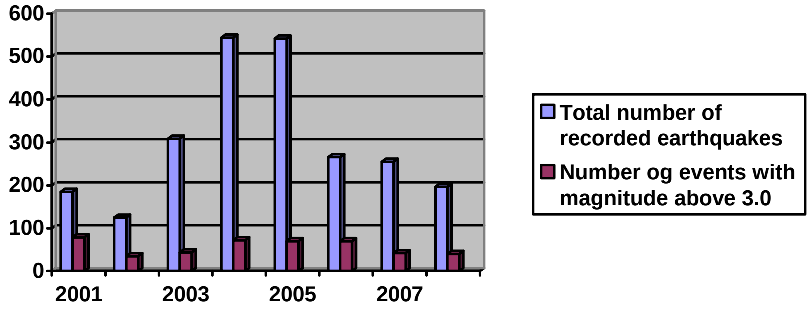

Figure 13: Yearly distribution of earthquakes located in the Jan Mayen area.

5. Felt earthquakes

From 2006 it is possible to report felt earthquakes using the internet. On the site www.skjelv.no., questionnaires are available for the public. In total, 18 earthquakes were reported felt during 2008 (see Table 5 and Figure 14).

Table 5: Earthquakes reported felt in the BER database in 2008. Abbreviations are: $\mathbf{M_c}$ = coda magnitude, $\mathbf{M_L}$ = local magnitude and $\mathbf{M_w}$ = moment magnitude, Q: questionnaires sent (Y/N), W: questionnaires received on web.

Nr	Date	Time (UTC)	Max. Intensity (MMI)	Magnitude (BER)	Instrumental epicentre location	Q	W
1	27.01.08	13:21	III	M_L=2.1,M_L=2.3 (BGS)	56.98N / 05.60W	-	-
2	30.01.08	07:34	III	M_c=2.2, M_L=1.7	67.88N / 15.09E	N	N
3	30.01.08	07:39	III	M_c=2.6, M_L=2.7	67.88N / 15.01E	N	N
4	12.02.08	06:35	III	M_c=2.8, M_L=2.5	67.84N / 15.23E	N	N
5	21.02.08	02:42	III	M_L=2.1, M_L=2.4 (BGS)	55.14N / 07.47W	-	-
6	21.02.08	02:46	VI	M_L=5.7, M_W=6.0	77.24N / 20.26E	N	Y
7	10.04.08	06:20	III	M_c=3.2, M_L=4.3, M_W=4.3	77.11N / 19.45E	N	N
8	11.04.08	06:02	IV	M_L=3.2, M_W=3.4	67.83N / 15.15E	N	Y
9	11.04.08	06:04	III	M_L=2.6	67.95N / 15.36E	N	N
10	24.04.08	17:14	III	M_c=3.2, M_L=2.7, M_W=3.0	69.69N / 18.45E	N	N
11	25.04.08	04:53	III	M_c=3.4, M_L=2.9, M_W=3.1	69.67N / 18.45E	N	N
12	15.05.08	09:05	V	M_c=2.4, M_L=2.0	66.82N / 13.78E	N	Y
13	25.05.08	01:10	V	M_c=2.8, M_L=2.6	60.07N / 10.73E	N	Y
14	29.05.08	16:22	V	M_L=2.6	69.69N / 30.06E	N	Y
15	07.07.08	22:42	III	M_c=2.4, M_L=2.1	67.83N / 15.19E	N	N
16	14.10.08	16:47	III	M_c=3.4, M_L=3.1, M_W=3.0	69.76N / 30.72E	N	Y
17	22.10.08	17:02	III	M_c=2.2, M_L=2.5	60.69N / 04.53E	N	N
18	03.11.08	09:53	III	M_L=2.4, M_L=2.5 (BGS)	56.37N / 05.50W	-	-

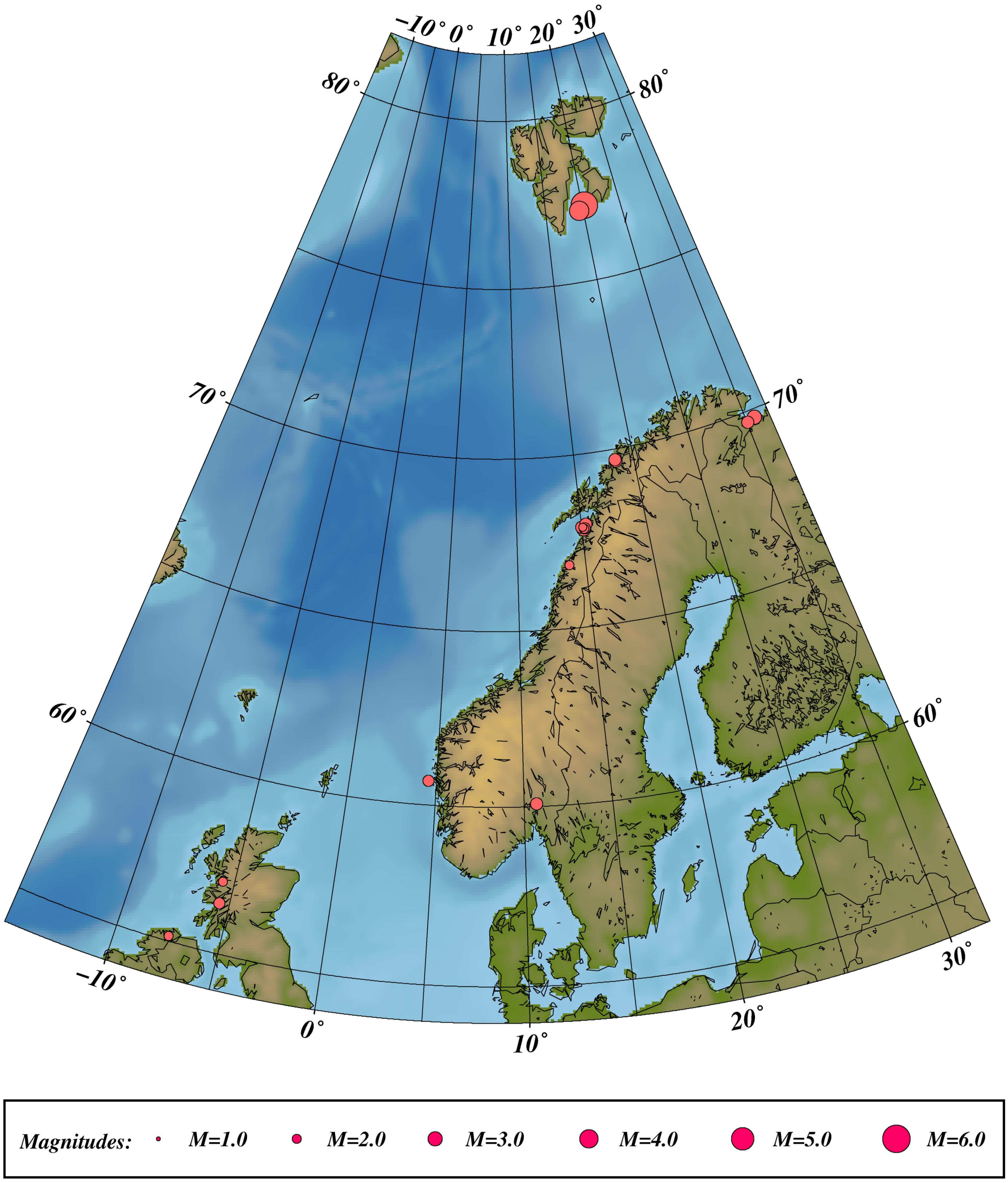

Figure 14: Location of the 18 earthquakes reported felt during 2008.

6. Use of NNSN data during 2008

Data collected on Norwegian seismic stations are made available through the Internet and is provided on request to interested parties. Therefore it is difficult to get a comprehensive overview on the use and all publication based on Norwegian data.

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