

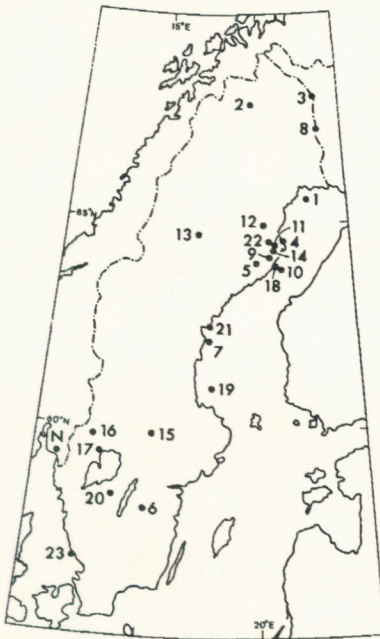
Research Papers

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Forskningsrapporter

Macroseismic observations in Sweden 1991–1995

Ota Kulhánek and Rutger Wahlström



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ABSTRACT

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Macroseismic data from 23 earthquakes in Sweden, one of them felt only in Finland, and from one earthquake in Norway, felt also in Sweden, in the period 1991–1995 were collected and analysed. About 60% of the earthquakes took place in the three most northerly provinces of Västerbotten (9 events), Norrbotten (3) and Lappland (2). Maximum intensity and, where data so permit, radius of perceptibility, focal depth, macroseismic magnitude and an isoseismal map are presented. The two largest earthquakes occurred in Lappland on January 5, 1993, max. intensity V–VI (MM-scale) and Kattegat on October 4, 1995, max. intensity VI, both with a magnitude, M_L (UPP), of 4.0 and a radius of perceptibility of more than 100 km. Intensity VI corresponds to an estimated total peak ground acceleration of 8% g.

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INTRODUCTION

During the 5-year period 1991–1995, 23 instrumentally recorded earthquakes located in Sweden were felt (Table 1; Fig. 1). One of the earthquakes, No 3, was only felt in Finland. One earthquake, No N, located on the Norwegian side of the southernmost Sweden–Norway border, has felt reports from both countries. The average number of 4–5 annually felt earthquakes has been the same for many years (see Kulhánek and Wahlström, 1981, 1985, 1992).

14 of the events occurred in the northerly provinces of Västerbotten, Norrbotten and Lappland. The largest events occurred near Vilhelmina, Lappland (No 13) and in Kattegat (No 23), both with magnitude, M_L (UPP)=4.0 and felt over areas with an average radius of more than 100 km. With a maximum intensity of V–VI and VI (MM-scale), respectively, the peak ground acceleration from these events is estimated at 5% g and 8% g, respectively (Trifunac and Brady, 1975). Another four events reached magnitudes of 3.5–3.6.

From maximum intensity, I_0 (MM scale), and radius of perceptibility, r_p (km), the focal depth, h (km), and macroseismic magnitude, M_M (UPP), are calculated from relations established for the Fennoscandian shield by Korhonen and Ahjos (1979):

$$I_0 - 2.5 = 4 \log \frac{\sqrt{r_p^2 + h^2}}{h} \quad (1)$$

and Wahlström and Ahjos (1984):

$$M_M(\text{UPP}) = 0.38 + 1.14 \log r_p + 0.23 I_0 \quad (2)$$

respectively. This was possible in 10 cases. Table 1 summarizes the instrumental and macroseismic parameters for each studied earthquake.

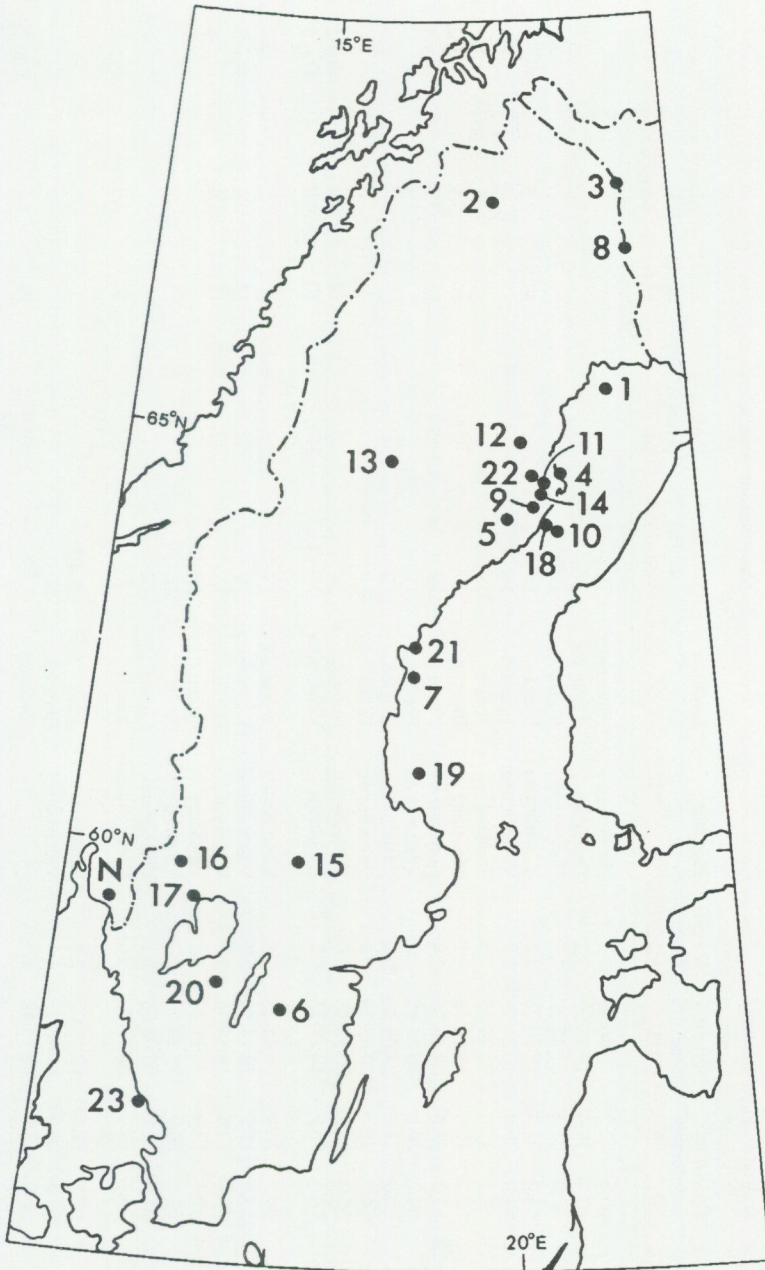


Fig. 1. Epicenters of earthquakes felt in Sweden 1991-1995. Enumeration follows Table 1.

TABLE 1. Instrumental and macroseismic parameters of earthquakes in Sweden recorded and felt in 1991–1995

Event No.	Date	Instrumental parameters				Macroseismic parameters						
		Epicentral coordinates °N °E		Origin time GMT	Magnitude M_L (UPP)	Province	Location	Max felt intensity MM, 1956	Radius of perceptibility km	Focal depth km	Magnitude M_M (UPP)	Isoseismal map
1	Jun. 6, 1991	65.6	22.7	12 46 13	3.6	Norrbottn	Hindersön	III				
2	Jun. 13	67.8	19.6	10 48 23	3.2	Lapland	Ratekjokk	IV				
3	Jul. 13	68.0	23.4	01 42 22	2.7	Norrbottn	Ruosteranta	IV ¹⁾				
4	Sep. 23	64.6	21.4	19 20 28	3.5	Västerbottn	Bureå	IV	91 ²⁾	42	3.5	Fig. 2
5	Oct. 28	64.0	19.9	16 21 29	2.9	Västerbottn	Tavelsjö	IV–V				
6	Nov. 8	58.1	15.0	01 20 35	2.5	Småland	Tranås	IV				
7	Dec. 15	62.2	17.6	15 18 49	3.1	Medelpad	Björkö	V	41 ²⁾	19	3.1	Fig. 3
8	Jan. 10, 1992	67.2	23.6	07 46 36	2.9	Norrbottn	Pajala	IV	35 ²⁾	16	3.1	Fig. 4
9	Apr. 16	64.2	20.6	10 21 43	2.8	Västerbottn	Botsmark	IV				
10	May 22	63.9	21.2	23 06 28	3.1	Västerbottn	Bygdeå	IV				
11	Aug. 11	64.5	21.0	20 43 19	2.6	Västerbottn	Vallen	IV				
12	Nov. 3	65.0	20.3	00 12 46	3.0	Västerbottn	Boliden	IV	26	12	2.9	Fig. 5
13	Jan. 5, 1993	64.7	16.9	10 19 35	4.0	Lapland	Vilhelmina	V–VI	113 48(IV) ³⁾	20	4.0	Fig. 6
14	Feb. 15	64.3	20.9	08 44 25	2.6	Västerbottn	Vebomark	IV				
15	Apr. 11	59.9	15.2	20 14 59	2.7	Västmanland	Kopparberg	IV	28	13	2.9	Fig. 7
16	Nov. 12	59.8	12.6	19 54 36	3.3	Värmland	Gunnarskog	V	47	11	3.4	Fig. 8
17	Feb. 11, 1994	59.4	12.9	00 11 20	2.2	Värmland	Grums	III–IV				
18	Sep. 30	64.0	20.9	23 32 40	2.7	Västerbottn	Sävar	III–IV				
19	Nov. 30	61.0	17.8	00 08 05	2.1	Hälsingland	Ljusne	IV				
20	Feb. 1, 1995	58.4	13.6	21 33 00	3.6	Västergötland	Axvall	V	39 17(IV) ³⁾	9	3.3	Fig. 9
21	Feb. 22	62.5	17.6	12 42 09	2.5	Medelpad	Alnö	II–III				
22	Apr. 17	64.6	20.6	13 48 13	3.6	Västerbottn	Burträsk	V				
23	Oct. 4	56.8	12.2	20 49 42	4.0		Kattegat	VI ²⁾	103 ²⁾	19	4.1	Fig. 10
N	Feb. 19, 1992	59.3	11.0	06 39 32	3.7	Norway ⁴⁾	Sarpsborg	IV–V	77 ²⁾	26	3.6	Fig. 11

¹⁾ Reported felt only in Finland.²⁾ Estimate due to epicenter location offshore, near coast or near national border.³⁾ Radius of perceptibility corresponding to intensity IV.

FELT EARTHQUAKES

JUNE 6, 1991, HINDERSÖN, NORRBOTTEN

A strong earthquake occurred on the afternoon on June 6, 1991, near Hindersön in the offshore area of Norrbotten. 25 questionnaires were collected by the department, however the felt intensity could be estimated only at Hindersön (III) and Ryssbält (III). The scarcity of positive reports is evidently due to the offshore location of the epicenter.

JUNE 13, 1991, RATEKJOKK, LAPPLAND

A strong earthquake took place in western Lappland on the early afternoon of June 13, 1991. Since this shock occurred in a rather sparsely populated part of Sweden, the shock was felt only at two localities, Puoltsa (III) and Ratekjokk (IV). A medium-size aftershock followed the main shock after approximately two hours. The aftershock was not felt.

JULY 13, 1991, RUOSTERANTA, NORRBOTTEN

On the early morning of July 13, 1991, a medium-size earthquake occurred in Norrbotten near the Sweden-Finland border. The instrumental location is near Ruosteranta, Norrbotten. The quake was felt in Finland at Hetta and Palojoensuu. From the Swedish part of the epicentral area no reports were received.

SEPTEMBER 23, 1991, BUREÅ, VÄSTERBOTTEN

A strong earthquake took place on the evening of September 23, 1991, in the central coastal part of Västerbotten. The department received 121 questionnaires, 68 of them with positive descriptions of felt effects. The quake was felt only in the coastal section of the province, around the city of Skellefteå. In spite of the high magnitude of 3.5, the maximum felt intensity was only of degree IV, as reported from several localities. The area over which the earthquake was generally perceptible is well defined by the collected macroseismic information and displayed in Fig. 2. Also exhibited is the area of felt intensity IV. The macroseismic field shown in Fig. 2 makes it possible to estimate the focal depth of this earthquake. As can be deduced from the figure, the area of perceptibility is about $13,000 \text{ km}^2$. The instrumental epicenter is located close to the coast-line. In order to be able to use eqs. (1) and (2), for the focal-depth and magnitude estimates, we consider a circular area twice as large as that determined from received questionnaires. This gives a radius of perceptibility, r_p , of 91 km. Introducing r_p into eqs. (1) and (2) provides a focal depth of 42 km and a magnitude, $M_M(\text{UPP})$, of 3.5. A similar, relatively large, focal depth has been observed for sev-

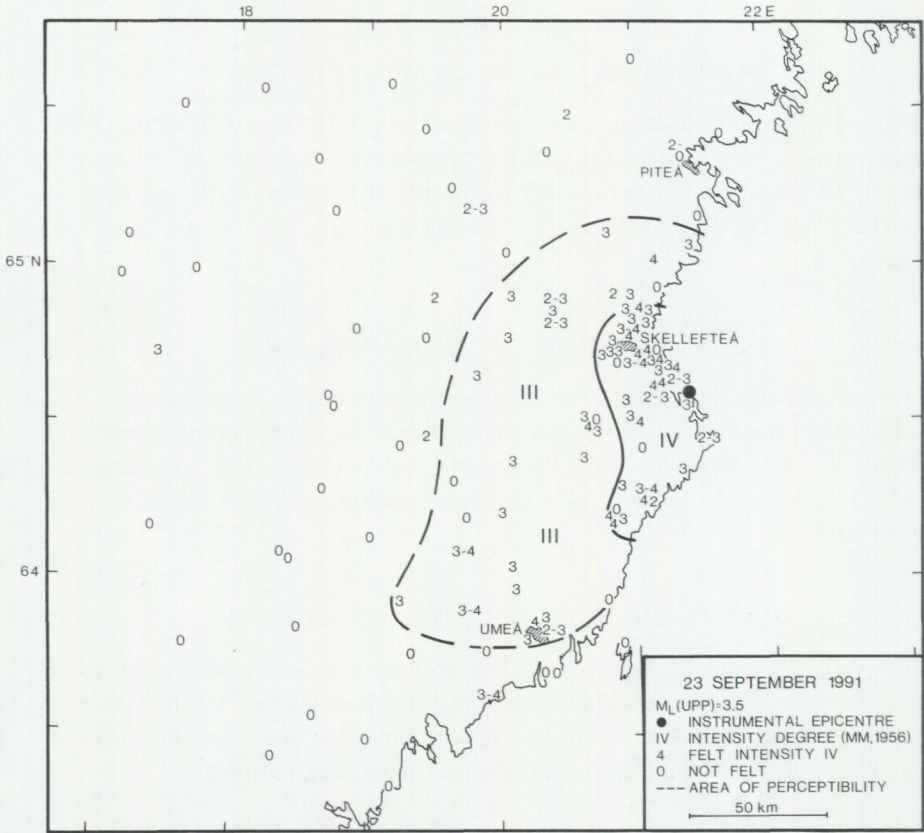


Fig. 2. Intensity distribution of the Bureå earthquake of September 23, 1991. In this and the following figures (No 2-11), numerals indicate intensity on the Modified Mercalli (MM) 1956 scale, the dashed line limits the estimated area of perceptibility and the solid line (optional) limits the area of intensity IV and more.

eral other Swedish earthquakes. The focal depth explains the discrepancy between the high magnitude and low maximum felt intensity obtained for this particular shock.

OCTOBER 28, 1991, TAVELSJÖ, VÄSTERBOTTEN

A medium-size earthquake was felt on the late afternoon of October 28, 1991, around Tavelsjö in Västerbotten. 20 questionnaires were collected. They were analysed together with a description of the earthquake in the local newspaper. Positive reports came from Ånäset (III), Ersmark (III), Gravmark (II), Rödånäs (III), Stöcke (III), Tavelsjö (IV-V), Vindelånäset (II) and V. Norrfors (III). No isoseismal map was drawn.

NOVEMBER 8, 1991, TRANÅS, SMÅLAND

A medium-size shock occurred on the early morning of November 8, 1991, in the vicinity of Tranås, where the shock was felt with the intensity of III–IV. 34 questionnaires were received at the department. Positive reports provide the following intensities: Åbonäs (III), Aneby (III), Asby (IV), Flisby (IV), Lövängen (II), Malexander (III), Österbymo (II), Sommen (III–IV), Svalsjö (II) and Tranås (III–IV). No isoseismals were drawn.

DECEMBER 15, 1991, BJÖRKÖN, MEDELPAD

A strong earthquake took place offshore southern Medelpad in the afternoon of December 15, 1991. 52 questionnaires have been collected. Positive reports were received from Ås (II), Åstön (II–III), Bergsjö (IV), Ede (III), Gnarp (III–IV), Harmånger (III), Juniskär (III–IV), Kölsjön (III), Kvissleby (III–IV), Matfors (III), Norrböle (III), Ovensjö (III–IV), Skedlo (III–IV), Söråker (III), Stocka (III–IV), Strömbacka (III), Strömsbruk (III), Sundsvall (IV) and Svedje (III). The portion of the macroseismic field on land covers an area of 2700 km² (Fig. 3). Assuming that the total macroseismic field is twice this size, we have the corresponding radius of perceptibility of 41 km. Introducing this value into eqs. (1) and (2) yields a focal depth of 19 km and $M_M(\text{UPP}) = 3.1$.

JANUARY 10, 1992, PAJALA, NORRBOTTEN

A medium-size earthquake occurred on the morning of January 10, 1992, in the vicinity of Pajala, in the Sweden–Finland border region of the province of Norrbotten. From the Swedish side, we collected 21 reports. The positive answers are the following: Aareavaara (III), Erkheikki (III), Kassa (III), Kaunisvaara (III), Käymäjärvi (III), Pajala (IV), Sattajärvi (III) and Tärendö (III). We also have access to four reports from the Finnish border city of Kolari (IV). The Swedish part of the macroseismic field is displayed in Fig. 4. On the Swedish side, the quake was felt over an area of almost 2000 km². Assuming that the total area of perceptibility is about twice this size, we obtain a radius of perceptibility of 35 km. Introducing this value into eqs. (1) and (2), we estimate the focal depth of this shock to be about 16 km and $M_M(\text{UPP})$ to be 3.1.

APRIL 16, 1992, BOTSMARK, VÄSTERBOTTEN

A medium-size shock was felt on the early afternoon of April 16, 1992, within a limited area of Västerbotten, north of Umeå. Altogether, 14 reports were received. The earthquake was felt in Åkullsjön (III), Bygdeå (III), Flurkmark (III–IV), Gravmark (IV), Mickelsträsk (III), Ratu (III), Robertsfors (II), Sjulsmark (III), Tålsmark (II) and

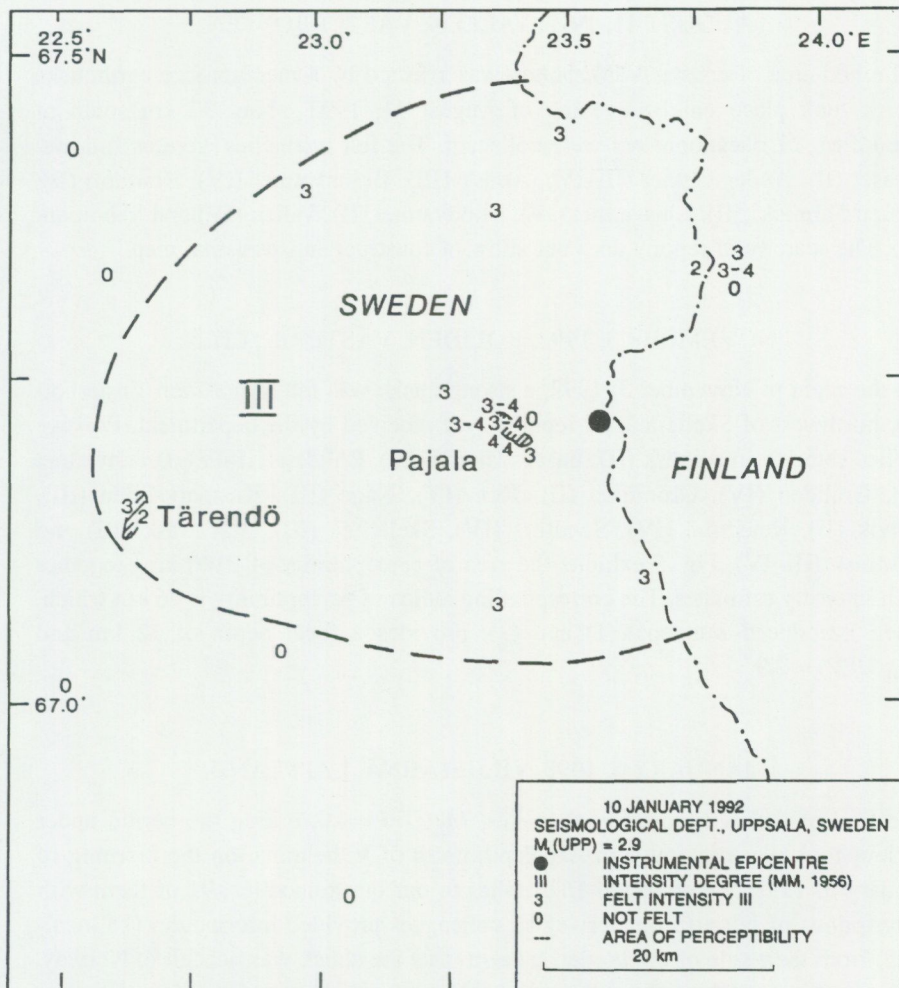


Fig. 4. Intensity distribution of the Pajala earthquake of January 10, 1992.

Ytterträsk (IV). With respect to the scarcity of data, no isoseismal map has been drawn.

MAY 22, 1992, BYGDEÅ, VÄSTERBOTTEN

On the night to May 23 (May 22 GMT), 1992, a strong earthquake occurred offshore the province of Västerbotten. From 17 localities we received answers to our questionnaires. Positive answers came from Bygdeå (III), Rödjtjärn (IV), Sandåsen (III) and Umeå (III-IV). The scarcity of observations and the low felt maximum intensity can be explained by the epicentral location. No isoseismal map was drawn.

AUGUST 11, 1992, VALLEN, VÄSTERBOTTEN

A limited area of coastal Västerbotten was affected by a medium-size earthquake which took place on the evening of August 11, 1992, about 30 km south of Skellefteå. 21 questionnaires were collected. The felt intensities were as follows: Ånäset (II), Andersvattnet (III–IV), Åträsk (III), Brännvattnet (IV), Brattjärn (II), Gamla Falmark (III), Ljusvattnet (IV), Mjödvattnet (II), Vallen (IV) and Vebomark (II). The scarcity of reports does not allow to construct an isoseismal map.

NOVEMBER 3, 1992, BOLIDEN, VÄSTERBOTTEN

On the night to November 3, 1992, a strong quake was felt in northern Västerbotten, northwest of Skellefteå. 37 reports were received by the department. Positive replies came from Åsträsk (II), Bastuträsk (III–IV), Boliden (III–IV), Brännvattnet (II), Grålidén (IV), Grönliden (II), Jörn (IV), Kåge (III), Kusmarksliden (III), Ostvik (II), Renström (IV), Sandfors (IV), Skellefteå (III), Stavaträsk (III) and Vänträsk (III–IV). Fig. 5 exhibits the area of perceptibility of 2100 km² together with intensity estimates. The corresponding radius of perceptibility is 26 km which, when introduced into eqs. (1) and (2), provides a focal depth of 12 km and $M_M(\text{UPP}) = 2.9$.

JANUARY 5, 1993, VILHELMINA, LAPPLAND

The first of the two largest earthquakes, $M_L(\text{UPP})=4.0$, during the period under review, took place in southern Lappland, north of Vilhelmina, on the morning of January 5, 1993. We collected 167 replies to our questionnaires, 91 of them with descriptions of felt effects. Norwegian colleagues provided information (15 localities) from their side of the border. It seems that the shock was not felt in Norway. A thorough search through local newspapers was carried out and acquired new data were included in the analysis. Intensity estimates are exhibited in Fig. 6. As follows from the figure, the macroseismic field covered a vast area of 40,000 km², whereas intensity IV and greater was felt within an area of 7100 km². The macroseismic field is somewhat elongated in the east–west direction. The ground shaking was felt with intensity greater than IV in Bäcksjö and Risträsk, where cans and packets fell off shelves, in Vilhelmina, where laundry appliances moved, and in Åsele, where smaller cracks appeared in several walls. It follows from Fig. 6 that the mean radius of the area of perceptibility is 113 km and that of intensity IV is 48 km. Introducing the former into eqs. (1) and (2), we obtain a focal depth of 20 km and $M_M(\text{UPP}) = 4.0$.

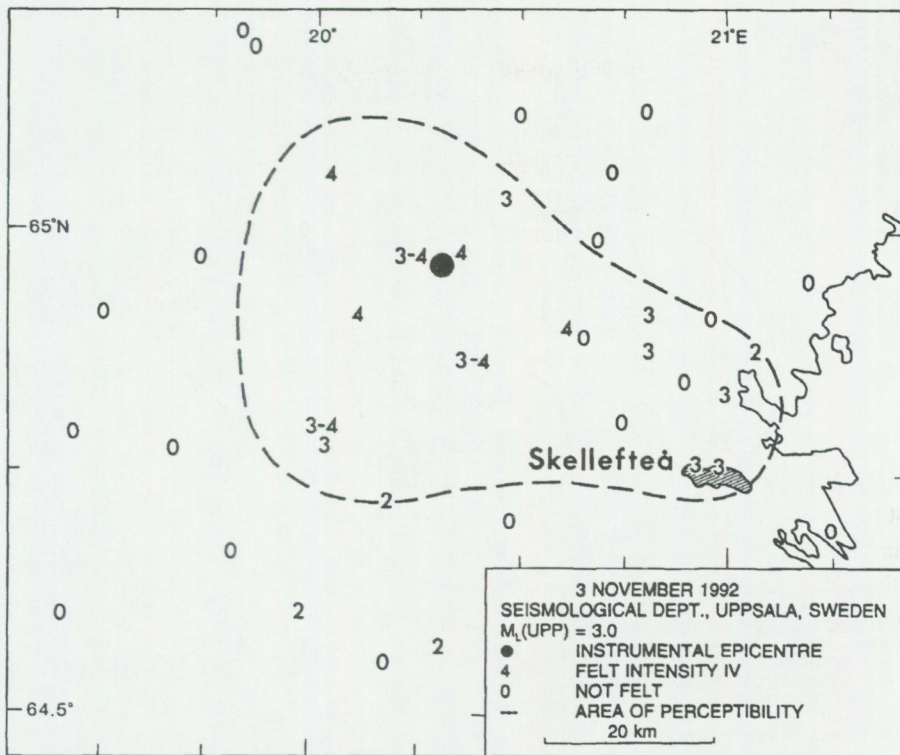


Fig. 5. Intensity distribution of the Boliden earthquake of November 3, 1992.

FEBRUARY 15, 1993, VEBOMARK, VÄSTERBOTTEN

A medium-size earthquake occurred on the morning of February 15, 1993, in the coastal area of Västerbotten. Written reports were received from 16 localities. Only five of them indicated felt effects. These were Brände (III), Burträsk (II), Flarken (III), Smårödningen (III) and Vebomark (IV). Due to the scarcity of data no isoseismal map was drawn.

APRIL 11, 1993, KOPPARBERG, VÄSTMANLAND

On the evening of April 11, 1993, a medium-size earthquake was felt within an area of 2400 km² in the province of Västmanland. The department collected 92 questionnaires of which 63 described the effects felt by the inhabitants of the epicentral area. The macroseismic information is presented in the map in Fig. 7. The corresponding radius of the area of perceptibility is 28 km, and we obtain from eqs. (1) and (2) a focal depth of 13 km and $M_M(\text{UPP}) = 2.9$.

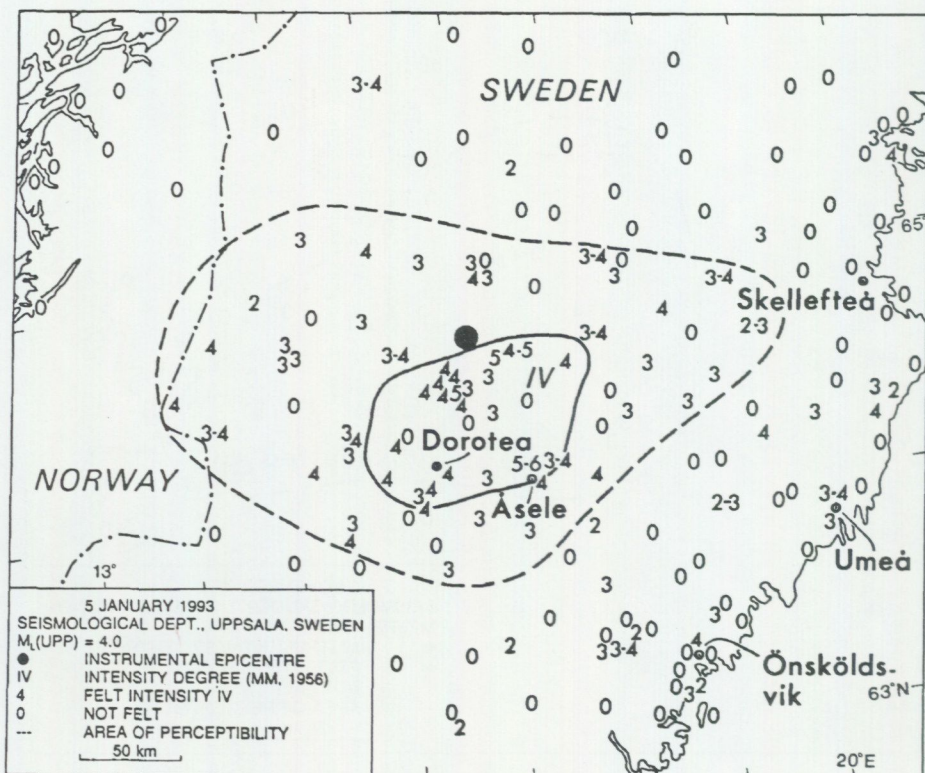


Fig. 6. Intensity distribution of the Vilhelmina earthquake of January 5, 1993.

NOVEMBER 12, 1993, GUNNARSKOG, VÄRMLAND

On the evening of November 12, 1993, a strong earthquake was felt around Gunnarskog in western Värmland. We received 90 replies to our questionnaires, including also several reports from the Norwegian side of the border. The quake was felt with the highest intensity of V in Tobol, near Gunnarskog, where fissures in plaster were observed. The collected macroseismic information is shown in Fig. 8. The area of perceptibility is 6900 km², corresponding to a radius of 47 km. Making use of eqs. (1) and (2), we obtain a focal depth of 11 km and $M_M(UPP) = 3.4$.

FEBRUARY 11, 1994, GRUMS, VÄRMLAND

A weak quake was felt around Grums in western Värmland on the night to February 11, 1994. 37 reports were collected by the department. Positive descriptions came

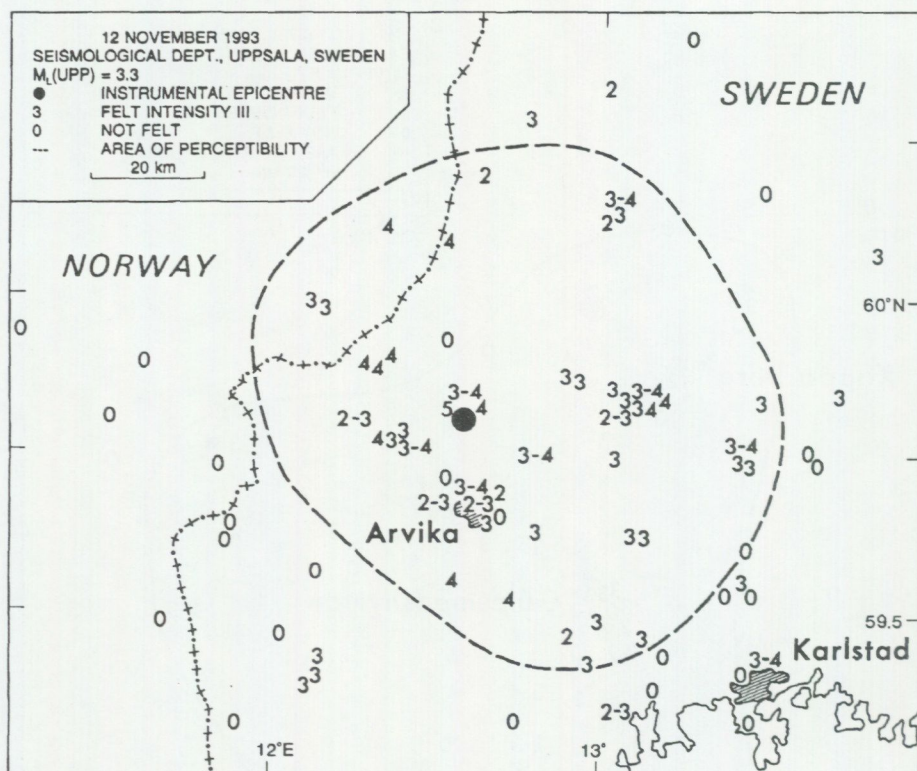


Fig. 8. Intensity distribution of the Gunnarskog earthquake of November 12, 1993.

from Ask (III), Borgvik (III), Flokerud (III), Glava (III), Grums (III), Karlstad (III), Liljedal (III), Skärmnäs (II), Södra Fjöle (II–III), Stavnäs (III) and Värmlands Nysäter (III–IV). Available macroseismic data is scarce and hence no macroseismic map was drawn.

SEPTEMBER 30, 1994, SÄVAR, VÄSTERBOTTEN

On the night to October 1 (September 30 GMT), 1994, a medium-size earthquake occurred offshore Västerbotten. It was felt in a limited area around Sävar, north of Umeå. Only ten reports reached the department. The quake was reported felt in Anumark (III), Dalkarlså (II–III), Sävar (III–IV) and Umeå (III). No macroseismic map was constructed.

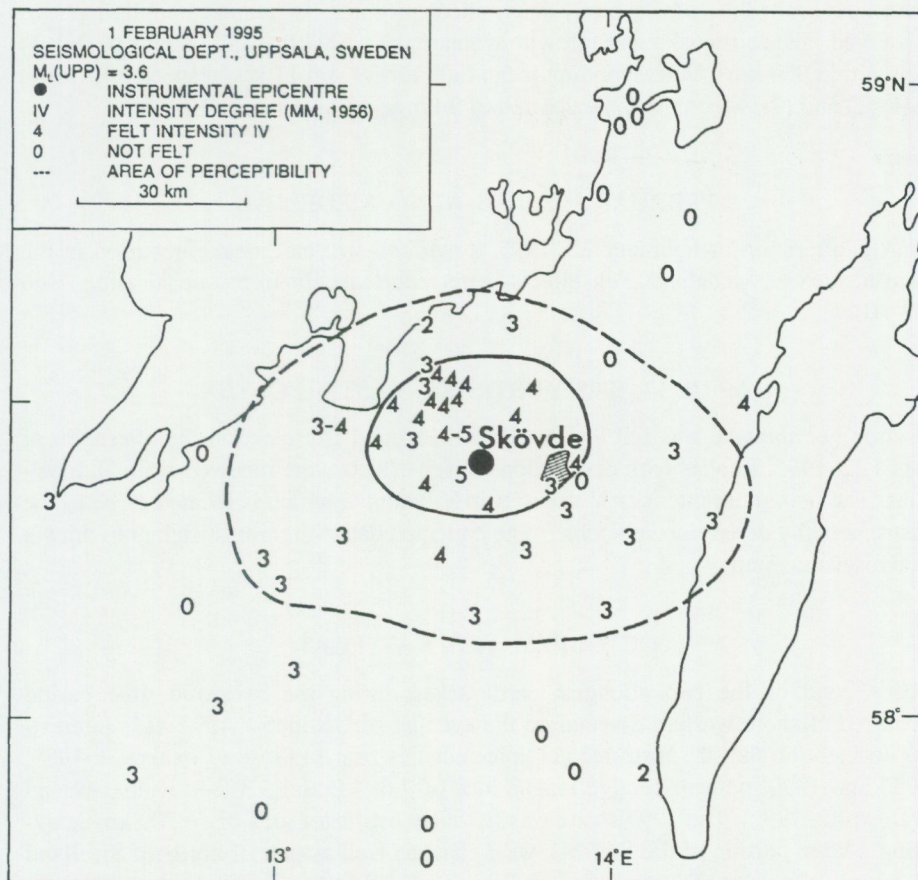


Fig. 9. Intensity distribution of the Axvall earthquake of February 1, 1995.

NOVEMBER 30, 1994, LJUSNE, HÄLSINGLAND

A weak earthquake took place offshore southern Hälsingland on the night to November 30, 1994. The shock was felt in a limited coastal area around Ljusne and Vallvik. Intensity information from 14 localities were collected. Positive answers were received from Ljusne (IV), Tönnebro (III) and Vallvik (II-IV). No macroseismic map was drawn.

FEBRUARY 1, 1995, AXVALL, VÄSTERGÖTLAND

A strong earthquake was felt in the area between Lake Vänern and Lake Vättern on the evening of February 1, 1995. 111 reports together with newspaper descriptions of the quake were analysed. The resulting macroseismic information is presented in the macroseismic map in Fig. 9. Maximum intensity of degree V was reported from

Axvall, close to the instrumentally determined epicenter. No damage to buildings was observed. The earthquake was felt within an area of 4700 km² while intensity IV was felt within 900 km². Corresponding mean radii are 39 and 17 km, respectively. From eqs. (1) and (2), we obtain a focal depth of 9 km and $M_M(\text{UPP}) = 3.3$.

FEBRUARY 22, 1995, ALNÖ, MEDELPAD

On the afternoon of February 22, 1995, a medium-size earthquake occurred in the coastal area of Medelpad. Felt effects were reported only from one locality, Alnö (II–III).

APRIL 17, 1995, BURTRÄSK, VÄSTERBOTTEN

A strong earthquake was felt in Västerbotten, around Burträsk, on the afternoon of April 22, 1995. Replies with descriptions of felt effects were received from 38 localities. The maximum intensity V was felt in Villvattnet, which is located close to the instrumentally determined epicenter. The collected data were not sufficient to draw a macroseismic map.

OCTOBER 4, 1995, KATTEGAT

The second of the two strongest earthquakes during the reviewed time period occurred offshore western Sweden on the evening of October 4, 1995. It is interesting to mention that the instrumental epicenter lies near to those of quakes in 1985, 1986 and 1990, with respective magnitudes of 4.6, 4.2 and 3.3 (see Kulhánek and Wahlström, 1992). The 1995 shock was felt in an estimated area of 16,700 km², covering a large portion of the Swedish west coast as well as part of northern Sjaelland (Denmark). Intensity IV and larger was observed within an area of almost 2000 km². 157 questionnaires and a number of relevant newspaper articles were collected by the department. The acquired macroseismic information is displayed in Fig. 10. Inhabitants in the epicentral area described vibrations similar to the passing of a heavy truck, furniture was moved and some thought their furnaces exploded. Minor damage (fissures in the plaster, part of a roof falling down) was reported from Skogstorp. By assuming the total area of perceptibility to be twice the one estimated above (see Fig. 10), a radius of perceptibility of 103 km is obtained. Due to the offshore epicenter, we assume the maximum intensity to be one degree higher than the maximum observed intensity, i.e., we put $I_0=VI$. Introducing these entries into eqs. (1) and (2) gives a focal depth of 19 km and $M_M(\text{UPP}) = 4.1$.

FEBRUARY 19, 1992, SARPSBORG, NORWAY

On the morning of February 19, 1992, a strong earthquake took place on the Norwegian side of the southernmost Sweden–Norway border region, in the vicinity of Sarpsborg–Fredrikstad. The quake was extensively felt on both sides of the border.

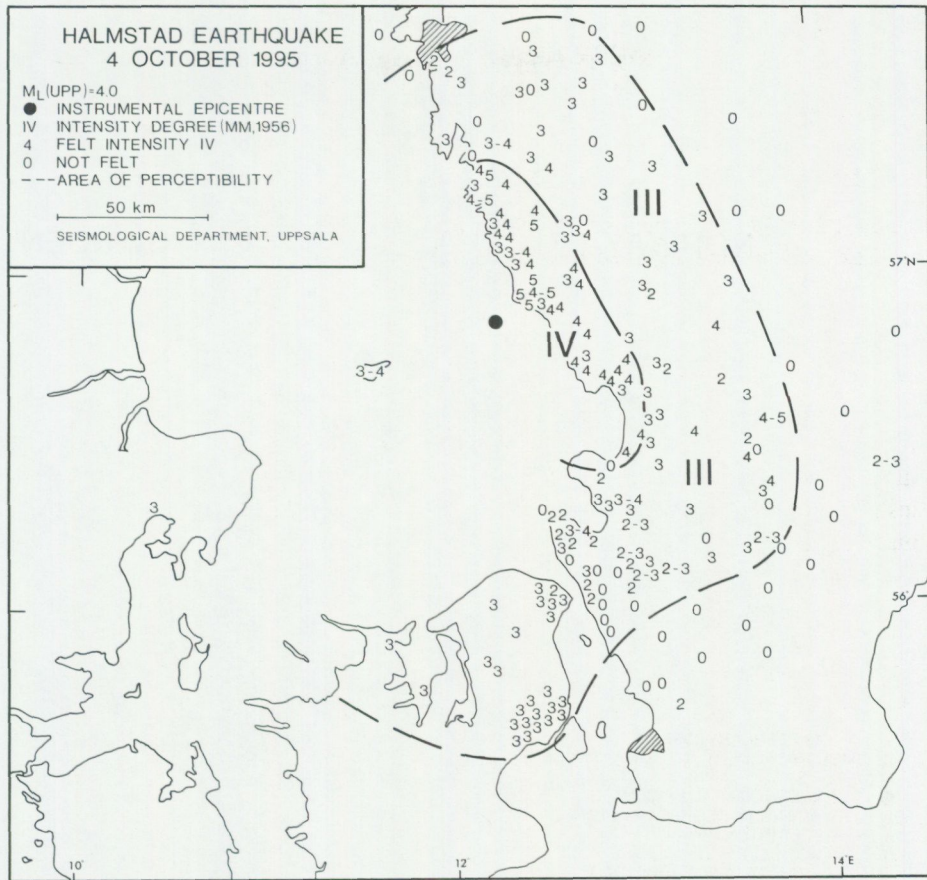


Fig. 10. Intensity distribution of the Kattegat earthquake of October 4, 1995.

We collected 143 questionnaires with reports covering the Swedish section of the macroseismic region and we were further supported by 116 reports covering the Norwegian side. We also evaluated descriptions presented in local newspapers. Results of our analysis are exhibited in the macroseismic map in Fig. 11. The highest intensity of degree IV-V was observed at Strömstad, about 30 km south of the instrumentally determined epicenter. In Sweden, the earthquake was felt over an area of 6200 km². Assuming that the total area of perceptibility is about three times this area (see Fig. 11), we arrive at a radius of perceptibility of 77 km. Introducing this into eqs. (1) and (2) gives an estimate of the focal depth of about 26 km and of $M_M(\text{UPP})$ of 3.6.



Fig. 11. Intensity distribution of the Sarsborg, Norway earthquake of February 19, 1992.

FELT EVENTS, POSSIBLY EARTHQUAKES

The Seismological Department, Uppsala University, receives many reports of suspected domestic earthquakes. Besides the instrumentally confirmed earthquakes (Table 1), many reports relate to other types of phenomena, such as military and industrial chemical explosions, rockbursts in mining areas, sonic booms from airplanes, frost chirps at rapid decrease of temperature in wintertime, etc. Many reported events remain unidentified, however, and can not be excluded as possible earthquakes, even if there is reason to believe that most of them have no seismic origin. The unidentified events are summarized in Table 2.

TABLE 2. Times and locations of felt, not instrumentally recorded, events, possibly earthquakes, 1991-1995.

Date		Approx. time, h (GMT)	Locality(-ies)/Province(s)		
1991	Jan.	1	22	Årliden-Skellefteå/Västerbotten	
		22	14	Göteborg/Västergötland	
		23	09-10	Göteborg/Västergötland	
	Feb.	14	06	Göteborg/Västergötland	
		Mar.	18	08	Piteå/Norrbottn
	27		08-09	Laholm/Halland; Munka-Ljungby/Skåne	
	Apr.	13	01-03	Uppsala/Uppland	
		19	12	Ulricehamn/Västergötland	
	May	18	00-04	Lövstabruk/Uppland	
	1)	Jul.	23	23-24	15 km SO Kiruna/Lapland
	1)	Jul.	24	00-01	15 km SO Kiruna/Lapland
	Aug.	3	01	Strängnäs/Södermanland	
		20	12	Kovikshamn-Kungälv/Bohuslän	
		22	05	15 km SO Kiruna/Lapland	
	Sep.	4	14	Järvsö/Hälsingland; Våmhus-Mora/Dalarna	
			19	14	Mollaryd, Västergötland
		23	08	V. Frölunda-Göteborg/Västergötland	
		24	08	Öregrund-Vingö-Grisslehamn/Uppland	
		26	10	Ånge/Medelpad	
		29	06	Bureå/Västergötland	
		Oct.	18	05	Burträsk/Västergötland
	Dec.	3	09	Björköby-Nävelsjö/Småland	
			8	08	Nacka-Skurusundet/Södermanland
13		02-03	10 km N Åseda/Småland		
1992	Jan.	8	08	Knukebo-Gränna/Småland	
	Feb.	3	13	Löparö-Vettershaga-Norrälje/Uppland	
		5	08	Fårösund/Gotland	
		9	09	Bygdeå/Västerbotten	
		19	23	Strömstad/Bohuslän	
		24	05	Kungsåra/Västmanland	
		27	15	Figeholm-Oskarshamn-Vånevik- Påskallavik-Mönsterås-Ruda/Småland	
	Mar.	5	09-10	Njurunda/Medelpad	
			18	00	Oskarshamn/Småland
		6	00	Oskarshamn/Småland	
		18	23	Landeryd-Nykil/Östergötland	
	Apr.	8		Alnön/Medelpad	
		9	00	V. Frölunda/Västergötland	
	Jun.	21	11	Örnsköldsvik/Ångermanland	
	Jul.	4	10	Göteborg/Västergötland	
	Aug.	4	09-10	Trosa/Södermanland	
	Sep.	15	21	Uppsala/Uppland	
		18	06-07	Bergthem-Umeå/Västerbotten	
		26	14	Örkelljunga/Skåne	
	Oct.	27	15	10 km V Mellerud/Dalsland	
	Nov.	11	06-07	Nordmaling/Ångermanland	

Table 2. (cont.)

Date	Approx. time, h (GMT)	Locality(-ies)/Province(s)	
	12	13	Vara/Västergötland
	18	24	Märsta/Uppland
	23	12-13	Storbäck/Lappland
1993	Jan. 27	13	Rimbo/Uppland
	29	20	Orsa/Dalarna
	29	21-22	Ljusdal/Hälsingland
	Feb. 3	17, 21	Tobo/Uppland
	Mar. 8	21-22	Strömstad/Bohuslän
	13	17	Vingåker/Södermanland
	15	17	Vingåker/Södermanland
	17	11	Skara/Västergötland
	May 18	23-24	5 km N Växjö/Småland
	Jul. 27	18-20	Boliden/Västerbotten
	Aug. 7	10	Älvsjö/Södermanland
	31	04	Malmö/Skåne
	Sep. 6	08	Haparanda/Norrbottn
	14	12-13	Vänersnäs/Västergötland /S Dalsland
	28	09-10	Hyllie-Malmö/Skåne
	Oct. 2	morning	Forsby-Gävle/Gästrikland
	22	09	Dorotea/Lappland
1)	24	05	Bergshamra-Vettarsö/Uppland
	27	24	Tyresö/Södermanland
	Nov. 9	23-00	Lillselet-N Överkalix/Norrbottn
	10	02-04	Lillselet-N Överkalix/Norrbottn
	15	13	Västorp-E Växjö/Småland
	Dec. 6	14	Färjestaden/Öland
	9	10	Katrineholm
1994	Jan. 7	11-12	10 km N Vårgårda/Västergötland
2)	16	19	Ekeby-Kumla/Närke
	17	01	Högsta-Mattmar/Jämtland
	17	21	Umeå/Västerbotten
	22	23	Arbrå/Hälsingland
	24	17	Storåsen-Föllinge/Jämtland
	Feb. 10	01	Skönsmon/Medelpad
	15	20-22	Karlskoga/Värmland
	23	12	Sollentuna/Uppland
	24	12	Ljusterö/Uppland
	27	10	Kista/Uppland
	Mar. 07	night	Nyteboda/Skåne
	08	05	Linköping-Kimstad/Östergötland
	10	22	Vellinge/Skåne
	12	10	Torö-Nynäshamn/Södermanland
	12	20	Åskilje-Gunnarn/Lappland
	21	06	Torstuna/Uppland
	21	09-10	Alunda/Uppland
	23	03	Alunda/Uppland
	Apr. 9	21	Eskilstuna/Södermanland

Table 2. (cont.)

Date	Approx. time, h (GMT)	Locality(-ies)/Province(s)	
	19	Eringsboda/Blekinge	
	24	Dannemora/Uppland	
May	17	07	Storuman/Lappland
Jul.	21	00	Söderhamn-Hudiksvall/Hälsingland
Aug.	6	11	Ljugarn/Gotland
	16	12-14	Lurö-Hammarön/Värmland
	17	16-17	10 km från Olofström/Blekinge
1)	Sep. 24	22	Karlholmsbruk/Uppland
	27		Torekov/Skåne
	Oct. 7	01	Malmö/Skåne
	10	00	Haninge/Södermanland
	12	08	Hörsjö/Ångermanland
1)	Nov. 21	19-23	Bogen/Värmland
	26	09	Kälarne/Jämtland
	30	23	Vallvik-coast E and N of Söderhamn/ Hälsingland
1)	Dec. 13	09-10	Skelleftehamn/Västerbotten
	22	morning	Östersund/Jämtland
1995	Jan. 2	19	Strömsund/Jämtland
	9	22	Lixerum-Lönneberga/Småland
	17	08	Lindome/Halland- Kålleröd/Västergötland
	19	11	Karesuando/Lappland
Feb.	6	23-24	Avesta/Dalarna
	8	23	Bergendal-Knivsta/Uppland
	9	10	Onsala Peninsula/Halland
	18	morning	Mariannelund/Småland
1)	Apr. 1	23-24	Stockholm/Uppland
	2	03	Gråbo/Västergötland
	3	15	Axvall/Västergötland
	4	22	Stora Skoga/Värmland
	6	15-16	Njurunda/Medelpad
	6	20-21	Ånge/Medelpad
	10	09	Fröstingstorp-Läckeby/Småland
1)	10	09	Vaxholm/Uppland
	15	21	Jönköping/Småland
	19	04-05	Täftefjärden/Västerbotten
May	6	04	Brölletorp-Häggum/Västergötland
	22	03	Gripenberg-Tranås/Småland
	27	09-10	Brämhult/Västergötland
	30	11	Simrishamn/Skåne
Jun.	5	08	Nötön-Piteå/Norrbottn
	22	04	Remsle/Ångermanland
	27	14-15	S of Hova/Västergötland
	28	08-09	S of Hova/Västergötland
Jul.	5	21	Bålsta/Uppland
	12	11	Axvall/Västergötland
Aug.	20	03	Sysne/Gotland
	25	14	Rottneros/Värmland
	27	15	Rottneros/Värmland

Table 2. (cont.)

Date	Approx. time, h (GMT)	Locality(-ies)/Province(s)	
Sep.	3	18-19	Bromma/Uppland
	8	03-04	Slåtered-Mullsjö-Habo/Västergötland
	14	10	Kungsbacka/Halland
Oct.	18	04	Sollentuna/Uppland
	9	11	Helsingborg/Skåne
	9	15	Höganäs/Skåne
	11	01-02	Njurunda/Medelpad
	11	10	Öregrund/Uppland
	15	17	Varberg/Halland
	16	19	Mala-Hässleholm/Skåne
	17	03	Västerhaninge/Södermanland
	24	11-13	Trelleborg/Skåne
	Nov.	3	13
7		13-14	Ängelholm/Skåne
8		13	Gräsö/Uppland
20		10	Västerås/Västmanland
24		14	Fröslunda-Altuna/Uppland
Dec.	5	09	Skelleftehamn/Västerbotten; Luleå/Norrbottn
	8	15	Haninge/Södermanland
	13	00-01, 13	Väddö kanal/Uppland
	24	20	Treskog-Gunnarskog/Värmland
	27	00	Charlottenberg/Värmland
	27	05	Treskog-Gunnarskog/Värmland
	28	01-02	Treskog-Gunnarskog/Värmland

1) Possibly one day later.

2) Possibly one week later.

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