Seismicity of Norway and surrounding areas

for 2006

Prepared by

Department of Earth Science
University of Bergen
Allegt. 41
N-5007 Bergen

e-mail: seismo@geo.uib.no
Phone: (+47) 55 58 36 00
Fax: (+47) 55 58 36 60

April 2007

CONTENTS

1. Introduction

This annual report on the seismicity of Norway and adjacent areas encompasses the time period January 1st - December 31st, 2006. 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 29 seismic stations where 8 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. During 2006 two temporary stations were installed in northern Norway at Stokvågen and one temporary station was installed in the northern part of Jan Mayen. 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 $\geq$ 2.0 on mainland Norway and M $\geq$ 3.0 around Jan Mayen and the midatlantic 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.

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 plotted on individual maps shown on the web pages.

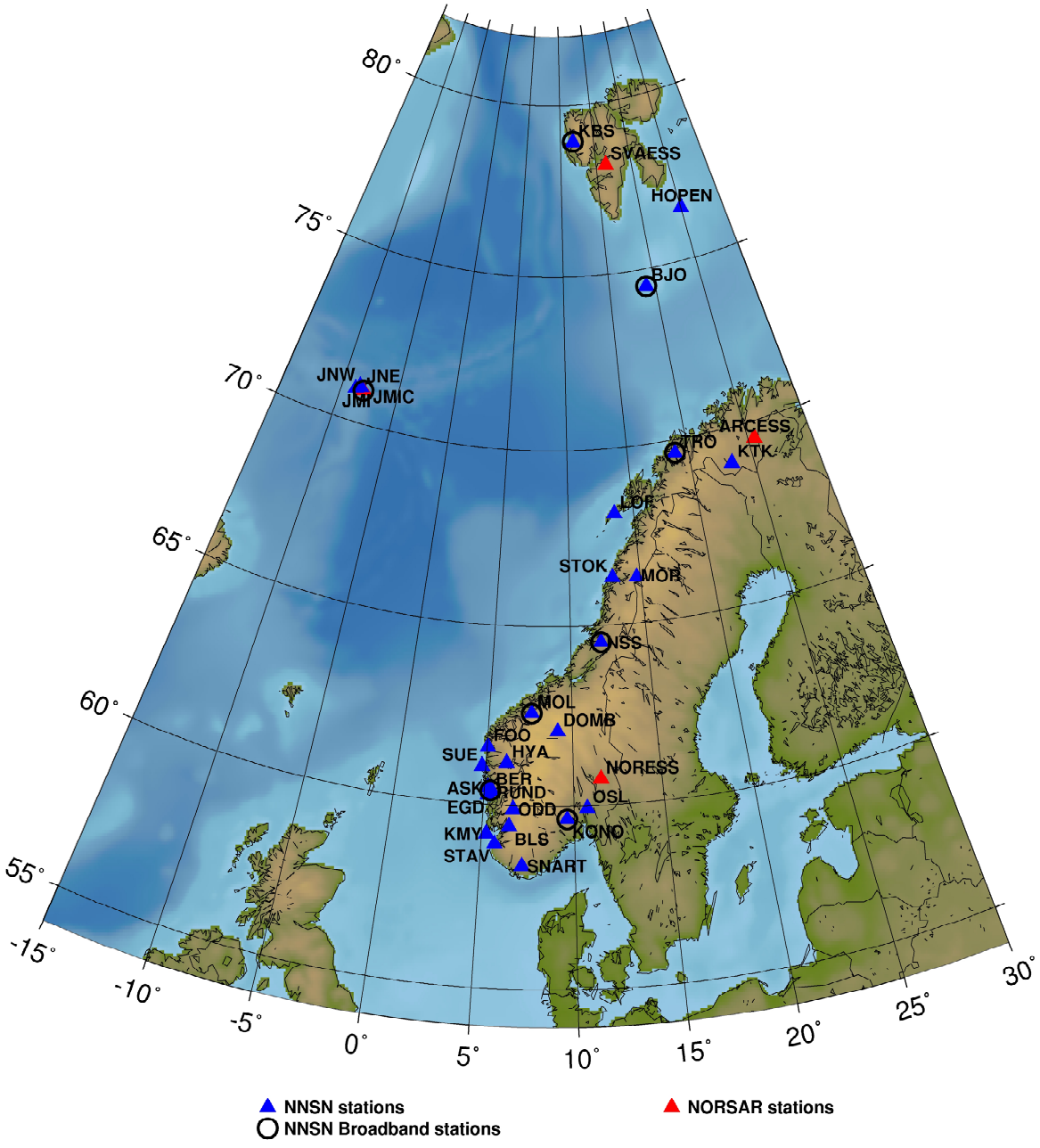

Figure 1: Norwegian seismic stations. UiB operates the 29 stations in the National Seismic Network (NNSN) and NORSAR operates the 3 arrays and the station JMIC.

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 (Sørnes and Navrestad, 1975).

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

P-wave velocity (km/sec)	Depth to layer interface (km)
3.14	0
6.33	3
8.27	18

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, a total of 4138 local and regional events, were detected by the Norwegian seismic stations during 2006. Of these local and regional events analysed, 47% were located. The number of local/regional and teleseismic events, recorded per month in 2006 is shown in Figure 2. The average number of local and regional events recorded per month is 345.

A total of 978 teleseismic events were recorded during 2006, of which 97% 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 81.

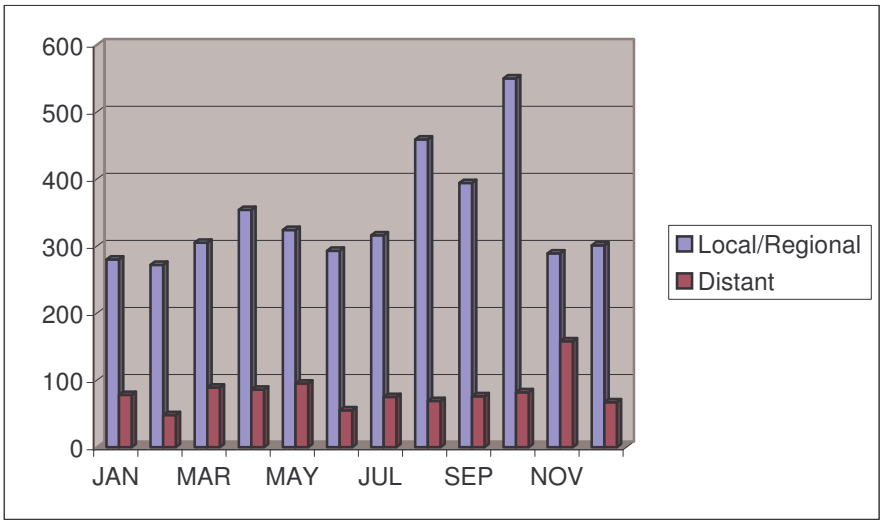

Figure 2: Monthly distribution of local/regional and distant events, recorded during 2006.

UiB, as an observatory in the global net 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 2006 with M ≥ 3 are plotted on Figure 3.

Monthly station recording statistics from January to December 2006 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 therefore the number of recorded local earthquakes increased.

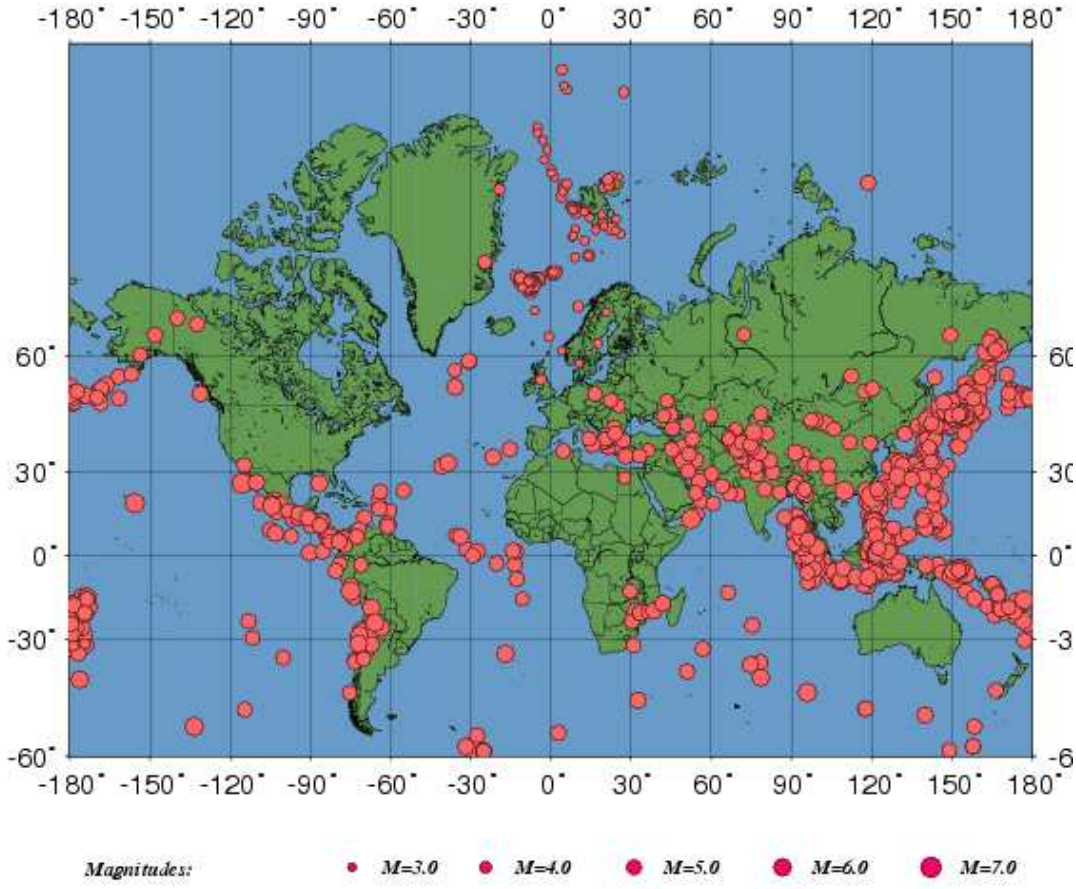

Figure 3: Epicentre distribution of earthquakes with M≥3.0, located by the Norwegian Seismic Network from January to December 2006. Teleseismic events recorded only by NORSAR have M≥5.0.

4. The seismicity of Norway and adjacent areas

A total of 1934 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), 37% of these events were identified as probable explosions. Figure 4 shows all local/regional events in the prime area, analyzed and located during 2006.

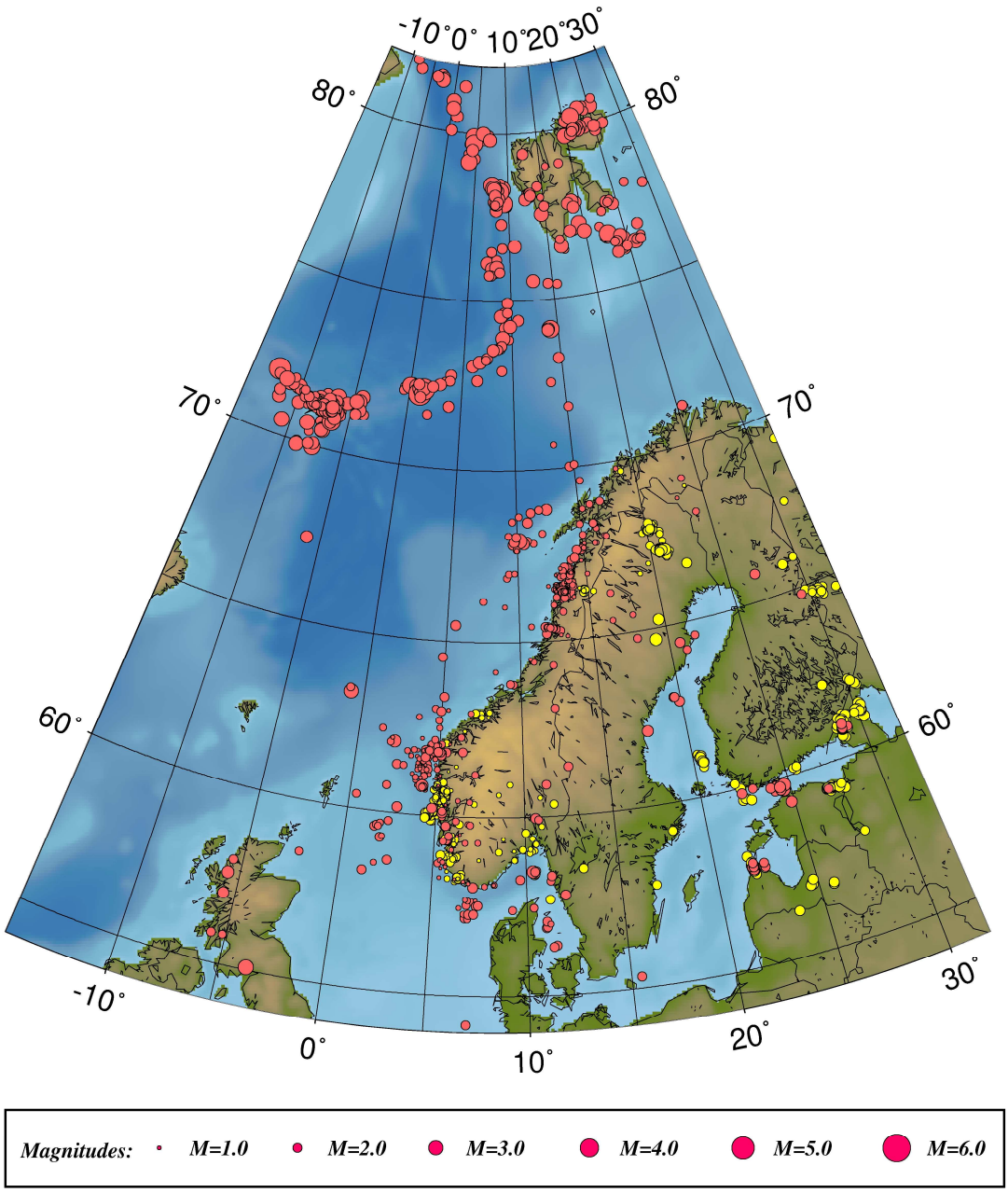

Figure 4: Epicentre distribution of events analyzed and located from January through December 2006. Earthquakes are plotted in red and probable and known explosions in yellow. For station locations, see Figure 1.

Table 3a: Monthly statistics of events recorded at each station for January-June 2006. 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 station TRON was shut down in June.

	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	39	0	11	31	0	3	34	0	7	34	0	5	28	0	12	25	0	5
BER	10	0	18	16	0	15	6	0	26	17	0	36	15	0	26	16	0	25
BJO1	0	0	11	1	0	13	2	0	14	2	0	20	6	0	21	5	0	17
BLS5	37	0	17	39	0	10	36	0	14	34	0	14	26	0	13	31	0	11
DOMB	7	0	12	8	0	10	5	0	10	10	0	17	11	0	11	2	0	10
EGD	28	0	8	27	0	3	22	0	6	30	0	5	26	0	10	24	0	5
FOO	20	0	9	22	0	5	12	0	5	16	0	5	18	0	13	12	0	1
HOPEN	12	10	1	18	6	0	26	17	0	13	8	0	25	9	1	26	13	0
HYA	21	0	8	21	0	4	16	0	3	23	0	1	19	0	11	27	0	6
JMI	14	0	1	21	0	0	18	0	0	16	0	0	20	0	0	26	0	0
JMIC	0	0	9	1	0	14	1	0	13	5	0	31	3	0	18	0	0	34
JNE	14	0	1	20	0	0	18	0	0	16	0	0	19	0	0	24	0	0
JNW	15	0	1	21	0	0	18	0	0	16	0	2	20	0	1	26	0	1
KBS	8	0	15	17	1	14	11	0	23	16	1	36	32	4	27	19	2	26
KMY	37	0	6	38	0	3	41	0	4	36	0	2	28	0	10	38	0	3
KONO	2	0	13	0	0	12	10	0	21	2	0	32	3	0	26	3	0	26
KTK1	15	0	22	36	2	7	16	0	17	41	2	33	28	1	18	22	2	20
LOF	18	0	10	32	0	11	18	1	14	29	0	22	37	1	17	20	1	13
MOL	24	2	18	18	0	11	19	3	15	26	5	29	2	0	6	1	0	17
MOR8	50	7	23	68	2	18	34	5	21	61	4	35	57	0	25	42	1	24
NSS	21	0	19	26	0	19	14	1	29	23	1	34	30	0	26	14	0	28
ODD1	48	0	13	45	0	7	44	0	8	40	0	2	28	0	11	24	0	4
OSL	0	0	7	0	0	5	0	0	2	1	0	14	0	0	7	0	0	6
RUND	12	0	5	10	0	7	11	0	5	10	0	5	16	0	6	14	0	5
SNART	23	0	5	27	0	4	19	0	2	19	0	8	22	0	7	26	0	6
STAV	3	0	3	6	0	3	3	0	1	7	0	5	6	0	7	12	0	2
STOK	39	0	6	80	37	11	54	29	3	92	48	6	52	0	9	48	0	8
SUE	18	0	6	15	0	4	13	0	1	25	0	3	18	0	9	24	0	2
TRO	13	0	25	34	0	23	3	0	14	28	0	46	16	0	31	17	0	32
TRON	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	-	-	-
NORSAR	22	0	56	26	0	44	32	0	66	16	0	79	46	0	76	27	0	53
ARCES	37	0	0	44	0	0	60	0	0	35	0	0	70	0	0	44	0	0
SPITS	14	0	0	16	0	0	24	2	0	17	0	0	34	0	0	17	0	0

Table 3b: Monthly statistics of events recorded at each station for July-December 2006. 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	33	0	8	42	0	6	40	0	14	43	0	4	30	0	24	23	0	8
BER	12	0	29	18	0	37	12	0	24	27	0	18	6	0	30	2	0	16
BJO1	14	1	21	7	0	15	4	0	9	3	0	19	9	1	22	2	0	13
BLS5	28	0	13	26	0	18	32	0	23	33	0	8	22	0	37	21	0	15
DOMB	6	0	4	8	0	19	2	0	10	2	0	8	6	0	23	6	0	13
EGD	22	0	5	34	0	6	37	0	14	42	0	4	23	0	22	18	0	6
FOO	19	2	1	28	0	2	23	0	7	33	0	1	12	0	3	1	0	0
HOPEN	84	58	0	77	32	0	42	14	0	23	8	0	13	5	0	6	3	0
HYA	23	0	5	35	0	4	30	0	7	49	0	1	26	1	19	20	2	7
JMI	32	0	0	35	1	0	24	0	0	23	1	0	19	0	0	21	0	0
JMIC	3	0	26	9	0	38	12	0	16	6	0	20	4	0	13	0	0	8
JNE	29	0	0	36	0	0	34	0	0	30	0	0	20	0	0	23	0	0
JNW	32	0	0	39	0	0	34	0	1	33	4	0	21	0	1	24	0	0
KBS	33	2	29	54	4	38	40	5	25	18	1	22	23	5	32	6	1	16
KMY	28	0	4	34	0	4	31	0	8	42	0	1	20	0	3	19	0	7
KONO	7	0	32	3	0	36	5	0	24	1	0	22	3	0	33	6	0	15
KTK1	16	0	5	30	0	26	24	0	36	33	2	15	18	0	57	20	0	23
LOF	17	3	15	43	5	18	32	0	24	33	3	13	18	0	36	11	0	13
MOL	7	0	17	0	0	2	0	0	4	3	0	10	3	0	13	9	0	10
MOR8	10	0	13	57	4	30	57	1	32	59	3	18	40	1	57	40	2	24
NSS	9	0	31	33	1	30	33	0	36	35	1	24	25	2	58	11	0	13
ODD1	26	0	10	36	0	5	26	0	12	36	0	3	23	0	21	19	0	11
OSL	1	0	1	0	0	5	0	0	7	0	0	5	0	0	12	0	0	9
RUND	10	0	3	10	0	3	9	0	11	17	0	3	3	0	10	7	0	9
SNART	21	0	7	17	0	5	23	0	8	16	0	2	13	0	16	13	1	7
STAV	9	0	0	9	0	4	5	0	6	2	0	3	3	0	4	1	0	3
STOK	19	3	5	25	2	6	53	0	12	21	6	1	36	0	12	40	1	7
SUE	19	0	2	26	0	3	24	0	8	37	0	2	11	0	6	8	0	4
TRO	11	0	41	28	0	45	20	0	42	22	0	29	13	0	64	13	0	25
NORSAR	22	0	70	30	0	66	96	0	66	33	0	77	19	0	149	16	0	66
ARCES	50	0	0	61	0	0	119	0	0	57	0	0	36	0	0	36	0	0
SPITS	25	0	0	30	0	0	30	0	0	20	0	0	18	0	0	11	0	0

Figure 5 and Table 4 show the 103 local and regional events, located in the prime area, with one of the calculated magnitudes greater than or equal to 3.0. 61 of these are located in the vicinity of the Jan Mayen Island. Depth is checked for the earthquakes listed in Table 4.
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 the earthquakes are recorded on Norwegian mainland stations.

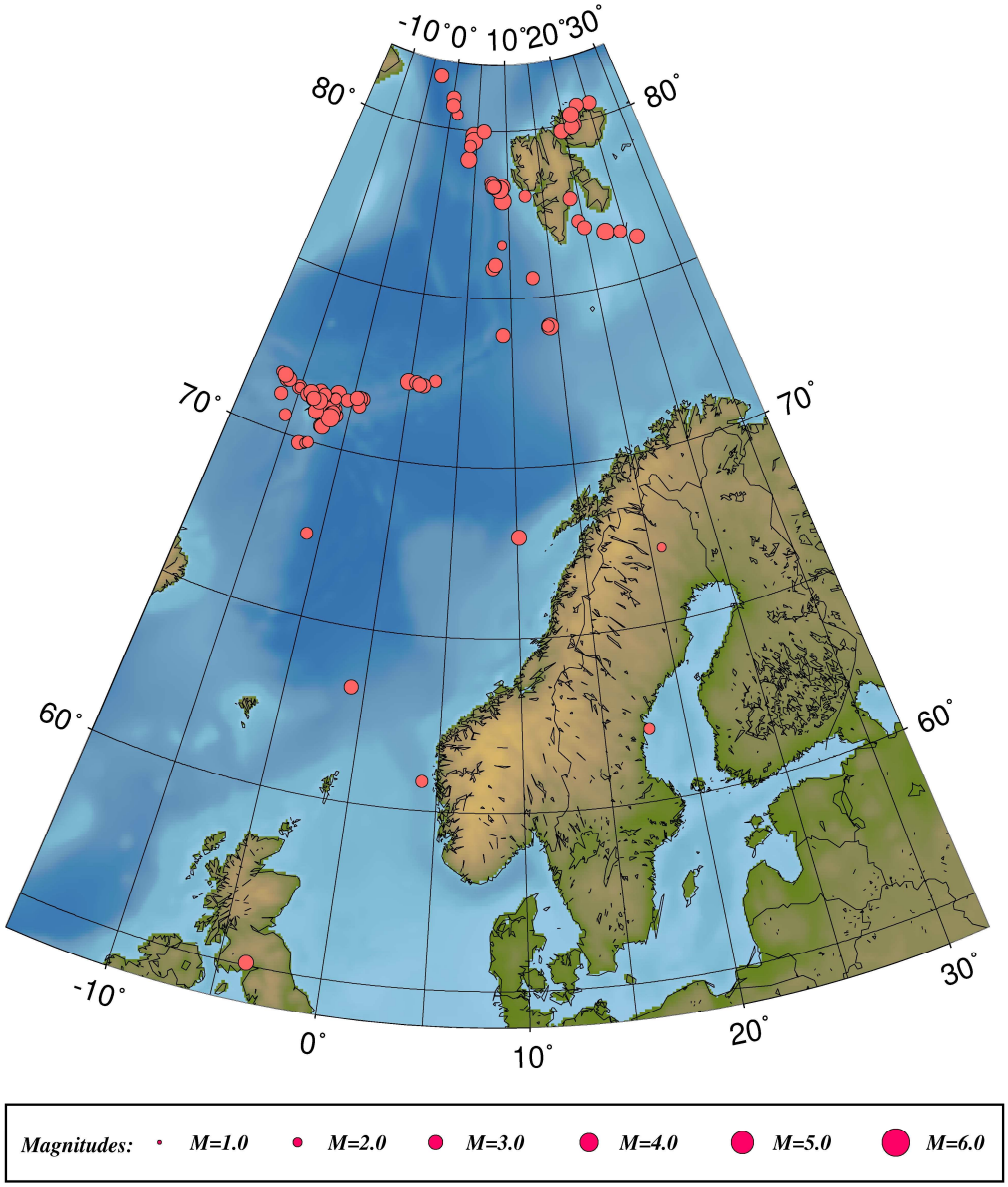

Figure 5: Epicentre distribution of located events with one of the calculated magnitudes above or equal to 3.0. All earthquakes are listed in Table 2. For station location, see Figure 1.

The largest local or regional earthquake in 2006, recorded on Norwegian stations and within the prime area, occurred on August 9th , 2006 at 22:31 (UTC) west of Spitsbergen. The earthquake had a magnitude of $M_L = 4.0$.

The largest earthquake in the vicinity of the Norwegian mainland occurred on July 19th at 20:42 (UTC). The earthquake was located west of Mo i Rana at 67.9°N, 10.1°E and had a magnitude of 3.3. This earthquake was reported felt by a tourist in Lofoten. Some of the recorded seismograms from the earthquake are shown in Figure 6.

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 2006. 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
2006	1 5	1321	27.1	L	71.083	-7.350	8.0	F	BER	3	0.1	3.0	3.4	
2006	114	0329	3.1	L	80.485	25.253	20.0	F	BER	3	1.0	2.1	3.1	
2006	124	1105	11.2	L	71.249	-8.597	20.0	F	BER	3	0.1	2.9	3.0	
2006	127	1016	20.2	L	71.087	-7.356	7.0	F	BER	3	0.1	3.6	3.5	
2006	129	1949	46.9	L	71.596	-4.153	10.0	F	BER	26	1.7	3.2	3.2	
2006	131	2213	2.6	L	70.927	-6.712	7.0	F	BER	3	0.1	2.8	3.1	
2006	2 2	1625	35.6	L	70.976	-6.759	13.0	F	BER	3	0.1	3.0	2.3	
2006	2 4	0117	57.5	L	71.132	-7.374	7.0	F	BER	3	0.1	2.5	3.0	
2006	2 6	2255	50.2	L	71.066	-6.721	6.0	F	BER	3	0.1	3.2	2.7	
2006	210	1706	8.0	L	79.808	19.428	10.0	F	BER	9	1.3	2.8	3.3	
2006	214	1309	52.5	L	77.915	9.198	10.0	F	BER	6	2.3		3.7	
2006	222	2357	43.4	L	70.936	-6.145	10.0	F	BER	5	0.3	3.5	2.8	
2006	3 4	2125	14.1	L	71.172	-7.503	10.0	F	BER	3	0.1	3.3	2.9	
2006	3 5	1001	8.2	L	67.146	20.821	0.0	F	BER	10	1.7	3.1	2.1	
2006	312	0610	9.3	L	71.426	-8.017	10.0	F	BER	3	0.5	3.0	2.8	
2006	318	1255	55.8	L	71.236	-7.468	10.0	F	BER	6	0.2	3.4	3.1	
2006	410	1412	27.2	L	71.250	-8.462	10.0	F	BER	4	0.1	3.2	3.4	
2006	410	1434	50.7	L	71.138	-7.528	10.0	F	BER	10	0.9	4.0	3.4	
2006	415	0332	6.9	L	67.378	-6.073	10.0	F	BER	14	1.5	2.5	2.7	
2006	428	1339	40.7	L	79.145	3.908	10.0	F	BER	3	0.8	1.4	3.5	
2006	428	1341	57.5	L	78.352	9.062	10.0	F	BER	12	1.2	3.8	3.7	
2006	429	0041	36.4	L	76.227	26.209	22.0	F	BER	9	1.3		3.3	
2006	5 3	0918	0.2	L	71.432	-10.106	10.0	F	BER	4	0.2	3.5	3.0	
2006	5 3	0949	4.4	L	75.899	8.046	10.0	F	BER	6	1.0	2.4	3.2	
2006	5 9	0302	14.5	L	71.497	-8.103	10.0	F	BER	4	0.3	3.6	3.1	
2006	5 9	1015	30.6	L	71.566	-6.478	10.0	F	BER	13	1.2	4.7	3.5	
2006	512	1142	24.0	L	71.420	-10.026	10.0	F	BER	4	0.4	3.0	2.2	
2006	516	0853	49.1	L	76.580	9.085	7.0	F	BER	4	0.8	3.0	2.0	
2006	520	0624	7.3	L	71.450	-5.516	10.0	F	BER	16	2.2	4.1	2.9	
2006	524	0327	50.7	L	80.445	1.277	10.0	F	BER	4	1.4	3.0	2.5	
2006	528	1323	29.2	L	74.107	14.197	5.0	F	BER	21	1.8	3.9	3.7	
2006	528	2310	27.0	L	80.925	0.156	10.0	F	BER	6	2.0	2.8	3.1	
2006	529	2201	18.6	L	74.118	13.956	10.0	F	BER	15	1.2	3.1	2.7	
2006	6 3	1211	24.9	L	79.952	21.718	22.2	F	BER	3	0.7	2.6	3.1	
2006	6 4	1140	41.0	L	70.746	-7.457	10.0	F	BER	4	0.9	3.2	2.3	
2006	6 4	1243	19.3	L	71.116	-6.286	5.0	F	BER	4	0.1	3.5	2.4	
2006	611	1411	12.0	L	77.806	18.807	10.0	F	BER	5	1.5	2.5	3.1	
2006	617	1937	5.6	L	71.393	-6.936	5.0	F	BER	3	0.3	3.2	2.3	
2006	630	0243	34.1	L	73.906	9.063	10.0	F	BER	20	1.2	3.3	3.1	
2006	7 3	1839	6.0	L	71.306	-9.173	10.0	F	BER	3	0.1	3.7	3.2	
2006	7 4	1848	23.4	L	79.864	4.488	18.0	F	BER	11	1.7	3.6	3.6	

2006	7	4	1853	42.0	L	79.705	4.544	10.0	F	BER	11	1.8	3.6	3.7	
2006	7	4	1949	52.6	L	79.992	6.157	10.0	F	BER	4	0.4	3.3	3.2	
2006	719	1404	7	5	L	71.108	-6.963	12.0	F	BER	3	0.1	3.2	2.4	
2006	719	2042	38.6	L		67.939	10.156	12.0	F	BER	19	1.1	3.5	3.3	
2006	723	0648	38.0	L		78.469	7.649	10.0	F	BER	9	1.6	2.8	3.0	
2006	729	1743	50.0	L		81.525	-2.970	10.0	F	BER	4	1.5	3.1	3.0	
2006	730	0716	56.7	L		72.334	-0.168	15.0	F	BER	27	1.8		3.6	5.3
2006	8	9	0815	14.4	L	60.833	4.107	15.0	F	BER	18	0.9	2.7	2.7	
2006	8	9	2231	13.8	L	78.277	8.796	10.0	F	BER	17	1.9	3.8	4.0	
2006	812	1238	24.9	L		79.911	21.273	23.0	F	BER	4	1.3	3.3	3.4	
2006	813	1903	9	4	L	71.585	-4.432	10.0	F	BER	25	1.6	4.4	3.3	
2006	813	1929	34.5	L		71.640	-4.614	10.0	F	BER	7	1.3	3.9	2.3	
2006	813	1943	11.4	L		71.347	-4.302	10.0	F	BER	15	2.1	4.4	2.8	
2006	814	0125	49.7	L		71.582	-4.662	10.0	F	BER	16	1.0	4.1	3.0	
2006	815	1949	45.6	L		78.368	7.853	10.0	F	BER	4	1.1	2.7	3.6	
2006	815	2018	14.3	L		78.341	7.931	10.0	F	BER	4	0.7	2.6	3.1	
2006	816	1331	39.9	L		77.100	19.303	7.0	F	BER	5	0.6	2.7	2.9	
2006	818	2045	44.2	L		63.274	-0.833	10.0	F	BER	33	1.5	3.3	3.1	
2006	820	1714	0.2	L		71.560	-11.396	10.0	F	BER	7	0.9	4.5	3.6	3.6
2006	820	1718	23.2	L		69.913	-8.283	10.0	F	BER	3	0.5	3.4	2.6	
2006	820	1726	49.4	L		71.077	-11.492	5.0	F	BER	3	0.2	3.6	2.8	
2006	820	1907	28.3	L		71.549	-11.182	5.0	F	BER	6	0.4	3.8	3.1	
2006	820	2017	42.6	L		69.875	-8.698	10.0	F	BER	3	0.6	3.9	3.1	
2006	820	2230	26.9	L		69.912	-8.358	5.0	F	BER	3	0.3	3.1	2.3	
2006	821	0617	58.3	L		69.974	-7.960	10.0	F	BER	3	0.3	3.1	2.5	
2006	821	2114	48.5	L		75.579	12.662	10.0	F	BER	13	1.6	3.2	2.8	
2006	822	0831	18.1	L		80.517	22.899	13.0	F	BER	5	0.8	2.8	3.1	
2006	824	0819	40.1	L		71.158	-6.604	11.0	F	BER	3	0.1	3.0	2.2	
2006	9	4	0033	54.5	L	71.685	-12.130	5.0	F	BER	3	0.1	3.2	2.4	
2006	9	4	1623	32.8	L	78.044	12.483	10.0	F	BER	4	1.8	3.0	2.6	
2006	9	6	0557	21.2	L	71.249	-6.706	10.0	F	BER	10	0.8	4.3	2.9	
2006	913	1106	44.9	L		71.076	-6.907	10.0	F	BER	3	0.3	2.7	3.1	
2006	918	0642	57.6	L		80.255	21.577	15.0	F	BER	9	1.5	2.8	3.5	
2006	919	0920	40.4	L		72.459	2.441	10.0	F	BER	11	1.4	2.8	2.7	
2006	922	1813	31.8	L		71.417	-6.653	8.0	F	BER	3	0.1	3.0	2.4	
2006	923	0406	56.2	L		70.522	-7.264	10.0	F	BER	7	1.3	4.2	3.1	
2006	923	0426	45.3	L		70.510	-7.116	10.0	F	BER	6	0.6	3.5	3.3	
2006	923	0437	51.0	L		70.956	-6.615	10.0	F	BER	10	1.7	2.9	3.3	
2006	923	0637	48.3	L		70.988	-6.488	9.5	F	BER	3	0.0	3.1	3.0	
2006	923	0720	2.5	L		70.826	-6.640	10.0	F	BER	20	1.8		4.1	4.5
2006	923	0814	24.3	L		71.398	-6.598	10.0	F	BER	3	0.2	3.3	2.4	
2006	929	1257	34.0	L		75.997	8.205	10.0	F	BER	6	1.0	3.0	3.1	
2006	10	6	1035	34.6	L	80.681	0.383	10.0	F	BER	4	1.0	2.8	3.0	
2006	1014	0022	13.6	L		79.533	4.031	10.0	F	BER	4	0.5	3.0	2.6	
2006	1017	0536	26.5	L		71.395	-8.913	10.0	F	BER	7	1.1	3.3	3.4	
2006	1020	0507	40.6	L		62.067	17.733	15.0	F	BER	12	2.1	3.2	2.4	
2006	1020	1935	48.9	L		71.634	-11.677	5.0	F	BER	6	0.2	4.0	3.3	
2006	1020	2253	4.7	L		71.217	-8.540	10.0	F	BER	3	0.2	3.0	3.1	
2006	1026	1642	25.0	L		76.568	22.649	17.0	F	BER	7	1.5	2.5	3.1	
2006	1028	2348	4.9	L		76.615	22.507	6.0	F	BER	12	1.2	3.4	3.8	3.8
2006	11	1	0840	6.9	L	71.429	-7.635	10.0	F	BER	3	0.4	3.2	2.8	
2006	11	2	2247	13.0	L	72.335	0.619	10.0	F	BER	26	1.4		3.2	
2006	11	2	2248	13.7	L	72.132	1.004	10.0	FF	PDE	3	2.2			
2006	11	2	2248	54.8	L	72.271	1.329	10.0	FF	PDE	6	2.5		3.0	3.2
2006	11	2	2252	42.0	L	72.290	0.950	11.0	F	BER	18	1.4	3.2	3.0	
2006	1110	1149	55.3	L		70.894	-8.034	10.0	F	BER	11	1.6	3.6	3.3	
2006	1116	0809	13.6	L		71.210	-7.985	8.0	F	BER	7	0.5	3.6	3.5	
2006	1119	0343	12.4	L		76.508	24.338	12.0	F	BER	7	1.3		2.8	
2006	12	5	0937	29.1	L	71.242	-8.540	10.0	F	BER	3	0.1	2.9	3.2	
2006	12	6	1421	1.2	L	76.868	19.919	13.0	F	BER	7	1.2	2.5	3.1	
2006	1226	1040	5.2	L		55.078	-3.679	15.0	F	BER	47	1.0	3.2	3.4	
2006	1229	0041	52.7	L		70.535	-10.491	5.0	F	BER	3	0.5	3.1	2.7	

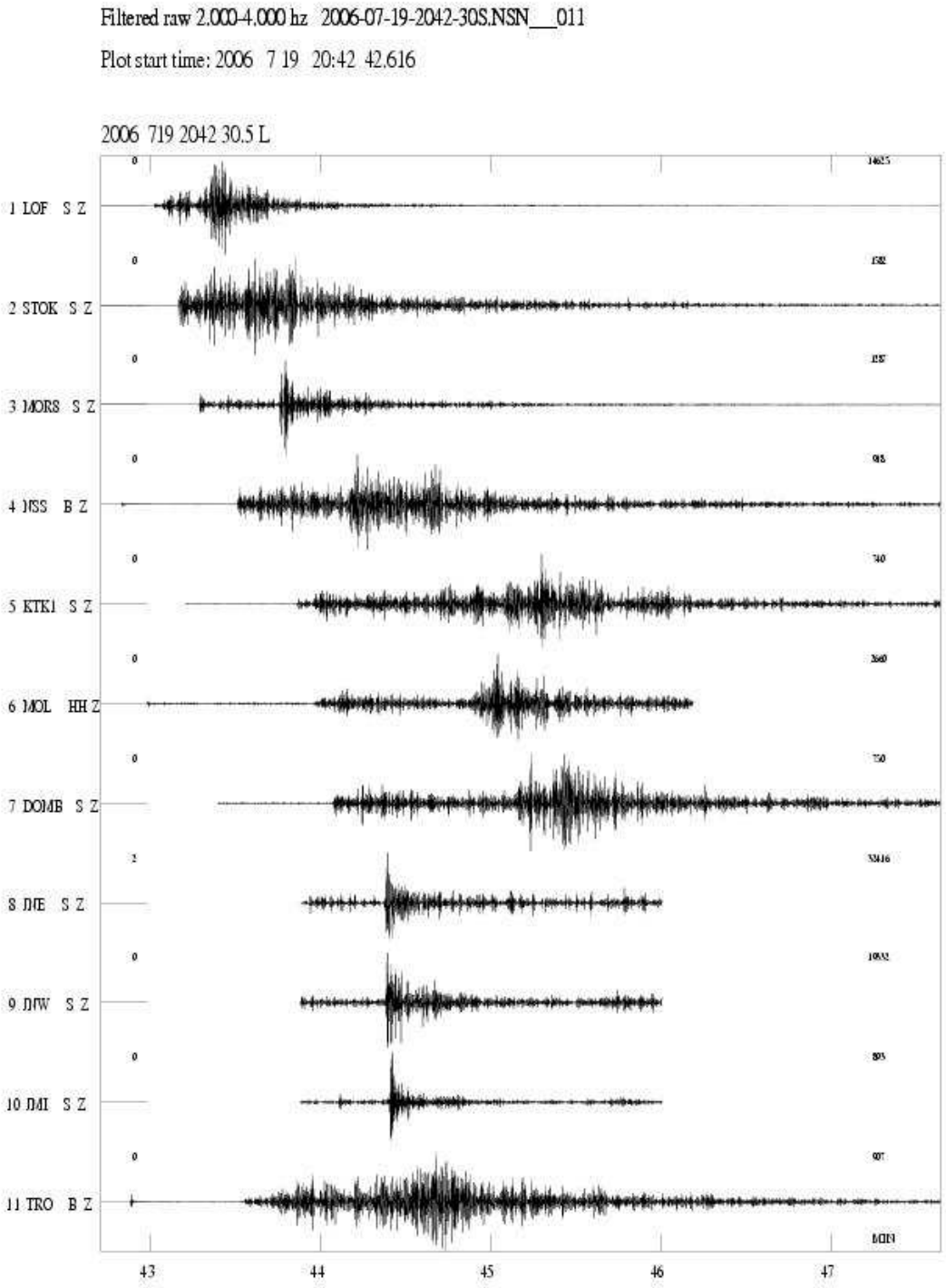

Figure 6: Seismograms for the earthquake on July 19th 2006 at 20:42 (UTC). This earthquake is located northwest of Mo i Rana, at 67.94N and 10.14E. The seismograms are filtered between 2-4 Hz. The horizontal time scale is minutes, first marking at 20:43 (UTC). The station abbreviations are: LOF: Lofoten, STOK: Stokkvågen, MOR: Mo i Rana, NSS: Namsos, KTK1: Kautokeino, MOL: Molde, DOMB: Dombås, JNE, JNW and JMI: Jan Mayen and TRO: Tromsø.

Earthquake recordings in the Stokkvågen area

The temporary network around Stokkvågen has continued operation in most of 2006. The area continues to be highly active and around 400 earthquakes were located in 2006 (Figure 8). There is a renewed research interest in the area and independent funding might be obtained for additional monitoring of seismicity and crustal motions (with GPS).

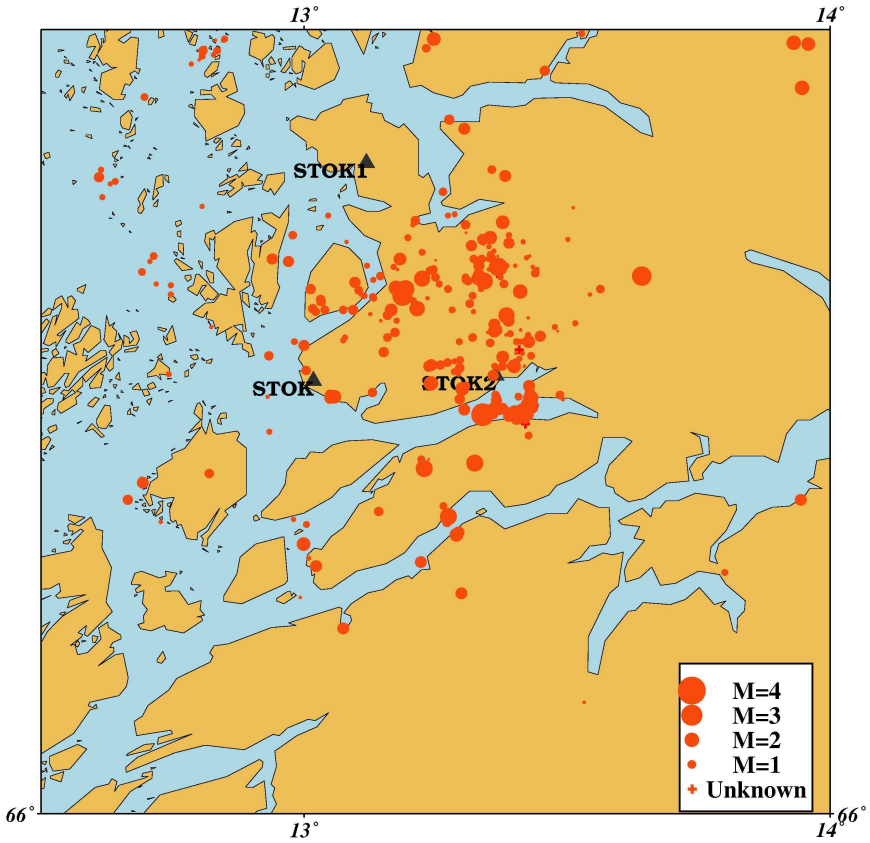

Figure 8: Earthquakes located in the Stokkvågen area during 2006. STOK1 and STOK2 are temporary stations.

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 2006 a total of 266 earthquakes were located as seen on Figure 8 and of these, 70 were calculated to have a magnitude equal to or above 3.0. It is interesting to notice that the number of small earthquakes (M<3.0) is reduced with app. 50% compared with 2005.
The temporarily installed station JMIN, which was located at the northern tip if the island, broke down in 2006. It has not been possible to reinstall this station due to bad weather conditions when attempt to visit has been made. The only access to this area is by boat.

The largest earthquake in the Jan Mayen region occurred September 23rd at 07:20 (UTC). This earthquake was located to 70.82N and 6.54W with magnitude 4.1.

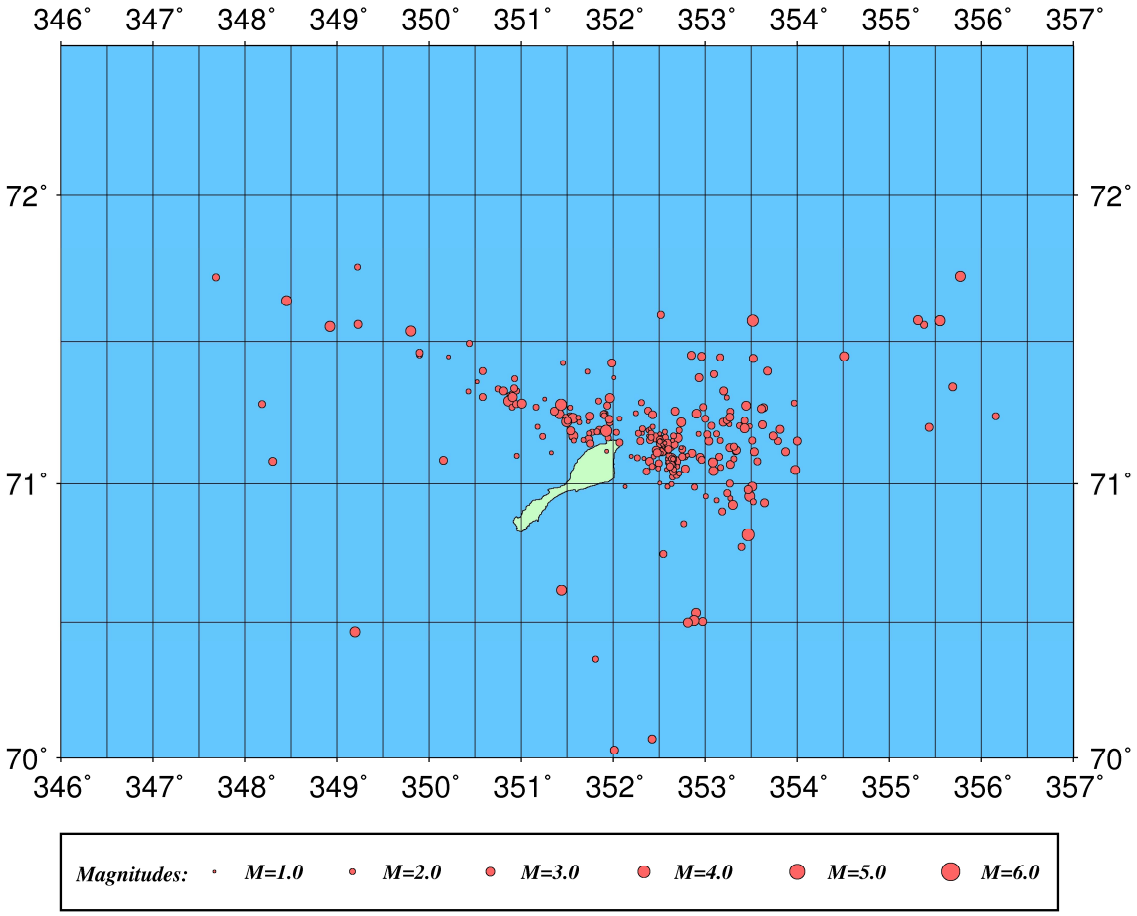

Figure 8: Earthquakes located in the vicinity of the Jan Mayen Island during 2006.

The number of recorded earthquakes in the Jan Mayen area has varied over the last years, see Figure 9. The number of relative strong earthquakes show smaller time variation than smaller earthquakes.

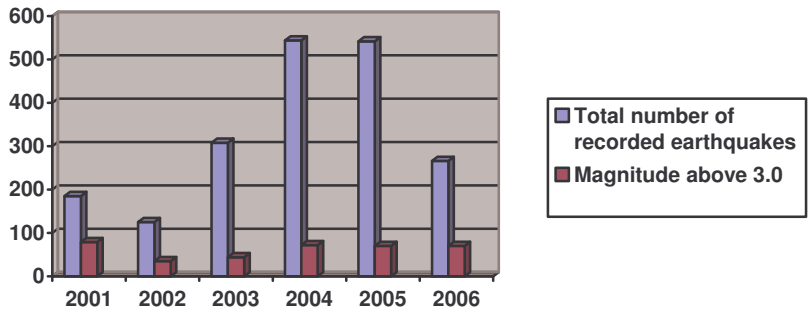

Figure 9: Yearly distribution of earthquakes located in the Jan Mayen area.

In the summers of 2005 and 2006, there were expeditions to the area around Jan Mayen. This gave the opportunity to place a seismic station on the north tip of Jan Mayen Island.

The main purpose of the new station was:

1) Give an accurate location of the earthquakes on the transform fault in order to determine if the fault goes through the Northern tip of Jan Mayen or if it is located outside the island.
2) Investigate if there are volcanic earthquakes not seen by the Jan Mayen Seismic Network (currently no volcanic earthquakes are seen).

The station had two independent seismic recorders: One Guralp 6TD broad band station and one SARA short period station, each with its own power system (Figure 10). Due to technical problem with communication and power systems, data is only available for about 3 months. The plan is to get the station working again at the next oportunity

A total of 64 local events were recorded of which 6 were only recorded on JMIN. The 58 local events recorded on both JMIN and the Jan Mayen network are seen on Figure 11. Most of the events (to the east) are aftershocks of a magnitude 5.5 event occurring on July 25, 2005.

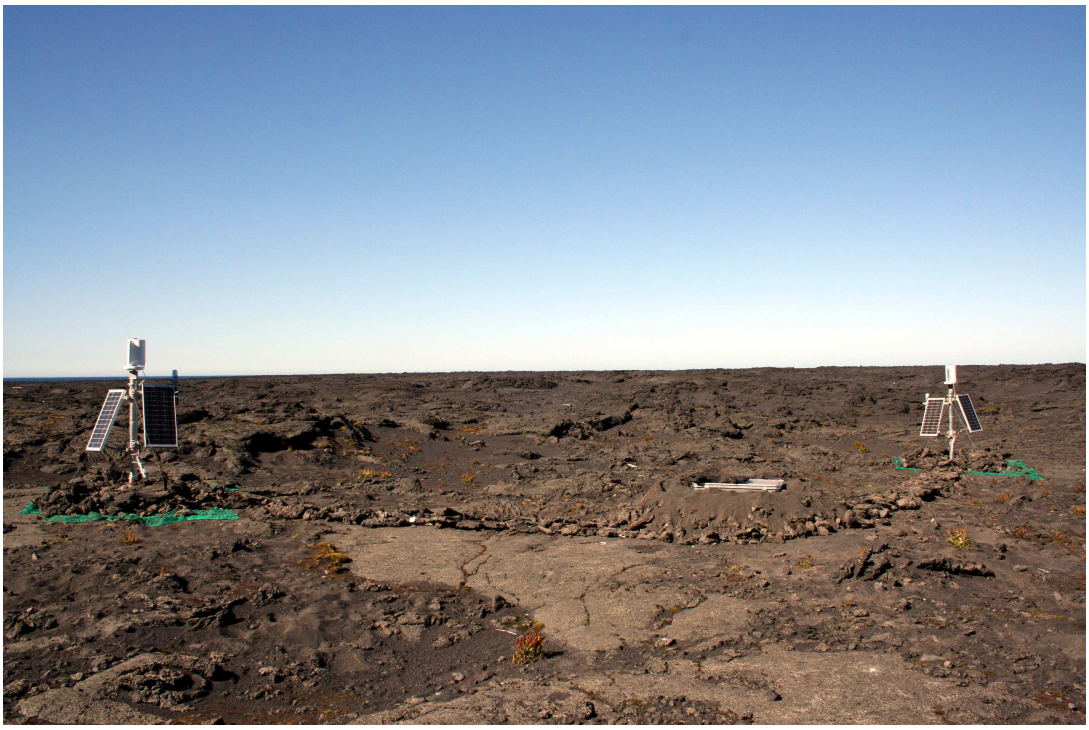

Figure 10: The two power systems and the instrument box at JMIN.

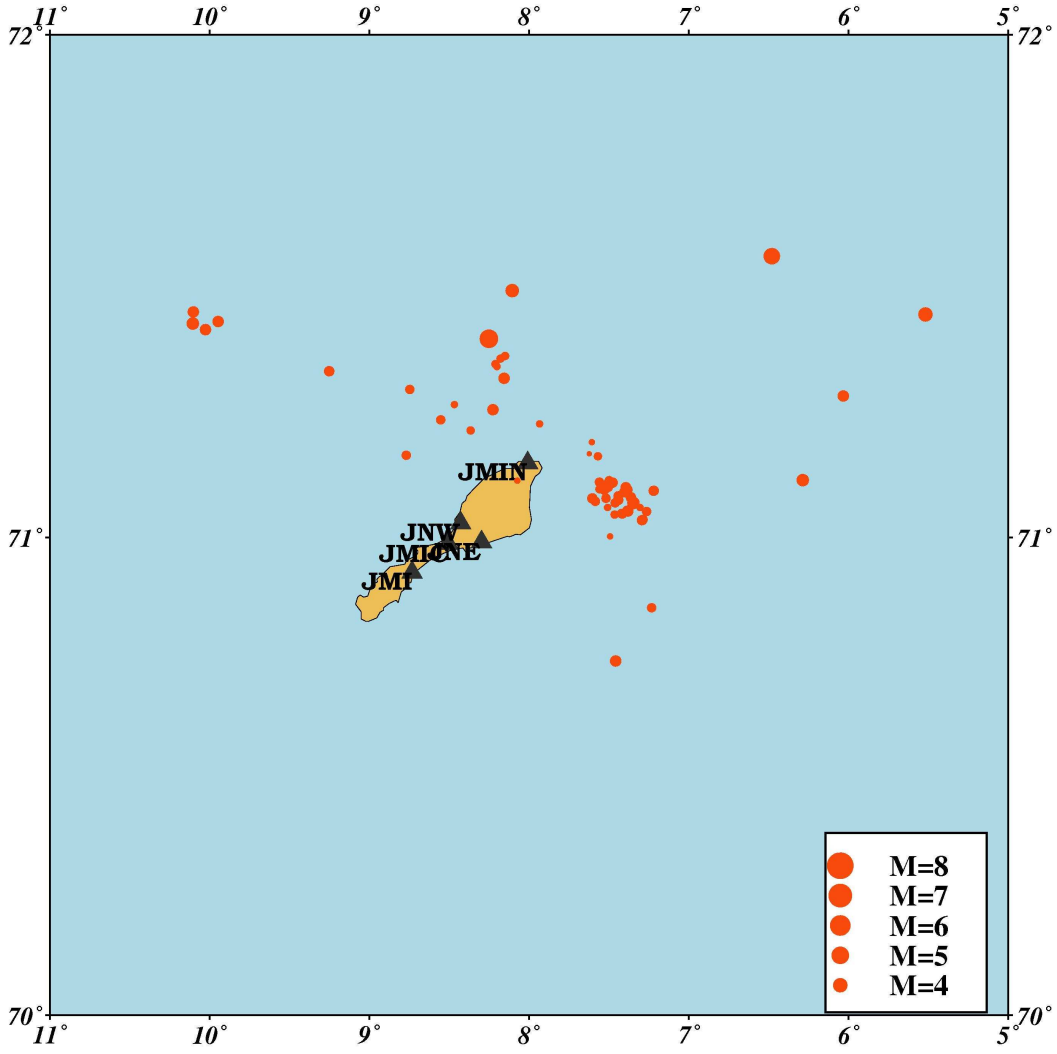

Figure 11: Local events recorded by JMIN and other stations on Jan Mayen

There are no events very close to Jan Mayen so it is hard to answer the question whether the fracture zone passes outside Jan Mayen or under Jan Mayen. However, by making a linear interpretation of the location of the event locations, it seems that the active zone is very close to the tip of Jan Mayen.
The continuous data was also checked for volcanic type events. No events were found.
It was surprising that there were no events nearer Jan Mayen. However, it has been observed that seismicty near Jan Mayen and in volcanic areas in general can have a large time variation so a longer recording period might have shown a very different result.

6. Felt earthquakes

From 2006 it is now possible to report felt earthquakes using the internet. On the site www.skjelv.no., questionnaires are available for the public. 6 earthquakes were reported felt during 2006 (see Table 5 and Figure 12). None of the earthquakes reported felt in Norway was felt by a sufficient number of people for questionnaires to be distributed by post.

Table 5: Earthquakes reported felt in the BER database in 2006. 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	11.05.06	14:30		M_c=1.7, M_L=2.0	59.73N / 5.58E	N	N
2	21.05.06	18:13		M_c=2.4, M_L=2.6	66.40N / 13.19E	N	N
3	03.07.06	04.42		M_c=2.1, M_L=2.2	59.97N / 10.62E	N	N
4	19.07.06	20:42		M_c=3.5, M_L=3.3	67.94N / 10.14E	N	N
5	28.10.06	23:48		M_c=3.4, M_L=3.8	76.64N / 22.76E	N	N
6	06.11.06	23:32		M_c=1.7, M_L=2.0	61.83N / 6.40E	N	N

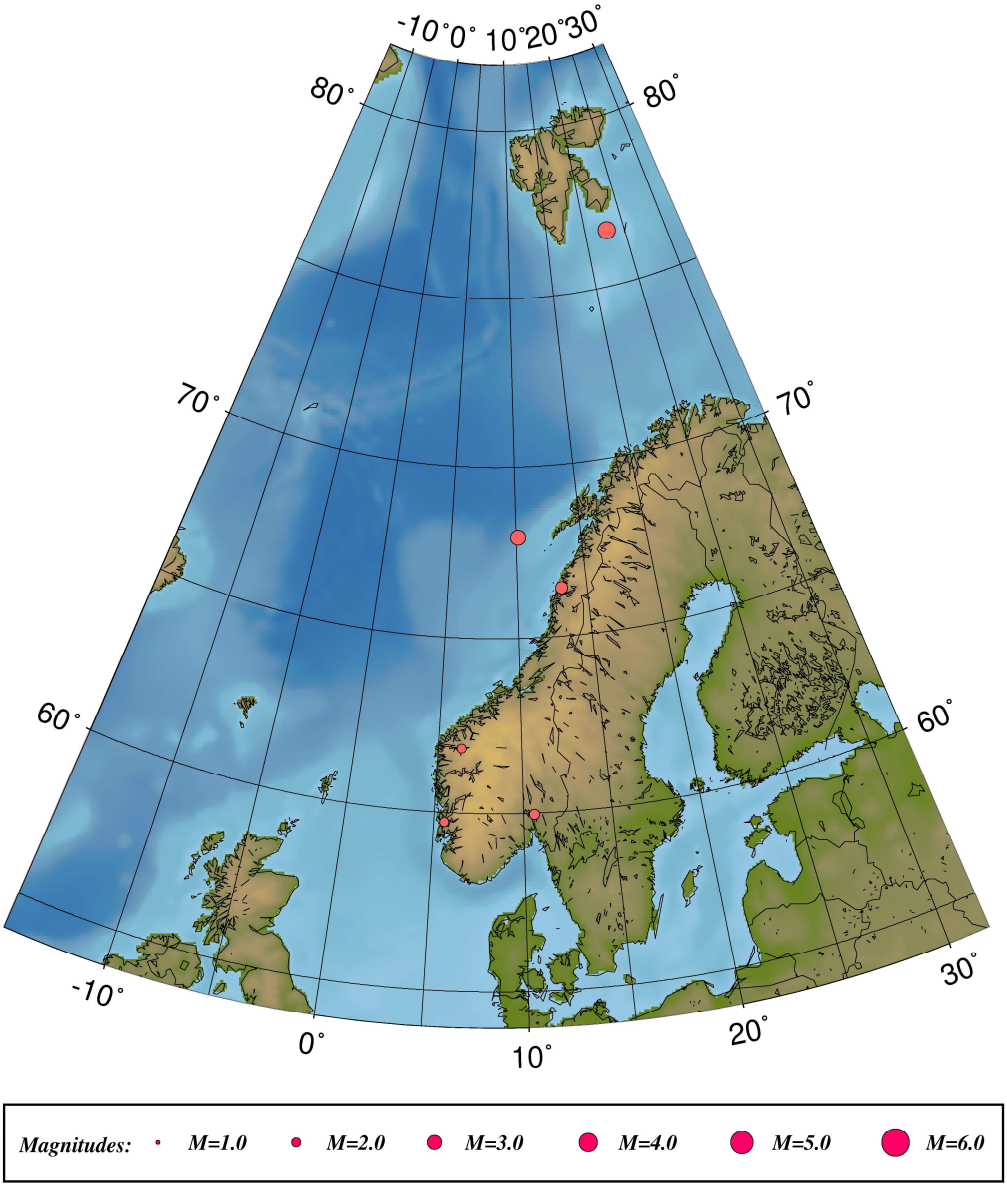

Figure 12: Location of the 6 earthquakes reported felt during 2006.

8. Use of NNSN data during 2006.

Data collected by Norwegian seismic stations are made available through the Internet and are provided on request to interested parties. The use and publication of this data is beyond our control.

Publications and reports.

Atakan, K., and Ojeda, A. 2006. Stress transfer in the Storegga area, offshore mid-Norway. *Marine and Petroleum Geology*, Vol 22/1-2, 161-170.

Havskov J. and M.B. Sørensen (2006): New coda magnitude scales for mainland Norway and the Jan Mayen region. NNSN technical report no.19.

Ivković A. (2006): Seismic swarms in the Steigen-Rana area in the period 1980- 2006. NNSN technical report no.23.

Novak D. (2006): Seismicity in time and space for one year in the Stokvågen area, Northern Norway. NNSN technical report no.22.

Ringdal F., T. Kværna, S. Mykkeltveit, S. Gibbons and J. Schweitzer: Basic research on seismic and infrasonic monitoring of the European Arctic
28th Seismic Research Review: Ground-based nuclear explosion monitoring technologies. Orlando, Florida, September 19 - 21, 2006, LA-UR-06-5471, Proceedings, CD Version file 7 - 06,Volume 2, 1017-1027.

Sørensen, M. B.: Challenges in seismic hazard assessment. Analyses of ground motion modelling and seismotectonic sources.
Dissertation for the degree of philosophiae doctor (PhD), University of Bergen, Norway, 2006,

Oral and poster presentations

Bungum, H. : Jordskjelv i Norge - Hva vet vi og hva gjør vi? Norges Tekniske Vitenskapsakademi, Oslo, 15 Mar 2006

J. Schweitzer: Array Seismology
NIEP, Bucharest, 16 October 2006 (invited lecture)

J. Schweitzer and T. Kværna: Infrasound observations of two meteor impacts with arrays and single stations. AG Seismologie, Haidhof, October 2006

J. Schweitzer, A. Levshin, Ch. Weidle, N. Maercklin, N. Shapiro and M. Ritzwoller: Surface wave tomography of the European Artic 66. Jahrestagung der Deutschen Geophysikalischen Gesellschaft, Bremen 6. - 9. März 2006, (poster)

J. Schweitzer, A. Levshin, Ch. Weidle, N. Maercklin, N. Shapiro and M. Ritzwoller: Surface wave tomography of the European Artic. 1st ECEES, Geneva September 2006 (poster)

J. Schweitzer and F. Ringdal: Infrasound observations in Northern Fennoscandia 66. Jahrestagung der Deutschen Geophysikalischen Gesellschaft, Bremen 6. - 9. März 2006

J. Schweitzer, F. Ringdal and T. Kværna: Seismic and infrasonic observations in Northern Fennoscandia. 1st ECEES, Geneva, September 2006

F. Krüger and J. Schweitzer: Crust and upper mantle structure of northernmost Fennoscandia. 1st ECEES, Geneva, September 2006 (poster)

D. Kühn, J. Schweitzer, T. Dahm and F. Krüger: Momententensorinversion regionaler Ereignisse in Fennoskandien und benachbarten Gebieten 66. Jahrestagung der Deutschen Geophysikalischen Gesellschaft, Bremen 6. - 9. März 2006.

T. Kværna, J. Schweitzer, F. Ringdal and S. J. Gibbons: Data processing and analysis of infrasound signals in Fennoscandia and NW Russia
37th Nordic Seminar on Detection Seismology, Iceland, August 2006

J. Pzybilla, M. Korn, J. Schweitzer and U. Wegler: Acoustic and elastic radiative transfer theory with nonisotropic scattering: applications to a local event in South Norway. EGU, General Assembly, Vienna 2006

F. Ringdal, T. Kværna, S. Mykkeltveit, S. Gibbons and J. Schweitzer: Basic research on seismic and infrasonic monitoring of the European Arctic.
28th Seismic Research Review: Ground-based nuclear explosion monitoring technologies. Orlando, Florida, September 19 - 21, 2006 (poster)

Mathilde B. Sørensen, Steven Gibbons and Jens Havskov. Earthquake activity in the Rana region recorded by a local seismic network and a seismic array. Nordic Detection Seminar, Iceland, September 2006.

Ch. Weidle, A. Levshin, J. Schweitzer, N. Maercklin, N. Shapiro and M. Ritzwoller: Surface wave tomography of the European Artic. EGU, General Assembly, Vienna 2006 (poster)

Ch. Weidle, V. Maupin, J. Schweitzer, A. Levshin and J. Ritter: Regional surface wave tomography for the European Arctic and deployment of KABBA in southern Norway. AG Seismologie, Haidhof, October 2006

8. References

Alsaker A., Kvamme, L.B., Hansen, R.A., Dahle, A. and Bungum, H. (1991): The ML scale in Norway. *Bull. Seism. Soc. Am.*, Vol. **81**, No. 2, pp.379-398.

Brune J.N. (1970): Tectonic stress and spectra of seismic shear waves. *Journal of Geophysical Research*, **75**, 4997-5009.

Grünthal, G. (1998): "European Macroseismic Scale 1998". Cahiers du Centre Européen de Géodynamique et de Séismologie Volume 15, Luxembourg.

Havskov J., and Bungum, H. (1987): Source parameters for earthquakes in the northern North Sea. *Norsk Geologisk Tidskrift*,Vol.**67**, pp 51-58.

Havskov, J. and Ottemöller, L. (1999): SEISAN earthquake analysis software. *Seism. Res. Letters*, Vol. 70, pp. 532-534.

Havskov, J. and Ottemöller, L. (2001): SEISAN: The earthquake analysis software. Manual for SEISAN v. 8.0, Department of Earth Science, University of Bergen, Norway.

Havskov, J. and Sørensen, M.B. (2006): New coda magnitude scales for mainland Norway and the Jan mayen region. *Technical report no. 19.*

Hicks, E.C., Bungum, H. and Lindholm, C., 2000b. Seismic activity, inferred crustal stresses and seismotectonics in the Rana region, Northern Norway, Quarternary Science Reviews, 19, 1423-1436.

Kanamori, H. (1977): The energy release in great earthquakes. *Journal of Geophysicsl Research* 82; 20, pp. 2981-2987.

Karnik, V., Kondorskaya, N.V., Riznichenko, Y. V., Savarensky, Y. F., Solovev, S.L., Shebalin, N.V., Vanek, J. and Zatopek, A. (1962): Standardisation of the earthquake magnitude scales. *Studia Geophys. et Geod.*, Vol. **6**, pp. 41-48.

Kennett, B.L.N. and Engdahl, E.R. (1991): Traveltimes for global earthquake location and phase identification. *Geophys. J. Int.*, Vol. **105**, pp. 429-465.

Kradolfer, U. (1996): AuroDRM – The First Five Years. *Seismological Research Letters,* vol. 67, no. 4, 30-33.

Lienert, B.R. and Havskov, J. (1995): HYPOCENTER 3.2 A computer program for locating earthquakes locally, regionally and globally. *Seismological Research Letters*,
Vol. **66**, 26-36.

Moreno, B, Ottemöller, L., Havskov, J. and Olesen, K.A. (2002): Seisweb: A Client-Server-Architecture-Based Interactive Processing Tool for Earthquake Analysis. *Seism. Res. Letters.* Vol.73, No.1.

Ottemöller, L. (1995): Explosion filtering for Scandinavia. *Technical Report* No. **2**, Institute of Solid Earth Physics, University of Bergen, Norway.

Sørensen, M. B., Ottemöller, L., Havskov, J., Atakan, K., Hellevang, B. And Pedersen, R. B. (in prep.): Tectonic processes in the Jan Mayen Fracture Zone based on earthquake occurrence and bathymetry, manuscript in preparation.

Sørnes A. and Navrestad, T. (1975): Seismic survey of Jan Mayen. *Norsk Polarinstitutt*, Årbok 37-52.

Veith K.F., and Clawson, G.E. (1972): Magnitude from short-period P-wave data. *Bull. Seism. Soc. Am.*, Vol. **62**, pp.435-452.

Westre S. (1975): Richter's lokale magnitude og total signal varighet for lokale jordskjelv på Jan Mayen. *Cand. real thesis*., Seismological Observatory, University of Bergen, Norway.