

SVERIGES GEOLOGISKA UNDERSÖKNING

SERIE C NR 750

AVHANDLINGAR OCH UPPSATSER

ÅRSBOK 72 NR 12

MARKUS BÅTH

EARTHQUAKES IN SWEDEN
1951–1976



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ABSTRACT

An earthquake catalogue and a seismicity map for Sweden are presented, covering the period from 1951 to 1976. The catalogue comprises 217 events in the magnitude range $M_L = 1.5$ to 4.7, with data based on all possible seismographic and macroseismic measurements. Thus, information is given on origin time, epicentral coordinates, focal depth, magnitude, maximum intensity, and radius of perceptibility. A new and more accurate structural model is used in the calculation of origin time, epicenter and focal depth. In combination with an efficient iterative calculation procedure, this model is able to yield results of good accuracy. The purpose of this work is to provide a data base, suitable for any type of application, such as for tectonophysical investigations or for engineering evaluation of ground motion.

INTRODUCTION

The last quarter century has seen an enormous development in seismicity studies. The following three points mark the most important milestones in this development:

1. Seismographic networks have been installed, which enable a far more detailed and accurate evaluation of seismicity than earlier.
2. Tectonophysical investigations, stimulated by recent theories on plate tectonics, require seismicity information more than ever before.
3. Engineering requests for accurate information on ground motion are nowadays far greater than earlier, especially in connection with installations in uninhabited areas or of a type that requires special safety measures.

These three factors are of significance for seismicity studies all over the world, naturally with greatest emphasis on the large well-established earthquake belts. But they are also of significance for Sweden. As to point 1, the modern seismographic networks in Fennoscandia have been created during this period. This is reflected in our catalogue, where the first years still to a great extent rely on macroseismic information, whereas a more complete instrumental documentation has been possible only for the last 10 years (1967–1976).

As to point 2 above, Fennoscandia offers interesting studies because of its location in a border area between the Eurasian continent and the North Atlantic. Finally, point 3 has recently become of significance in Sweden, primarily in connection with the design of nuclear power plants and the disposal of radioactive waste material.

Utilizing the development mentioned in point 1, the purpose of the present research is to provide a data base for applications, such as those mentioned in 2 and 3, for the territory of Sweden and the time interval from 1951 to 1976.

LIST OF SYMBOLS

a	ground acceleration, microns/sec ²
A, B, C	depth parameters, equation (6)
D	average rupture on fault plane, cm
E	seismic wave energy, ergs
E, N, Z	components of short-period seismographs, equation (8)
G (Δ , T)	calibrating function in acceleration formula, equation (12)
h	instrumental focal depth, km
h _a	macroseismic focal depth, km
H	layer thickness, km
I ₀	maximum macroseismic intensity, MSK scale
log	decadic logarithm
m	body-wave magnitude
M	surface-wave magnitude
M _a	macroseismic magnitude
M _L	regional magnitude (instrumental)
M ₀	seismic moment, dynes. cm
N, N'	number of earthquakes
r	radius of perceptibility, km
S	area of fault plane, cm ²
t	travel time, sec
T	wave period, sec
v	wave velocity, km/sec
δt	travel time difference, sec
Δ	epicentral distance, km
μ	modulus of rigidity, dynes/cm ²

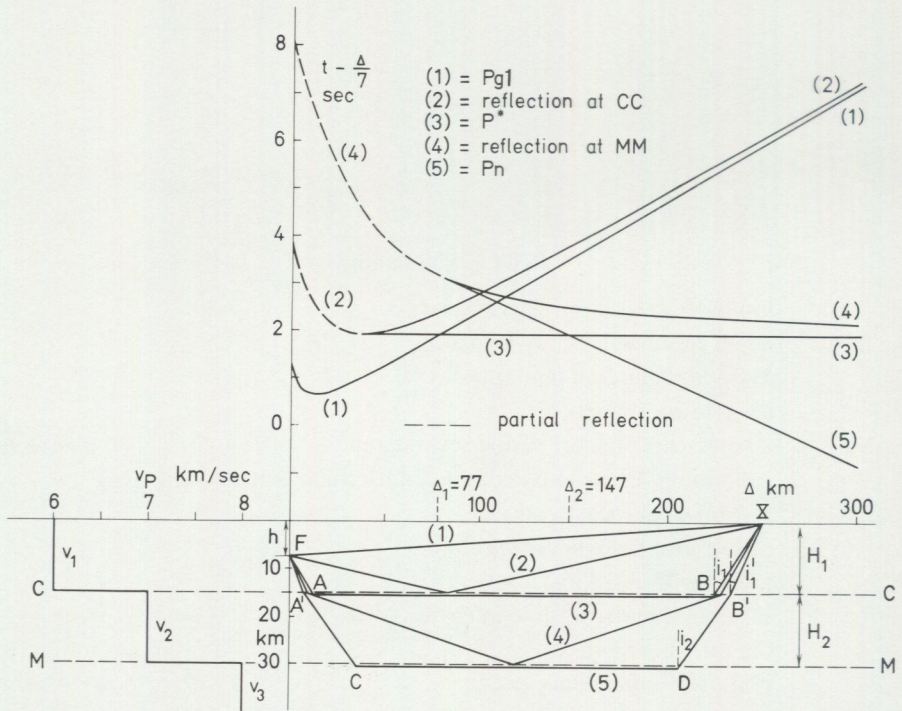


Fig. 1. Wave propagation paths and travel time curves (quantitatively calculated) for an assumed velocity profile. CC = Conrad discontinuity, MM = Mohorovičić discontinuity (after Bâth 1973, where further explanation is given).

STRUCTURAL MODEL

The structural model used in the evaluation of the seismographic measurements is presented in Table 1. It is a two-layered crust, with granitic and basaltic layers both of 19 km thickness, thus making the total crustal thickness equal to 38 km. As the model will serve as an average over the whole area investigated, it should be both as accurate and as simple as possible, leaving out local variations. The wave propagation in such a two-layered crustal model is shown in Fig. 1, where the numerical values deviate somewhat from those adopted here. Fig. 1 shows the ray paths for direct, reflected and refracted waves and the corresponding travel time curves, all calculated quantitatively for the model shown.

For a focal depth h of an event in the upper, granitic layer, we get the following equations for the travel time curves:

$$\text{Pgl and Sgl: } t = (\Delta^2 + h^2)^{1/2}/v_1 \quad (1)$$

$$\text{P}^* \text{ and S}^*: t = \Delta/v_2 + (2H_1 - h)(v_2^2 - v_1^2)^{1/2}/v_1v_2 \quad (2)$$

$$\text{Pn and Sn: } t = \Delta/v_3 + (2H_1 - h)(v_3^2 - v_1^2)^{1/2}/v_1v_3 + 2H_2(v_3^2 - v_2^2)^{1/2}/v_2v_3 \quad (3)$$

TABLE 1. Structural model

Layer	Thickness km	Wave velocity km/sec
1 = Granitic	$H_1 = 19$	$v_1 = \begin{cases} 6.22 \text{ (Pg1)} \\ 3.58 \text{ (Sg1)} \end{cases}$
2 = Basaltic	$H_2 = 19$	$v_2 = \begin{cases} 6.64 \text{ (P}^*) \\ 3.69 \text{ (S}^*) \end{cases}$
3 = Upper mantle	$H_3 = \infty$	$v_3 = \begin{cases} 7.84 \text{ (Pn)} \\ 4.55 \text{ (Sn)} \end{cases}$

Explanation of symbols used for seismic waves:

Pg1 and Sg1 = longitudinal and transverse seismic waves, respectively, through the granitic layer;

Pg2 and Sg2 = longitudinal and transverse seismic waves, respectively, through a superficial granitic layer of 1.4 km thickness, here ignored; their velocities are 5.82 and 3.38 km/sec, respectively;

P* and S* = longitudinal and transverse seismic waves, respectively, through the basaltic layer;

Pn and Sn = longitudinal and transverse seismic waves, respectively, through the upper mantle immediately underlying the Mohorovičić discontinuity.

For $h = 0$ we get immediately the equations for a surface focus. Corresponding formulas for a focus in the lower, basaltic layer can be easily written down.

Our structural model of Table 1 has been derived in the following way:

1. Wave velocities are based on experimental field works, from which we have chosen those values that exhibit the smallest standard deviations (Båth 1971, Båth et al. 1976b).

2. The thickness of the granitic layer (19 km) is calculated from the S* time intercept 2.62 for $h = 0$ (Båth 1971). Similarly, the thickness of the basaltic layer (also 19 km) is calculated from the Sn time intercept 12.54 for $h = 0$ (Båth 1971).

3. A number of tests has been performed with actual records of earthquakes within our area in order to check that the adopted model is able to yield satisfactory accuracy.

It should be remarked that the presently adopted model deviates from an earlier proposed model (Båth 1971), particularly with regard to the layer thicknesses. In calculating layer thicknesses for the earlier model, it was assumed that the granitic layer is characterized by the lower velocities of Pg2 and Sg2. However, the present

TABLE 2. Minimum distance (km) of crustal waves

Wave	Focal depth, km	
	h = 0	h = 12
Pg1	0	0
P*	102	70
Pn	110	94
Sg1	0	0
S*	152	104
Sn	101	86

study has demonstrated that in records of regional events, Pg1 and Sg1 are the dominating granitic phases, while Pg2 and Sg2 hardly exist at all. Therefore, the granitic velocities are more correctly identical with those of Pg1 and Sg1. The correctness of this procedure is furthermore evidenced by tests as mentioned in 3 above, which demonstrate that the new model is able to yield far greater accuracy than the earlier one. In our model (Table 1) we have ignored any superficial granitic layer of about 1.4 km thickness (Båth et al. 1976b), as being of no significance for our present problem.

Travel times for use in evaluation of seismic records have been calculated for every 10 km distance from $\Delta = 0$ to $\Delta = 1500$ km both for a surface focus ($h = 0$) and for a focal depth of $h = 12$ km (Appendix 1 and 2). While Pg1 and Sg1 exist from $\Delta = 0$ and outwards, the other waves cannot exist within certain minimum distances (Table 2). The Moho-reflected P wave, denoted PmP, has been listed only for a restricted distance range, where it is most likely to be expected. But even in this range, we have not been able to identify PmP reliably in our records. Appendix 1 ($h = 0$) contains also travel times for the short-period Rayleigh wave Rg, calculated from $t = \Delta/3.02$. This wave exists only for sources in the uppermost few kilometers of the crust and is a most efficient depth discriminator (Båth 1975).

The phases listed in Appendix 1 and 2 are able to explain all the main features of our records. However, as our model (Table 1) is no doubt simple and in reality more details should exist, we could expect this to show up in our records, at least when crustal features are more consistent and not just purely local. In examining our records we found a few phases which exhibit quite some degree of consistency and which are not explained by our simple model of Table 1. These unidentified phases (Table 3) generally show travel time equations of much greater standard deviations than the regular phases of Appendix 1 and 2, probably due to structural variations. The phases of Table 3 could be explained as follows:

TABLE 3. Unidentified phases

Reference number	Travel time (least-squares solutions) sec	Number of observations	Distance range km
1	$t = \Delta / (6.14 \pm 0.38) + (3.82 \pm 1.80)$	44	40-385
2	$t = \Delta / (3.54 \pm 0.13) + (4.39 \pm 3.92)$	66	105-1085
3	$t = \Delta / (4.06 \pm 0.09) + (5.70 \pm 3.36)$	34	270-955
4	$t = \Delta / (5.20 \pm 0.37) + (9.75 \pm 3.79)$	18	140-525

1 and 2 with velocities slightly lower than Pgl and Sgl, respectively, could be due to leaking low-velocity channels within the lower granite. The average focal depth of earthquakes producing these phases is 12 km. The P wave with the velocity 6.14 km/sec is particularly pronounced in many records as a very sharp phase 3.9-4.6 seconds after Pgl. It may be absent in other cases, suggesting that the channel is narrow, and hence the existence of this phase is sensitive to focal depth. The corresponding S phase is harder to establish reliably because of the larger motion within the Sgl wave train.

3 has permitted the most reliable explanation. It is an S phase arriving between S* and Sn and is explained by a lower basaltic layer, with a velocity of 4.06 km/sec and a thickness of about 7 km lying immediately above the Moho, i.e. occupying the depth range between 31 and 38 km. This layer has been reported from several other investigations. However, the corresponding P phase has not been found reliably in our records.

4, arriving about halfway between Pgl and Sgl in the records, has so far resisted any reliable explanation. It could be some mixture of P and S wave propagation.

Even though these phases, listed in Table 3, suggest certain improvements of our model of Table 1, they have not been considered to be of such a decisive importance as to modify our adopted model.

Another question concerns the use of the notation Pgl and Sgl in case a focus is located in the basaltic layer. We have kept this notation for the direct upward propagating wave, refracted at the Conrad discontinuity, i.e. for $h > 19$ km. Due to the relatively small difference in velocities at the Conrad discontinuity, especially between Sgl and S*, the apparent velocities Δ/t for a focus at 25 km depth deviate only very little from the true Sgl velocity of 3.58 km/sec. For the distance range from 117 km to 422 km, these apparent velocities vary from 3.53 km/sec to 3.65 km/sec. The deviations may be still smaller if suggested low-velocity channels in the granite could be taken into account. Therefore, Pgl and especially Sgl velocities stand to a certain extent for averaged crustal velocities for direct upward propagating waves.

FOCAL DEPTH

Any travel time equation can in general be written as follows:

$$t = t(\Delta, h) \quad (4)$$

For any given distance Δ and travel time t , we could in principle solve this equation for h . As such a calculation would depend upon a knowledge of the origin time, it could be preferred instead to combine phases two and two. This means that having two phases 1 and 2 at a given station with travel times

$$\left. \begin{aligned} t_1 &= t_1(\Delta, h) \\ t_2 &= t_2(\Delta, h) \end{aligned} \right\} (5)$$

we form the corresponding travel time difference $\delta t = t_2 - t_1$, which is independent of origin time. The expression for this travel time difference is solved with respect to h , which gives us a formula for h expressed in epicentral distance Δ and the chosen travel time difference δt :

$$h = A + B\Delta + C\delta t \quad (6)$$

A , B and C are parameters characteristic for our model and different for different phases 1 and 2 that are combined. Table 4 summarizes the numerical evaluation of equation (6) for our model. Numerical tests demonstrate that calculations of h from phase differences (independent of origin time) or from single phases (dependent on origin time) give practically identical results with comparable accuracy. In our calculations of h , the phase-pair method has been used.

Even though Table 4 includes all possible phase combinations two and two, some of them are more accurate than others. Some idea of their relative accuracy can be obtained from the values of the parameters B and C , considering errors of Δ and δt . However, quite generally it can be stated that the method involves rather large errors for any phase combination. In our calculations we have used for each earthquake all possible phase combinations, but only for layer 1, then calculated an average depth and its standard deviation, leaving out obviously erroneous depth values. The relatively large scatter is due to the fact that h comes out as a small difference between large numbers, and it is therefore sensitive to errors in these numbers, due to local variations in the structure (cf. Greensfelder 1965).

Fig. 2 gives an idea of the relative use of different travel time differences for focal depth calculation (analogous to a teleseismic study by Båth 1943). As the travel times of Pgl and Sgl become practically independent of h from about $\Delta = 300$ km onwards, the difference Sgl-Pgl cannot be used for depth calculation. On the other hand, this difference is the most useful one for distance calculation. Other time differences in Fig. 2 depend in general both on distance and depth, and they are the more useful for depth calculation the steeper the curves are. We have also constructed a difference that

TABLE 4. Depth parameters in equation (6)

Travel time difference	A	B	C
Layer 1: P _{g1} -P _n	69.1	-0.3391	+10.21
S _{g1} -S _n	73.0	-0.3451	+ 5.80
S _n -P _n	78.0	+1.2376	-13.42
S _{g1} -P _n	69.1	-1.5495	+10.21
S _n -P _{g1}	73.0	+0.3422	- 5.80
S [*] -S _{g1}	38.0	-0.1226	-14.77
P [*] -P _{g1}	38.0	-0.1812	-17.76
S [*] -P [*]	38.6	+10.5614	-87.72
P [*] -P _n	111.2	-0.5529	+24.04
S _n -P [*]	89.9	+0.5960	- 8.61
S _{g1} -P [*]	38.0	-2.2860	+17.76
S [*] -P _n	138.8	-4.7483	+33.11
S [*] -P _{g1}	38.0	+1.6278	-14.77
S [*] -S _n	95.6	-0.4890	+ 9.55
Layer 2: P [*] -P _n	66.9	-0.2871	+12.48
S _n -P _n	75.0	+1.1745	-12.74
S [*] -S _n	69.5	-0.3228	+ 6.31
S _n -P [*]	70.9	+0.4363	- 6.31
S [*] -P _n	64.2	-1.7903	+12.48

is independent of distance, namely between pP_n (analogous to the teleseismic pP) and P_n. This difference would permit a calculation of depth, independently of distance, from the formula:

$$\begin{aligned}
 h &= [t(\text{pPn}) - t(\text{Pn})] v_1 v_3 / 2(v_3^2 - v_1^2)^{1/2} \\
 &= [t(\text{pPn}) - t(\text{Pn})] 5.11
 \end{aligned}
 \tag{7}$$

It is of interest to note that the factor 5.11 for our model conforms well to the corresponding factor of the teleseismic difference pP-P extrapolated to short distances, i.e. 0°-10°. However, the disagreeable fact is that the phase pP_n cannot be identified reliably in our records.

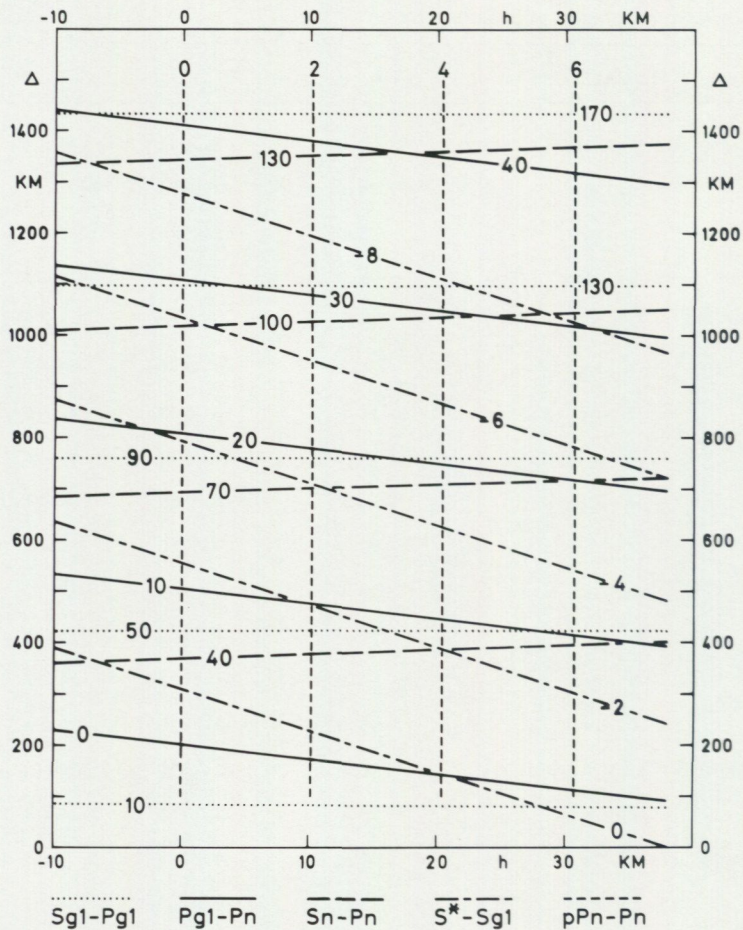


Fig. 2. Given travel time differences (sec) in dependence upon epicentral distance (km) and focal depth (km).

In general, a depth formula is independent of epicentral distance if the two waves combined are of the same type (i.e. either P or S) and have passed through the same layers, as for example pPn and Pn. If, on the other hand, waves are combined that are of different type or have passed through different layers, then velocities enter in such a way that epicentral distances cannot be eliminated.

MAGNITUDE

Magnitudes are calculated in the regional M_L scale by means of methods developed by Båth et al. (1976a). As amplitude and period have been available only through direct measurements on the records of the Seismological Institute at Uppsala, only its stations

TABLE 5. Magnitude corrections

Station	1951-1970			1971-1976		
	Distance range, km			Distance range, km		
	0-300	301-600	> 600	0-300	301-600	> 600
Uppsala	-0.1 (54)	-0.2 (29)	-0.2 (20)	+0.1 (60)	+0.1 (43)	± 0.0 (9)
Kiruna	+0.1 (22)	+0.1 (24)	+0.1 (9)	± 0.0 (13)	-0.1 (12)	+0.1 (10)
Skalstugan	± 0.0 (5)	± 0.0 (65)	+0.1 (14)	± 0.0 (10)	± 0.0 (35)	± 0.0 (9)
Umeå	+0.1 (29)	± 0.0 (30)	-0.1 (14)	± 0.0 (32)	+0.1 (28)	± 0.0 (19)
Uddeholm	± 0.0 (50)	-0.1 (5)	± 0.0 (16)	-0.1 (75)	± 0.0 (21)	± 0.0 (13)
Delary	+0.1 (25)	± 0.0 (7)	± 0.0 (1)	± 0.0 (55)	-0.1 (14)	-0.1 (8)
Göteborg	+0.1 (25)	± 0.0 (3)	+0.1 (7)			
Karlskrona	+0.2 (10)	± 0.0 (7)	± 0.0 (5)			

Number of observations (natural and artificial events) is given in brackets.

have entered the M_L calculation. In each case, M_L is given as an average of individual station values of M_L together with the corresponding standard deviation.

In developing the method for the M_L calculation by Båth et al. (1976a), a number of tests was performed to check the reliability of the magnitudes. With the far greater number of observations now available, these tests have been repeated, as described under the following four points.

1. Our measurements consist of vertical-component amplitudes Z , whereas the M_L scale is defined for the average of the two horizontal components, i.e. $(E + N)/2$. Comparing the two procedures on 60 cases using Umeå records, we find as an average the following result:

$$\log[(E + N)/2Z] = -0.02 \pm 0.14 \quad (8)$$

This demonstrates that there is no significant difference between Z and $(E + N)/2$.

2. Station corrections have been calculated from differences between individual station determinations and corresponding averages in each case (Table 5). Even though these corrections have been included in our calculations, only the few cases exceeding ± 0.1 need to be taken into account. The conclusion is that there are in general no significant station corrections.

3. Attenuation effects, i.e. dependence on distance, are included in Table 5, where a subdivision into three distance ranges has been made. As seen from this table, there are

no significant variations of the corrections with distance. This means that our magnitude calculations are based on reliable attenuation values.

4. Examining the standard deviations of M_L , we find that for a sample of 308 determinations (including natural and artificial events) the arithmetic average of the standard deviation is ± 0.23 , while its root-mean-square is ± 0.26 . Thus, in general the standard deviation of M_L is around ± 0.25 .

In summary, all points 1 to 4 confirm the results of Båth et al. (1976a), even though the latter are based on a much smaller material than now available.

With M_L known, the released seismic wave energy can be calculated from the following equation (derived by Båth et al. 1976a):

$$\log E = 12.30 + 1.27 M_L \quad (9)$$

In this connection we note that there are at least two different ways to average M_L calculations of each earthquake:

1. To calculate simple averages of the individual station determinations of M_L . This is the method we have followed.

2. To calculate E for each station determination of M_L , then average the E values and finally to get the M_L that corresponds to this averaged E .

The difference is that 1 averages $\log E$, while 2 averages E . In principle, it could be argued that 2 is a more correct procedure. In practice, however, the two methods prove to give the same result in almost all our cases. In order to yield different results, the individual station values of M_L would have to diverge from each other much more than our values do.

With M_L known, we can also calculate other parameters, following Båth et al. (1976a):

$$\text{Body-wave magnitude: } m = 2.93 + 0.49 M_L \quad (10)$$

$$\text{Surface-wave magnitude: } M = 0.04 + 0.88 M_L \quad (11)$$

$$\text{Ground acceleration: } \log a = M_L - G(\Delta, T) \quad (12)$$

The function $G(\Delta, T)$ in equation (12) is tabulated in detail in Båth et al. (1976a). This equation permits the calculation of acceleration at any locality at distance Δ from any earthquake with given M_L and is therefore of a certain engineering interest. It can also be used for the construction of a seismic zoning map.

Another information of engineering significance concerns the amount of displacement (rupture) at the focus. This can only be estimated approximately. Starting from the following relation between the seismic moment M_0 and M_L (Wyss and Brune 1968):

$$\begin{aligned} \log M_0 &= 15.1 + 1.7 M_L \\ 3 < M_L < 6 \end{aligned} \quad (13)$$

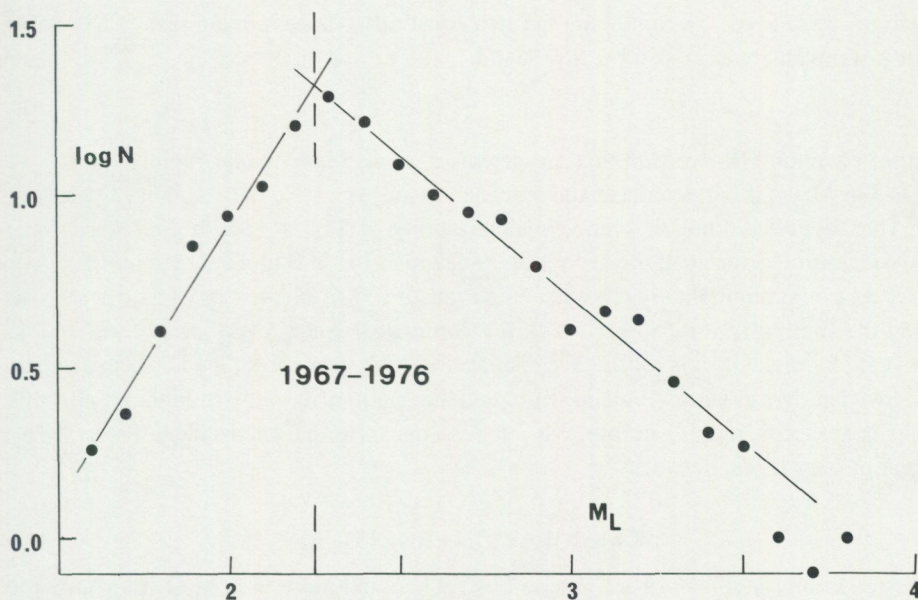


Fig. 3. Frequency-magnitude graph for the period 1967-1976.

and considering that $M_0 = \mu DS$, we find with $\mu = 0.6 \cdot 10^{12}$ dynes/cm², the following expression for the rupture:

$$\log D = 3.3 + 1.7 M_L - \log S \quad (14)$$

For a given M_L and a reasonable assumption about the fault area S (cm²), equation (14) gives an estimate of the rupture D (cm).

For 1967-1976 the total number of recorded Swedish earthquakes is 155, i.e. 15.5 earthquakes/year. Frequency-magnitude relations have been deduced for this period, when our instrumental data are most homogeneous and complete. With the number of earthquakes smoothed according to the formula $(N_1 + 2N_2 + N_3)/4$ for successive magnitudes, we find the data very well arranged according to two straight lines (Fig. 3) with the following least-squares solutions:

$$\left. \begin{array}{l} M_L \geq 2.3 \text{ (105 earthquakes):} \\ \log N = (3.22 \pm 0.05) - (0.84 \pm 0.02) M_L \\ M_L \leq 2.2 \text{ (50 earthquakes):} \\ \log N' = (1.60 \pm 0.03) M_L - (2.29 \pm 0.06) \end{array} \right\} \quad (15)$$

N and N' refer to a period of 10 years and magnitude intervals of 0.1 unit. The results suggest that data are complete for $M_L \geq 2.3$, while they are definitely incomplete for lower magnitudes. For $M_L \leq 2.2$, we can express the detectability of our present

stations as follows, by combining the two equations (15), assuming that (15.1) holds for a complete data set also for $M_L < 2.3$:

$$\log(N'/N) = 2.44 M_L - 5.51 \quad (16)$$

From equation (16) we find that the detectability decreases rather rapidly for $M_L < 2.3$. For $M_L = 2.0$ it amounts to 23 percent and for $M_L = 1.5$ only to about 1 percent.

The suggested limit of complete detectability at $M_L = 2.3$ is confirmed by a consideration of our magnitude formula (equation (14) in Båth et al. 1976a). For $M_L = 2.3$, a minimum reliably recorded amplitude of 0.007 microns and $T = 0.5$ sec, we find the limiting $\Delta = 550$ km. With this limiting distance, every part of our area is covered by three or more of the Swedish stations only, except for the northeastern part of Sweden, bordering on Finland. But including stations in northern Finland, also this part is well covered. Therefore, $M_L = 2.3$ appears to be a reasonable detectability limit of our present networks.

CALCULATION PROCEDURE

Seismograph stations used are reported in Table 6 and those used most frequently are shown in Fig. 4. In Table 6 the stations are listed in order of percentage frequency, i.e. in percentage of the total number of events (=217) for which a station has been used. It should be emphasized that this tabulation does not reflect station sensitivity alone. There is a number of factors that influence this frequency, as the period of operation of a station, its location in relation to the seismic belt, and to a smaller extent the degree of availability of data. In general, our investigated events are well surrounded by stations in different directions from the epicenter.

All records from the network of the Seismological Institute, Uppsala, have been re-examined and in numerous cases re-measured and readings made more complete. Information from other stations has been collected from all available bulletins.

In calculating epicenter and origin time, an efficient iterative procedure has been applied, which can be stated in the following points:

1. Get an origin time, e.g. from Sgl-Pgl at one or several stations as an average. Use tables in Appendix 2, unless Rg is recorded, when Appendix 1 should be used.
2. From this origin time, get the epicentral distances from all stations recording the event.
3. From these distances, plotted on a map or otherwise, select a point (the epicenter), which minimizes the standard deviation.
4. Get the distances from this selected epicenter to all stations.
5. From these distances get a new origin time as an average of all clear phases (either all clear Sgl phases or all phases, if reliable).
6. With this revised origin time, proceed as in 2 and the following points.
7. The iteration is continued, oscillating between origin time and epicenter location, until these do not change any more or stay within acceptably small error limits.

TABLE 6. Seismograph stations

Percentage frequency	Station		Location	
>50	Skalstugan	SKA	63 ^o .58 N	12 ^o .28 E
	Uppsala	UPP	59.86	17.63
	Umeå	UME	63.82	20.24
	Uddeholm	UDD	60.09	13.61
	Kiruna	KIR	67.84	20.42
25-50	Sodankylä	SOD	67.37	26.63
	Kajaani	KJN	64.09	27.71
	Kajaani	KJF	64.20	27.71
	Delary	DEL	56.47	13.87
	Nurmijärvi	NUR	60.51	24.66
10-25	Oulu	OUL	65.09	25.90
	Kevo	KEV	69.76	27.01
	Joensuu	JOE	62.65	29.68
	Kongsberg	KON	59.65	9.63
	Porkkala	PKK	60.01	24.52
	Porvoo	PRV	60.36	25.56
	Tromsø	TRO	69.63	18.93
	Göteborg	GOT	57.70	11.98
	Lillehammer	LHN	61.05	10.88
<10	Karlskrona	KLS	56.17	15.59
	Bergen	BER	60.40	5.31
	Maaselkä	MA	65.91	29.04
	Hagfors	HFS	60.13	13.70
	Copenhagen	COP	55.68	12.43
	Helsinki	HEL	60.18	24.96
	Kungsör	Ku	59.40	16.13
	Hedemora	Hd	60.29	15.95
	NORSAR	NAO	60.82	10.83
	Kirkenes	KRK	69.72	30.06
	Lycksele	Ly	64.52	18.85
	Äppelbo	APP	60.54	13.93
	Mora	Mo	61.03	14.66
	Stöllet	SLL	60.48	13.49

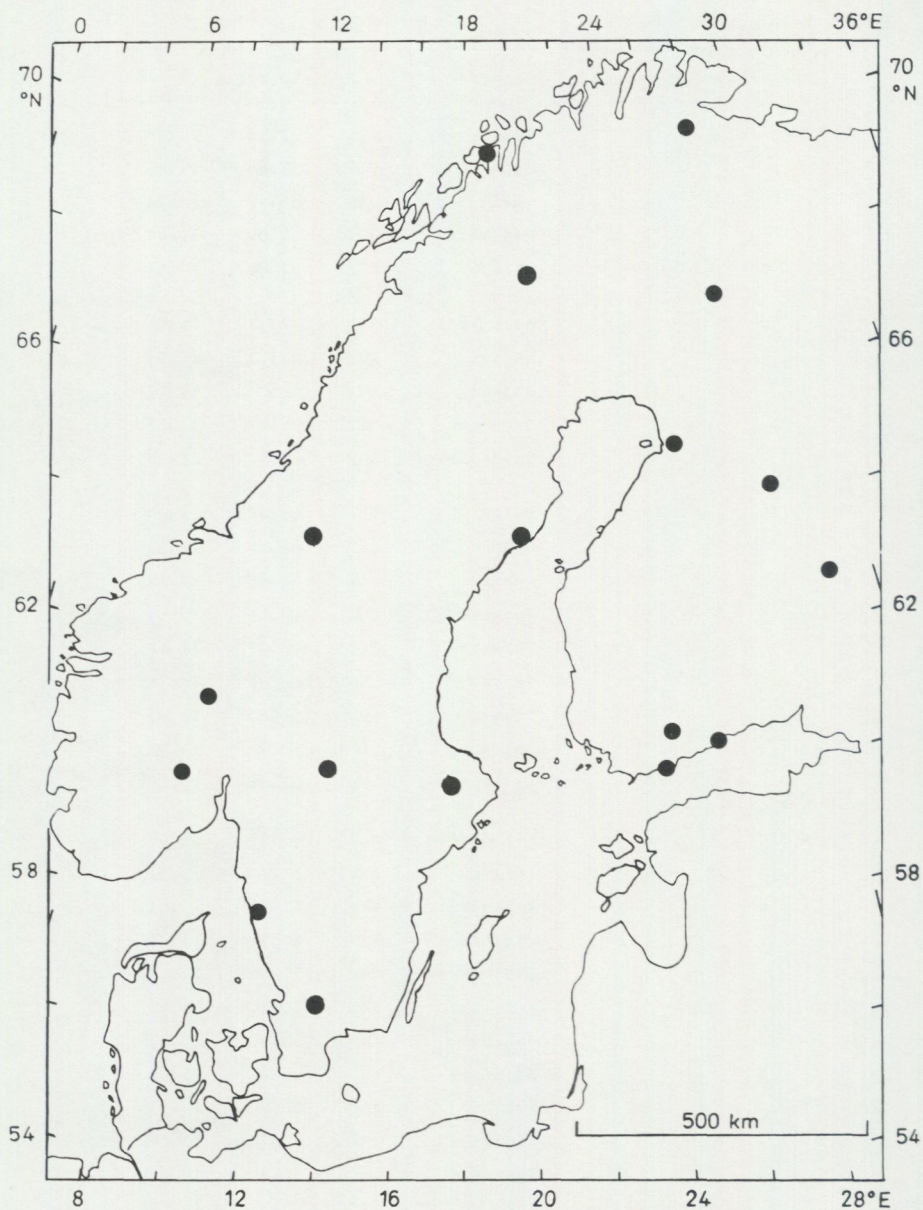


Fig. 4. Seismograph stations, each one used in at least 10 percent of investigated earthquakes (cf. Table 6).

Naturally, this calculation procedure is well adapted to a computer. However, with seldom over a dozen stations, the calculation work is not laborious. It can easily and accurately be performed manually with a desk calculator together with an exact map (or just an exact net of latitudes and longitudes), in a scale of at least $1 : 5 \cdot 10^6$. This procedure has the advantage of clearly exhibiting every step, e.g. every deviation, which may call for revision of readings or of phase interpretations. The iteration procedure is apt to prohibit effectively any personal influence on the manual calculation.

It should be born in mind that the major problem in this work is not the calculations as such. The major problem consists in the availability of exact readings from records of significant phases and in their correct identification as well as in the applicability of the assumed crustal model. With the Swedish records directly available, the work has proceeded with close record examination. For other stations whose records are not directly available, the most plausible phase interpretation has been made from reported data. Once phase readings and their identification can be relied upon, the iterative calculation proceeds quite automatically without difficulty. It is also a powerful technique. Test examples demonstrate that it is possible to start with practically any assumed epicenter within our region, and the iterative procedure will after a few turns shift the epicenter location into its correct position. Alternatively, it is possible to start with any reasonable assumption of the origin time, e.g. when Sgl-Pgl is not available, and the iteration will soon yield the correct answer.

When an acceptable solution for the origin time and the epicentral coordinates has been reached, the focal depth is calculated from all available phase differences (Table 4). Strictly, when this calculation results in an *h*-value different from 12 km used in the iteration procedure (Appendix 2), the calculation of origin time and epicenter should be repeated with this new *h*-value. In other words, calculation of depth should be included in the iterations. However, this has not been done in our calculations, partly because of the large errors of any calculated depth, partly because effects on origin time and epicenter are in general negligible.

The possibilities and potentialities of performing an iteration also on the whole material have been considered. This would imply a calculation of a new set of travel times from the obtained results, followed by a recalculation of all events. However, the relatively small errors of origin time and epicentral location in our catalogue convince us that there would hardly be any hope for improvements of an average model for the whole area. Improvements would rather have to be set in on developing local travel times, differing according to local structure. Clearly, this procedure would not be successful with our material, as perfect source accuracy, i.e. controlled explosions, would then be necessary. In conclusion, further progress in seismicity studies of Sweden has to be achieved by using local travel times deduced from an optimal distribution of controlled explosions, coupled with denser networks.

MACROSEISMIC OBSERVATIONS

In addition to the instrumental data, all available macroseismic information has been evaluated. The macroseismic data have been accumulated by questionnaires, distributed especially among post offices, as well as by information through newspapers and individuals. In our catalogue, the macroseismic data are expressed in the maximum intensity I_0 and the radius of perceptibility r together with a listing of places where a shock has been felt.

The intensity I_0 is rated according to the 12-degree MSK (Medvedev-Sponheuer-Kárník) scale. It is reproduced here from Willmore and Kárník (1970) up to degree 6, which is sufficient for our purposes:

''1 Not noticeable

a The intensity of the vibration is below the limit of sensibility; the tremor is detected and recorded by seismographs only.

2 Scarcely noticeable (very slight)

a Vibration is felt only by individual people at rest in houses, especially on upper floors of buildings.

3 Weak, partially observed only

a The earthquake is felt indoors by a few people, outdoors only in favourable circumstances. The vibration is like that due to the passing of a light truck. Attentive observers notice a slight swinging of hanging objects, somewhat more heavily on upper floors.

4 Widely observed

a The earthquake is felt indoors by many people, outdoors by a few. Here and there people awake, but no one is frightened. The vibration is like that due to the passing of a heavily loaded truck. Windows, doors and dishes rattle. Floors and walls creak. Furniture begins to shake. Hanging objects swing slightly. Liquids in open vessels are slightly disturbed. In standing motor cars the shock is noticeable.

5 Awakening

a The earthquake is felt indoors by all, outdoors by many. Many sleeping people awake. A few run outdoors. Animals become uneasy. Buildings tremble throughout. Hanging objects swing considerably. Pictures knock against walls or swing out of place. Occasionally pendulum clocks stop. A few unstable objects may be overturned or shifted. Open doors and windows are thrust open and slam back again. Liquids spill in small amounts from well-filled open containers. The sensation of vibration is like that due to a heavy object falling inside the building.

b Slight damage of Grade 1 in buildings of Type A is possible.

c Sometimes change in flow of springs.

6 Frightening

a Felt by most people indoors and outdoors. Many people frightened and run outdoors. A few persons lose their balance. Domestic animals run out of their stalls. In a few instances, dishes and glassware may break, books fall down. Heavy furniture may possibly move and small steeple bells may ring.

b Damage of Grade 1 is sustained in single buildings of Type B, and in many of Type A. Damage in a few buildings of Type A is of Grade 2.

c In a few cases cracks up to widths of 1 cm possible in wet ground; in mountains occasional landslips; change in flow of springs and in level of well-water is observed.''

The following explanations apply to the scale:

''Structure A: Buildings in field-stone, rural structures, adobe houses, clay houses.

B: Ordinary brick buildings, buildings of the large block and prefabricated type, half timbered structures, buildings in natural hewn stone.

Definition of quantity: Single, few	about 5 %
Many	about 50 %
Most	about 75 %

Classification of damage to buildings:

Grade 1	Slight damage	Fine cracks in plaster; fall of small pieces of plaster.
Grade 2	Moderate damage	Small cracks in walls; fall of fairly large pieces of plaster; pantiles slip off; cracks in chimneys; parts of chimneys fall down.

Arrangement of the scale: Introductory letters are used in paragraphs throughout the scale as follows

- a Persons and surroundings.
- b Structures of all kinds.
- c Nature."

The radius of perceptibility r is measured from maps, with all points plotted. It is evaluated as the radius of a circle with an area equal to the macroseismic area. Therefore, in case macroseismic areas would be wanted, they can be immediately obtained as πr^2 . In collecting macroseismic observations, great effort is put into obtaining the limits of the macroseismic area. Therefore, questionnaires are distributed widely, such that the central macroseismic area is surrounded on practically all sides by points where the earthquake has not been felt.

RELATIONS BETWEEN INSTRUMENTAL AND MACROSEISMIC PARAMETERS

The combined evaluation of instrumental and macroseismic parameters has made it possible to deduce relations between the two, which we summarize in the following points:

1. Epicentral locations from instrumental and macroseismic data (in the latter case defined as the points of maximum intensity) generally agree well with each other within their respective error limits. This is also to be expected considering that our earthquakes are practically point sources with no extended faulting.

2. Focal depth h_a is calculated from macroseismic data by the following equation (Båth 1954):

$$\log [(r^2 + h_a^2)/h_a^2] = (I_0 - 2)/3 \quad (17)$$

From 53 pairs of calculated h and h_a , we find the following relation:

$$h_a = h \pm 9 \quad (18)$$

TABLE 7. Values of M_L for given M_a (equation 20.1)

M_a	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2.	1.8	1.9	2.0	2.1	2.1	2.2	2.3	2.4	2.5	2.6
3.	2.6	2.7	2.8	2.9	3.0	3.1	3.1	3.2	3.3	3.4
4.	3.5	3.6	3.6	3.7	3.8	3.9	4.0	4.1	4.1	4.2
5.	4.3	4.4	4.5	4.5	4.6	4.7	4.8	4.9	5.0	5.0

i.e. a standard deviation of 9 km between the two depth measures. The correlation coefficient between h and h_a from the same set of 53 observations is $+0.23 \pm 0.13$, which is hardly significant, although it is positive. The averages of the same set of values agree: $h = h_a = 16$ km, which suggests an overall agreement in spite of the scatter. Practically without exception, our earthquakes are located within the crust.

It should be noticed that h is calculated exclusively from kinematic data, while h_a is calculated from dynamic data. They are both subject to quite large errors. Nevertheless, it is interesting to note that a histogram of 123 h -values shows a primary maximum at 14 km and a secondary maximum at 23 km, in striking agreement with a histogram of h_a produced by Båth (1954). It seems likely that these depths agree with low-velocity (weakness) channels, while the depth histogram exhibits a minimum around the Conrad discontinuity (19 km depth). Such regularities of the histogram might suggest that the h -averages are more reliable than their standard deviations indicate.

3. Macroseismic magnitudes M_a are calculated by Båth (1954, 1956) from the following relation:

$$M_a = 0.61 I_0 + 1.78 \log h_a - 1.33 \quad (19)$$

Contrary to the focal depths, the magnitudes M_a and M_L show a remarkably good correlation. From 64 pairs of magnitudes we find the following least-squares orthogonal regression:

$$\left. \begin{aligned} M_L &= (0.83 M_a + 0.15) \pm 0.33 \\ M_a &= (1.20 M_L - 0.18) \pm 0.40 \end{aligned} \right\} (20)$$

The orthogonal standard deviation is not more than ± 0.25 , which is equal to the standard deviation of any single M_L determination. The equations (20) have the advantage of relating the magnitudes M_a used in my earlier catalogue (Båth 1956) with M_L , used in the present catalogue. Table 7 gives numerical results.

Assuming $I_0 = 2$ to correspond to the limit of human perception (Båth 1954), we find from equation (19) for $h_a = 20$ km the corresponding limiting magnitude to be

$M_a = 2.2$, which corresponds to $M_L = 2.0$ by equation (20.1). This agrees with rockburst results (cf. Fig. 5 in Båth and Wahlström 1976). However, this estimation presupposes that shocks occur in populated areas. In fact, the latter is a much more important condition for perception than the magnitude.

NATURAL AND ARTIFICIAL EVENTS

A major problem in making an earthquake catalogue is to decide which events should be included and which should be excluded. In other words, the problem is to decide if an event is a natural earthquake or not. Cases with only macroseismic observations without instrumental records must nowadays always be approached with suspicion. Macroseismic observations (assumed) may be strikingly similar to those from natural earthquakes, even when caused by other phenomena, such as local settings in soil layers under single buildings, frost effects (Svensson 1967) and sonic booms from airplanes. In none of these cases are any seismographic records obtained (for sonic booms only when a plane passes right over the station). Cases like these should therefore be excluded from a catalogue (for further discussion, see Båth 1972).

On the other hand, the existence of a seismograph record is neither a guarantee that a natural earthquake has happened. Nowadays, major explosions are made at many places which are recorded at our stations even to large distances. These have to be excluded also, and in order to make the discrimination reliable, the following factors have been considered:

1. Existence of R_g : a reliable indication of shallow depth, about 0-1 km mostly (Båth 1975). Therefore, if R_g is absent, the phenomenon is accepted as an earthquake. As R_g has a limited range of propagation, some problem can arise when no near enough station is available.

2. Origin time: explosions are generally made at regular working hours, and often around certain fixed hours for any given site. Sequences of events also suggest artificial origin.

3. Location: an indication if found to agree with known blasting areas, especially if these are outside well-established seismic belts.

4. Magnitude M_L : generally relatively small, i.e. ≤ 2.5 , for artificial events, considering that blasting mostly uses only a few tons, up to 10 tons around, of explosives.

5. Macroseismic observations: absent in case of explosive events, even in populated areas.

Application of criteria as those mentioned is found more helpful than inquiries at various organizations, especially many years after an event. Examining a sample of 85 cases, all with clear R_g recorded, from these viewpoints, we found that the origin times are within regular working hours without exception, that all events (except one)

have occurred on weekdays with a maximum frequency around Wednesday and Thursday, that many events from the same place have origin times closely agreeing with each other, that locations agree with known blasting areas (mines, quarries, dam constructions, military operations), that magnitudes are below 2.5 in almost every case, and that macroseismic observations are missing in all cases even in populated areas. Such events can safely be excluded as artificial. As the sample is based on the existence of R_g in the records, the results indicate that R_g has a very high discrimination value. If R_g is present, the other criteria for artificial events are practically always fulfilled. Therefore, it could be tempting to classify all events with clear R_g as artificial. The question remains whether natural earthquakes could happen in the top kilometer of the crust. The expected lower ability of this top layer to accumulate enough strain makes it unlikely as a source location of natural events, excepting rockbursts. The latter have also been excluded from our catalogue, as many of them have been documented elsewhere (Båth and Wahlström 1976, Båth 1977a and 1977b).

In the course of the present research, all events, even if artificial, have been subjected to the same complete analysis as the natural earthquakes. The artificial events have been excluded from our catalogue, except in a few doubtful cases.

EXPLANATION OF THE CATALOGUE

The catalogue is arranged in chronological order, with a geographical index at the end. This makes it possible to find rapidly all earthquakes that have happened within any region. This index can also be used conveniently in combination with my earlier catalogue (Båth 1956), which together with the present one covers the time span from 1891 to 1976.

The origin time is given in Greenwich Mean Time (GMT) with standard deviation in seconds and the number of phases used in its calculation. The epicenter is defined by its geographic latitude and longitude with the standard deviation expressed in kilometers (not in degrees!) and the number of stations used in brackets. The depth column gives the instrumentally calculated h and/or h_a when macroseismic observations are available. The instrumental depth is given with its standard deviation and the number of phase pairs in brackets. The magnitude is on the M_L scale, with standard deviation and the number of (Swedish) stations used for its calculation. In case only macroseismic observations are available, M_L has been calculated from equation (20.1). Intensity refers to the estimated maximum intensity I_0 . In the Remark column we find the province where the epicenter is located. The rule has been to include only events which can be localized and have epicenters within Sweden or in neighbouring seas, especially the Bothnian Bay. A few earthquakes with epicenters in other countries (Norway) have been included when they have been felt rather widely in Sweden. After "Felt" we have listed all places alphabetically where an earthquake has been felt, including Swedish places only. These names refer to towns, villages,

parishes, post offices, railway stations, farms, etc, whence some overlapping cannot be avoided. With a detailed map, any reader will be able to plot the extent and shape of the macroseismic area with this information. It should be noted that in provincial names, Swedish spelling has been used throughout. For the period 1951-1957, macroseismic data given by Sahlström and Båth (1958), are repeated here for completeness sake.

THE SEISMICITY MAP

The seismicity map (Fig. 5) corresponds to the catalogue, but if two or more epicenters coincide only the one with the largest magnitude is plotted in such a point. A comparison between older maps (for example, one for the interval 1891-1930, see Båth 1953) and the present map can be summarized in the following points.

1. The old map is almost exclusively based upon macroseismic observations, while the new map is based mostly on seismographic records.

2. As a consequence of 1, the new map exhibits considerably increased precision of epicenter locations. Moreover, the new material is far more complete and homogeneous, being totally independent of population density. Whereas incompleteness and inaccuracy of the old map are mostly due to population density, the instrumental data are equally representative for the whole country for the magnitude $M_L = 2.3$ and over.

3. The geographical distribution of Swedish earthquakes gives rise to interesting comparison between the old and the new map. On the new map, an area in the interior of northern Norrland is pronounced seismic, but not so according to the old map. Moreover, the new map shows that the central part of the northern Bothnian Bay is at least as seismic as the area around Lake Vänern, something which is not obvious from the old map. Both these findings can be explained by the negative effects of population density on the old map.

The new map exhibits a practically linear belt between the two "poles" of increased activity - Lake Vänern region in the south and northern Bothnian Bay in the north. The concentration of activity to these poles is in harmony with the well-known observation that seismicity is highest at points where an earthquake belt either changes direction, branches or ends. The pole at Lake Vänern marks the area of southern termination of the belt, while the pole in the northern Bothnian Bay marks the splitting of the belt into two branches, one extending towards northwest over north Sweden and the other towards northeast over north Finland. The two poles are connected by a continuous, rectilinear belt of smaller seismicity, with some variation, especially a secondary maximum about midway between the two poles. Seismically quiet areas are found on the new map in the interior of central and southern Norrland, eastern Svealand and southeastern Götaland. As this result is based on instrumental data, it is not caused by variation in population density.

4. The fact that different time intervals are pictured in the two maps, could be suspected to be a reason for the differences mentioned, considering temporal variations

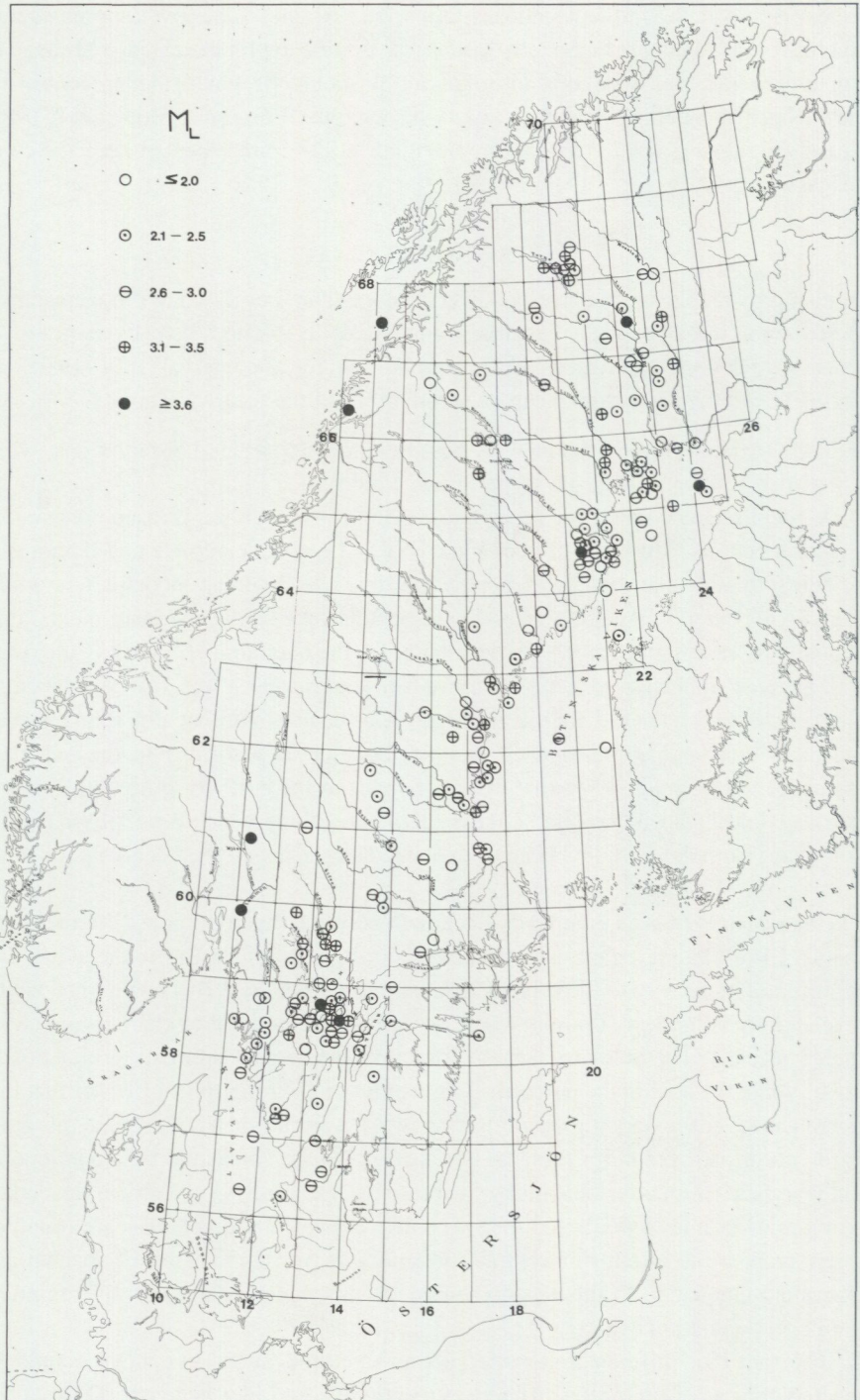


Fig. 5. Seismicity map of Sweden for the interval 1951-1976.

of seismicity. However, as intervals of representative lengths are studied, this factor is considered as only secondary, the main factor being the different efficiency of methods of collecting data.

5. In conclusion, even though macroseismic information is still of great importance as a supplement to instrumental data, the old macroseismic maps, for a long time considered as standard, will now have to be replaced by new instrumental maps.

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APPENDIX 1. Travel times for $h=0$

Δ	Pg1		P*		Pn		Sg1		S*		Sn		Sg1-Pg1		PmP		Rg	
km	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s
0	0							0						0				0
10	1.6							2.8						1.2				3.3
20	3.2							5.6						2.4				6.6
30	4.8							8.4						3.6				9.9
40	6.4							11.2						4.8	13.7			13.2
50	8.0							14.0						6.0	14.2			16.6
60	9.6							16.8						7.2	15.1			19.9
70	11.3							19.6						8.3	16.1			23.2
80	12.9							22.3						9.4	17.2			26.5
90	14.5							25.1						10.6	18.3			29.8
100	16.1							27.9						11.8	19.5			33.1
110	17.7		18.7		20.8		30.7					36.8		13.0	20.8			36.4
120	19.3		20.2		22.1		33.5					39.0		14.2	22.1			39.7
130	20.9		21.7		23.3		36.3					41.2		15.4	23.4			43.0
140	22.5		23.2		24.6		39.1					43.4		16.6	24.8			46.4
150	24.1		24.7		25.9		41.9					45.6		17.8	26.1			49.7
160	25.7		26.2		27.2		44.7		45.9			47.7		19.0	27.5			53.0
170	27.3		27.7		28.5		47.5		48.6			49.9		20.2	28.9			56.3
180	28.9		29.2		29.7		50.3		51.4			52.1		21.4	30.3			59.6
190	30.6		30.8		31.0		53.1		54.1			54.3		22.5	31.8	1	02.9	
200	32.2		32.3		32.3		55.9		56.8			56.5		23.7	33.2	1	06.2	
210	33.8		33.8		33.6		58.7		59.5			58.7		24.9		1	09.5	
220	35.4		35.3		34.8	1	01.4	1	02.2	1	00.9		26.0			1	12.8	
230	37.0		36.8		36.1	1	04.2	1	04.9	1	03.1		27.2			1	16.2	
240	38.6		38.3		37.4	1	07.0	1	07.6	1	05.3		28.4			1	19.5	
250	40.2		39.8		38.7	1	09.8	1	10.3	1	07.5		29.6			1	22.8	
260	41.8		41.3		39.9	1	12.6	1	13.0	1	09.7		30.8			1	26.1	
270	43.4		42.8		41.2	1	15.4	1	15.7	1	11.9		32.0			1	29.4	
280	45.0		44.3		42.5	1	18.2	1	18.5	1	14.1		33.2			1	32.7	
290	46.6		45.8		43.8	1	21.0	1	21.2	1	16.3		34.4			1	36.0	
300	48.2		47.3		45.0	1	23.8	1	23.9	1	18.5		35.6			1	39.3	
310	49.8		48.8		46.3	1	26.6	1	26.6	1	20.7		36.8			1	42.6	
320	51.5		50.3		47.6	1	29.4	1	29.3	1	22.9		37.9			1	46.0	
330	53.1		51.8		48.9	1	32.2	1	32.0	1	25.1		39.1			1	49.3	
340	54.7		53.3		50.1	1	35.0	1	34.7	1	27.3		40.3			1	52.6	
350	56.3		54.9		51.4	1	37.8	1	37.4	1	29.5		41.5			1	55.9	

APPENDIX 1, continued

△ km	Pgl		P*		Pn		Sgl		S*		Sn		Sgl-Pgl		Rg	
	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s
360	57.9		56.4		52.7	1 40.5	1 40.1	1 31.7		42.6		1 59.2				
370	59.5		57.9		54.0	1 43.3	1 42.8	1 33.9		43.8		2 02.5				
380	1 01.1		59.4		55.2	1 46.1	1 45.6	1 36.1		45.0		2 05.8				
390	1 02.7	1 00.9			56.5	1 48.9	1 48.3	1 38.3		46.2		2 09.1				
400	1 04.3	1 02.4			57.8	1 51.7	1 51.0	1 40.5		47.4		2 12.4				
410	1 05.9	1 03.9			59.1	1 54.5	1 53.7	1 42.7		48.6		2 15.8				
420	1 07.5	1 05.4	1 00.4		1 57.3	1 56.4	1 44.9		49.8		2 19.1					
430	1 09.1	1 06.9	1 01.6		2 00.1	1 59.1	1 47.1		51.0		2 22.4					
440	1 10.8	1 08.4	1 02.9		2 02.9	2 01.8	1 49.3		52.1		2 25.7					
450	1 12.4	1 09.9	1 04.2		2 05.7	2 04.5	1 51.5		53.3		2 29.0					
460	1 14.0	1 11.4	1 05.5		2 08.5	2 07.2	1 53.7		54.5		2 32.3					
470	1 15.6	1 12.9	1 06.7		2 11.3	2 09.9	1 55.9		55.7		2 35.6					
480	1 17.2	1 14.4	1 08.0		2 14.1	2 12.7	1 58.1		56.9		2 38.9					
490	1 18.8	1 15.9	1 09.3		2 16.9	2 15.4	2 00.3		58.1		2 42.2					
500	1 20.4	1 17.4	1 10.6		2 19.7	2 18.1	2 02.5		59.3		2 45.6					
510	1 22.0	1 18.9	1 11.8		2 22.4	2 20.8	2 04.7	1 00.4		2 48.9						
520	1 23.6	1 20.5	1 13.1		2 25.2	2 23.5	2 06.9	1 01.6		2 52.2						
530	1 25.2	1 22.0	1 14.4		2 28.0	2 26.2	2 09.1	1 02.8		2 55.5						
540	1 26.8	1 23.5	1 15.7		2 30.8	2 28.9	2 11.3	1 04.0		2 58.8						
550	1 28.4	1 25.0	1 16.9		2 33.6	2 31.6	2 13.5	1 05.2		3 02.1						
560	1 30.0	1 26.5	1 18.2		2 36.4	2 34.3	2 15.7	1 06.4		3 05.4						
570	1 31.7	1 28.0	1 19.5		2 39.2	2 37.0	2 17.9	1 07.5		3 08.7						
580	1 33.3	1 29.5	1 20.8		2 42.0	2 39.8	2 20.1	1 08.7		3 12.0						
590	1 34.9	1 31.0	1 22.0		2 44.9	2 42.5	2 22.3	1 10.0		3 15.3						
600	1 36.5	1 32.5	1 23.3		2 47.6	2 45.2	2 24.5	1 11.1		3 18.7						
610	1 38.1	1 34.0	1 24.6		2 50.4	2 47.9	2 26.7	1 12.3		3 22.0						
620	1 39.7	1 35.5	1 25.9		2 53.2	2 50.6	2 28.9	1 13.5		3 25.3						
630	1 41.3	1 37.0	1 27.1		2 56.0	2 53.3	2 31.1	1 14.7		3 28.6						
640	1 42.9	1 38.5	1 28.4		2 58.8	2 56.0	2 33.3	1 15.9		3 31.9						
650	1 44.5	1 40.0	1 29.7		3 01.5	2 58.7	2 35.5	1 17.0		3 35.2						
660	1 46.1	1 41.5	1 31.0		3 04.3	3 01.4	2 37.6	1 18.2		3 38.5						
670	1 47.7	1 43.0	1 32.3		3 07.1	3 04.1	2 39.8	1 19.4		3 41.8						
680	1 49.3	1 44.5	1 33.5		3 09.9	3 06.9	2 42.0	1 20.6		3 45.1						
690	1 51.0	1 46.1	1 34.8		3 12.7	3 09.6	2 44.2	1 21.7		3 48.5						
700	1 52.6	1 47.6	1 36.1		3 15.5	3 12.3	2 46.4	1 22.9		3 51.8						

APPENDIX I, continued

△ km	Pgl		P*		Pn		Sgl		S*		Sn		Sgl-Pgl		Rg	
	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s
710	1	54.2	1	49.1	1	37.4	3	18.3	3	15.0	2	48.6	1	24.1	3	55.1
720	1	55.8	1	50.6	1	38.6	3	21.1	3	17.7	2	50.8	1	25.3	3	58.4
730	1	57.4	1	52.1	1	39.9	3	23.9	3	20.4	2	53.0	1	26.5	4	01.7
740	1	59.0	1	53.6	1	41.2	3	26.7	3	23.1	2	55.2	1	27.7	4	05.0
750	2	00.6	1	55.1	1	42.5	3	29.5	3	25.8	2	57.4	1	28.9	4	08.3
760	2	02.2	1	56.6	1	43.7	3	32.3	3	28.5	2	59.6	1	30.1	4	11.6
770	2	03.8	1	58.1	1	45.0	3	35.1	3	31.2	3	01.8	1	31.3	4	14.9
780	2	05.4	1	59.6	1	46.3	3	37.9	3	34.0	3	04.0	1	32.5	4	18.3
790	2	07.0	2	01.1	1	47.6	3	40.6	3	36.7	3	06.2	1	33.6	4	21.6
800	2	08.6	2	02.6	1	48.8	3	43.4	3	39.4	3	08.4	1	34.8	4	24.9
810	2	10.2	2	04.1	1	50.1	3	46.2	3	42.1	3	10.6	1	36.0	4	28.2
820	2	11.9	2	05.6	1	51.4	3	49.0	3	44.8	3	12.8	1	37.1	4	31.5
830	2	13.5	2	07.1	1	52.7	3	51.8	3	47.5	3	15.0	1	38.3	4	34.8
840	2	15.1	2	08.6	1	53.9	3	54.6	3	50.2	3	17.2	1	39.5	4	38.1
850	2	16.7	2	10.2	1	55.2	3	57.4	3	52.9	3	19.4	1	40.7	4	41.4
860	2	18.3	2	11.7	1	56.5	4	00.2	3	55.6	3	21.6	1	41.9	4	44.7
870	2	19.9	2	13.2	1	57.8	4	03.0	3	58.3	3	23.8	1	43.1	4	48.1
880	2	21.5	2	14.7	1	59.0	4	05.8	4	01.1	3	26.0	1	44.3	4	51.4
890	2	23.1	2	16.2	2	00.3	4	08.6	4	03.8	3	28.2	1	45.5	4	54.7
900	2	24.7	2	17.7	2	01.6	4	11.4	4	06.5	3	30.4	1	46.7	4	58.0
910	2	26.3	2	19.2	2	02.9	4	14.2	4	09.2	3	32.6	1	47.9	5	01.3
920	2	27.9	2	20.7	2	04.2	4	17.0	4	11.9	3	34.8	1	49.1	5	04.6
930	2	29.5	2	22.2	2	05.4	4	19.7	4	14.6	3	37.0	1	50.2	5	07.9
940	2	31.2	2	23.7	2	06.7	4	22.5	4	17.3	3	39.2	1	51.3	5	11.2
950	2	32.8	2	25.2	2	08.0	4	25.3	4	20.0	3	41.4	1	52.5	5	14.5
960	2	34.4	2	26.7	2	09.3	4	28.1	4	22.7	3	43.6	1	53.7	5	17.9
970	2	36.0	2	28.2	2	10.5	4	30.9	4	25.4	3	45.8	1	54.9	5	21.2
980	2	37.6	2	29.7	2	11.8	4	33.7	4	28.2	3	48.0	1	56.1	5	24.5
990	2	39.2	2	31.2	2	13.1	4	36.5	4	30.9	3	50.2	1	57.3	5	27.8
1000	2	40.8	2	32.7	2	14.4	4	39.3	4	33.6	3	52.4	1	58.5	5	31.1
1010	2	42.4	2	34.2	2	15.6	4	42.1	4	36.3	3	54.6	1	59.7		
1020	2	44.0	2	35.8	2	16.9	4	44.9	4	39.0	3	56.8	2	00.9		
1030	2	45.6	2	37.3	2	18.2	4	47.7	4	41.7	3	59.0	2	02.1		
1040	2	47.2	2	38.8	2	19.5	4	50.5	4	44.4	4	01.2	2	03.3		
1050	2	48.8	2	40.3	2	20.7	4	53.3	4	47.1	4	03.4	2	04.5		

APPENDIX 1, continued

Δ	Pgl		P*		Pn		Sgl		S*		Sn		Sgl-Pgl	
	km	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s
1060	2	50.4	2	41.8	2	22.0	4	56.1	4	49.8	4	05.6	2	05.7
1070	2	52.1	2	43.3	2	23.3	4	58.9	4	52.5	4	07.8	2	06.8
1080	2	53.7	2	44.8	2	24.6	5	01.6	4	55.3	4	10.0	2	07.9
1090	2	55.3	2	46.3	2	25.8	5	04.4	4	58.0	4	12.2	2	09.1
1100	2	56.9	2	47.8	2	27.1	5	07.2	5	00.7	4	14.4	2	10.3
1110	2	58.5	2	49.3	2	28.4	5	10.0	5	03.4	4	16.6	2	11.5
1120	3	00.1	2	50.8	2	29.7	5	12.8	5	06.1	4	18.8	2	12.7
1130	3	01.7	2	52.3	2	30.9	5	15.6	5	08.8	4	21.0	2	13.9
1140	3	03.3	2	53.8	2	32.2	5	18.4	5	11.5	4	23.2	2	15.1
1150	3	04.9	2	55.3	2	33.5	5	21.2	5	14.2	4	25.4	2	16.3
1160	3	06.5	2	56.8	2	34.8	5	24.0	5	16.9	4	27.5	2	17.5
1170	3	08.1	2	58.3	2	36.1	5	26.8	5	19.6	4	29.7	2	18.7
1180	3	09.7	2	59.8	2	37.3	5	29.6	5	22.4	4	31.9	2	19.9
1190	3	11.4	3	01.4	2	38.6	5	32.4	5	25.1	4	34.1	2	21.0
1200	3	13.0	3	02.9	2	39.9	5	35.2	5	27.8	4	36.3	2	22.2
1210	3	14.6	3	04.4	2	41.2	5	38.0	5	30.5	4	38.5	2	23.4
1220	3	16.2	3	05.9	2	42.4	5	40.7	5	33.2	4	40.7	2	24.5
1230	3	17.8	3	07.4	2	43.7	5	43.5	5	35.9	4	42.9	2	25.7
1240	3	19.4	3	08.9	2	45.0	5	46.3	5	38.6	4	45.1	2	26.9
1250	3	21.0	3	10.4	2	46.3	5	49.1	5	41.3	4	47.3	2	28.1
1260	3	22.6	3	11.9	2	47.5	5	51.9	5	44.0	4	49.5	2	29.3
1270	3	24.2	3	13.4	2	48.8	5	54.7	5	46.7	4	51.7	2	30.5
1280	3	25.8	3	14.9	2	50.1	5	57.5	5	49.5	4	53.9	2	31.7
1290	3	27.4	3	16.4	2	51.4	6	00.3	5	52.2	4	56.1	2	32.9
1300	3	29.0	3	17.9	2	52.6	6	03.1	5	54.9	4	58.3	2	34.1
1310	3	30.6	3	19.4	2	53.9	6	05.9	5	57.6	5	00.5	2	35.3
1320	3	32.3	3	20.9	2	55.2	6	08.7	6	00.3	5	02.7	2	36.4
1330	3	33.9	3	22.4	2	56.5	6	11.5	6	03.0	5	04.9	2	37.6
1340	3	35.5	3	23.9	2	57.7	6	14.3	6	05.7	5	07.1	2	38.8
1350	3	37.1	3	25.5	2	59.0	6	17.1	6	08.4	5	09.3	2	40.0
1360	3	38.7	3	27.0	3	00.3	6	19.8	6	11.1	5	11.5	2	41.1
1370	3	40.3	3	28.5	3	01.5	6	22.6	6	13.8	5	13.7	2	42.3
1380	3	41.9	3	30.0	3	02.8	6	25.4	6	16.6	5	15.9	2	43.5
1390	3	43.5	3	31.5	3	04.1	6	28.2	6	19.3	5	18.1	2	44.7
1400	3	45.1	3	33.0	3	05.4	6	31.0	6	22.0	5	20.3	2	45.9

APPENDIX 1, continued

Δ	Fgl		F*		Pn		Sgl		S*		Sn		Sgl-Fgl	
	km	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	
1410	3	46.7	3	34.5	3	06.7	6	33.8	6	24.7	5	22.5	2	47.1
1420	3	48.3	3	36.0	3	08.0	6	36.6	6	27.4	5	24.7	2	48.3
1430	3	49.9	3	37.5	3	09.2	6	39.4	6	30.1	5	26.9	2	49.5
1440	3	51.6	3	39.0	3	10.5	6	42.2	6	32.8	5	29.1	2	50.6
1450	3	53.2	3	40.5	3	11.8	6	45.0	6	35.5	5	31.3	2	51.8
1460	3	54.8	3	42.0	3	13.1	6	47.8	6	38.2	5	33.5	2	53.0
1470	3	56.4	3	43.5	3	14.3	6	50.6	6	40.9	5	35.7	2	54.2
1480	3	58.0	3	45.0	3	15.6	6	53.4	6	43.7	5	37.9	2	55.4
1490	3	59.6	3	46.5	3	16.9	6	56.2	6	46.4	5	40.1	2	56.6
1500	4	01.2	3	48.0	3	18.2	6	59.0	6	49.1	5	42.3	2	57.8

APPENDIX 2. Travel times for $h = 12$ km

Δ km	Pg1		P*		Pn		Sg1		S*		Sn		Sg1-Pg1		PmP	
	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s
0		1.9						3.4						1.5		
10		2.5						4.4						1.9		
20		3.7						6.5						2.8		
30		5.2						9.0						3.8		
40		6.7						11.7						5.0	11.7	
50		8.3						14.4						6.1	12.6	
60		9.8						17.1						7.3	13.6	
70		11.4	12.0					19.8						8.4	14.7	
80		13.0	13.5					22.6						9.6	15.8	
90		14.6	15.0					25.4			30.3		10.8		17.0	
100		16.2	16.5	18.4				28.1			32.5		11.9		18.3	
110		17.8	18.0	19.6	30.9			30.9	31.6		34.7		13.1		19.7	
120		19.4	19.5	20.9	33.7	34.3		33.7	34.3	36.9		14.3		21.0		
130		21.0	21.0	22.2	36.5	37.0		36.5	37.0	39.1		15.5		22.4		
140		22.6	22.5	23.5	39.2	39.7		39.2	39.7	41.3		16.6		23.8		
150		24.2	24.1	24.7	42.0	42.4		42.0	42.4	43.5		17.8		25.2		
160		25.8	25.6	26.0	44.8	45.1		44.8	45.1	45.7		19.0		26.6		
170		27.4	27.1	27.3	47.6	47.8		47.6	47.8	47.9		20.2		28.0		
180		29.0	28.6	28.6	50.4	50.5		50.4	50.5	50.1		21.4		29.5		
190		30.6	30.1	29.8	53.2	53.3		53.2	53.3	52.3		22.6		30.9		
200		32.2	31.6	31.1	56.0	56.0		56.0	56.0	54.5		23.8		32.4		
210		33.8	33.1	32.4	58.8	58.7		58.8	58.7	56.7		25.0				
220		35.4	34.6	33.7	1 01.5	1 01.4		1 01.5	1 01.4	58.9		26.1				
230		37.0	36.1	34.9	1 04.3	1 04.1	1 01.1	1 04.3	1 04.1	1 01.1		27.3				
240		38.6	37.6	36.2	1 07.1	1 06.8	1 03.3	1 07.1	1 06.8	1 03.3		28.5				
250		40.2	39.1	37.5	1 09.9	1 09.5	1 05.5	1 09.9	1 09.5	1 05.5		29.7				
260		41.8	40.6	38.8	1 12.7	1 12.2	1 07.7	1 12.7	1 12.2	1 07.7		30.9				
270		43.5	42.1	40.0	1 15.5	1 14.9	1 09.9	1 15.5	1 14.9	1 09.9		32.0				
280		45.1	43.6	41.3	1 18.3	1 17.6	1 12.1	1 18.3	1 17.6	1 12.1		33.2				
290		46.7	45.1	42.6	1 21.1	1 20.4	1 14.3	1 21.1	1 20.4	1 14.3		34.4				
300		48.3	46.6	43.9	1 23.9	1 23.1	1 16.5	1 23.9	1 23.1	1 16.5		35.6				
310		49.9	48.1	45.1	1 26.6	1 25.8	1 18.6	1 26.6	1 25.8	1 18.6		36.7				
320		51.5	49.7	46.4	1 29.4	1 28.5	1 20.8	1 29.4	1 28.5	1 20.8		37.9				
330		53.1	51.2	47.7	1 32.2	1 31.2	1 23.0	1 32.2	1 31.2	1 23.0		39.1				
340		54.7	52.7	49.0	1 35.0	1 33.9	1 25.2	1 35.0	1 33.9	1 25.2		40.3				
350		56.3	54.2	50.3	1 37.8	1 36.6	1 27.4	1 37.8	1 36.6	1 27.4		41.5				

APPENDIX 2, continued

Δ	P _{g1}		P*		P _n		S _{g1}		S*		S _n		S _{g1} -P _{g1}	
	km	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s
360		57.9		55.7		51.5	1	40.5	1	39.3	1	29.6		42.6
370		59.5		57.2		52.8	1	43.3	1	42.0	1	31.8		43.8
380	1	01.1		58.7		54.1	1	46.1	1	44.7	1	34.0		45.0
390	1	02.7	1	00.2		55.4	1	48.9	1	47.5	1	36.2		46.2
400	1	04.3	1	01.7		56.6	1	51.7	1	50.2	1	38.4		47.4
410	1	05.9	1	03.2		57.9	1	54.5	1	52.9	1	40.6		48.6
420	1	07.5	1	04.7		59.2	1	57.3	1	55.6	1	42.8		49.8
430	1	09.1	1	06.2	1	00.5	2	00.1	1	58.3	1	45.0		51.0
440	1	10.8	1	07.7	1	01.7	2	02.9	2	01.0	1	47.2		52.1
450	1	12.4	1	09.2	1	03.0	2	05.7	2	03.7	1	49.4		53.3
460	1	14.0	1	10.7	1	04.3	2	08.5	2	06.4	1	51.6		54.5
470	1	15.6	1	12.2	1	05.6	2	11.3	2	09.1	1	53.8		55.7
480	1	17.2	1	13.7	1	06.8	2	14.1	2	11.8	1	56.0		56.9
490	1	18.8	1	15.3	1	08.1	2	16.9	2	14.6	1	58.2		58.1
500	1	20.4	1	16.8	1	09.4	2	19.7	2	17.3	2	00.4		59.3
510	1	22.0	1	18.3	1	10.7	2	22.4	2	20.0	2	02.6	1	00.4
520	1	23.6	1	19.8	1	11.9	2	25.2	2	22.7	2	04.8	1	01.6
530	1	25.2	1	21.3	1	13.2	2	28.0	2	25.4	2	07.0	1	02.8
540	1	26.8	1	22.8	1	14.5	2	30.8	2	28.1	2	09.2	1	04.0
550	1	28.4	1	24.3	1	15.8	2	33.6	2	30.8	2	11.4	1	05.2
560	1	30.0	1	25.8	1	17.0	2	36.4	2	33.5	2	13.6	1	06.4
570	1	31.7	1	27.3	1	18.3	2	39.2	2	36.2	2	15.8	1	07.5
580	1	33.3	1	28.8	1	19.6	2	42.0	2	38.9	2	18.0	1	08.7
590	1	34.9	1	30.3	1	20.9	2	44.9	2	41.7	2	20.2	1	10.0
600	1	36.5	1	31.8	1	22.2	2	47.6	2	44.4	2	22.4	1	11.1
610	1	38.1	1	33.3	1	23.4	2	50.4	2	47.1	2	24.6	1	12.3
620	1	39.7	1	34.8	1	24.7	2	53.2	2	49.8	2	26.8	1	13.5
630	1	41.3	1	36.3	1	26.0	2	56.0	2	52.5	2	29.0	1	14.7
640	1	42.9	1	37.8	1	27.3	2	58.8	2	55.2	2	31.2	1	15.9
650	1	44.5	1	39.4	1	28.5	3	01.5	2	57.9	2	33.4	1	17.0
660	1	46.1	1	40.9	1	29.8	3	04.3	3	00.6	2	35.6	1	18.2
670	1	47.7	1	42.4	1	31.1	3	07.1	3	03.3	2	37.8	1	19.4
680	1	49.3	1	43.9	1	32.4	3	09.9	3	06.0	2	40.0	1	20.6
690	1	51.0	1	45.4	1	33.6	3	12.7	3	08.8	2	42.2	1	21.7
700	1	52.6	1	46.9	1	34.9	3	15.5	3	11.5	2	44.4	1	22.9

APPENDIX 2, continued

Δ	Pgl		P*		Pn		Sgl		S*		Sn		Sgl-Pgl	
	km	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s
710	1	54.2	1	48.4	1	36.2	3	18.3	3	14.2	2	46.6	1	24.1
720	1	55.8	1	49.9	1	37.5	3	21.1	3	16.9	2	48.8	1	25.3
730	1	57.4	1	51.4	1	38.7	3	23.9	3	19.6	2	51.0	1	26.5
740	1	59.0	1	52.9	1	40.0	3	26.7	3	22.3	2	53.2	1	27.7
750	2	00.6	1	54.4	1	41.3	3	29.5	3	25.0	2	55.4	1	28.9
760	2	02.2	1	55.9	1	42.6	3	32.3	3	27.7	2	57.6	1	30.1
770	2	03.8	1	57.4	1	43.8	3	35.1	3	30.4	2	59.8	1	31.3
780	2	05.4	1	58.9	1	45.1	3	37.9	3	33.1	3	02.0	1	32.5
790	2	07.0	2	00.4	1	46.4	3	40.6	3	35.9	3	04.2	1	33.6
800	2	08.6	2	01.9	1	47.7	3	43.4	3	38.6	3	06.4	1	34.8
810	2	10.2	2	03.4	1	48.9	3	46.2	3	41.3	3	08.5	1	36.0
820	2	11.9	2	05.0	1	50.2	3	49.0	3	44.0	3	10.7	1	37.1
830	2	13.5	2	06.5	1	51.5	3	51.8	3	46.7	3	12.9	1	38.3
840	2	15.1	2	08.0	1	52.8	3	54.6	3	49.4	3	15.1	1	39.5
850	2	16.7	2	09.5	1	54.1	3	57.4	3	52.1	3	17.3	1	40.7
860	2	18.3	2	11.0	1	55.3	4	00.2	3	54.8	3	19.5	1	41.9
870	2	19.9	2	12.5	1	56.6	4	03.0	3	57.5	3	21.7	1	43.1
880	2	21.5	2	14.0	1	57.9	4	05.8	4	00.2	3	23.9	1	44.3
890	2	23.1	2	15.5	1	59.2	4	08.6	4	03.0	3	26.1	1	45.5
900	2	24.7	2	17.0	2	00.4	4	11.4	4	05.7	3	28.3	1	46.7
910	2	26.3	2	18.5	2	01.7	4	14.2	4	08.4	3	30.5	1	47.9
920	2	27.9	2	20.0	2	03.0	4	17.0	4	11.1	3	32.7	1	49.1
930	2	29.5	2	21.5	2	04.3	4	19.7	4	13.8	3	34.9	1	50.2
940	2	31.2	2	23.0	2	05.5	4	22.5	4	16.5	3	37.1	1	51.3
950	2	32.8	2	24.5	2	06.8	4	25.3	4	19.2	3	39.3	1	52.5
960	2	34.4	2	26.0	2	08.1	4	28.1	4	21.9	3	41.5	1	53.7
970	2	36.0	2	27.5	2	09.4	4	30.9	4	24.6	3	43.7	1	54.9
980	2	37.6	2	29.0	2	10.6	4	33.7	4	27.3	3	45.9	1	56.1
990	2	39.2	2	30.6	2	11.9	4	36.5	4	30.1	3	48.1	1	57.3
1000	2	40.8	2	32.1	2	13.2	4	39.3	4	32.8	3	50.3	1	58.5
1010	2	42.4	2	33.6	2	14.5	4	42.1	4	35.5	3	52.5	1	59.7
1020	2	44.0	2	35.1	2	15.7	4	44.9	4	38.2	3	54.7	2	00.9
1030	2	45.6	2	36.6	2	17.0	4	47.7	4	40.9	3	56.9	2	02.1
1040	2	47.2	2	38.1	2	18.3	4	50.5	4	43.6	3	59.1	2	03.3
1050	2	48.8	2	39.6	2	19.6	4	53.3	4	46.3	4	01.3	2	04.5

APPENDIX 2, continued

△ km	Fgl		P*		Pn		Sgl		S*		Sn		Sgl-Pgl	
	m	s	m	s	m	s	m	s	m	s	m	s	m	s
1060	2	50.4	2	41.1	2	20.8	4	56.1	4	49.0	4	03.5	2	05.7
1070	2	52.1	2	42.6	2	22.1	4	58.9	4	51.7	4	05.7	2	06.8
1080	2	53.7	2	44.1	2	23.4	5	01.6	4	54.4	4	07.9	2	07.9
1090	2	55.3	2	45.6	2	24.7	5	04.4	4	57.2	4	10.1	2	09.1
1100	2	56.9	2	47.1	2	26.0	5	07.2	4	59.9	4	12.3	2	10.3
1110	2	58.5	2	48.6	2	27.2	5	10.0	5	02.6	4	14.5	2	11.5
1120	3	00.1	2	50.1	2	28.5	5	12.8	5	05.3	4	16.7	2	12.7
1130	3	01.7	2	51.6	2	29.8	5	15.6	5	08.0	4	18.9	2	13.9
1140	3	03.3	2	53.1	2	31.1	5	18.4	5	10.7	4	21.1	2	15.1
1150	3	04.9	2	54.7	2	32.3	5	21.2	5	13.4	4	23.3	2	16.3
1160	3	06.5	2	56.2	2	33.6	5	24.0	5	16.1	4	25.5	2	17.5
1170	3	08.1	2	57.7	2	34.9	5	26.8	5	18.8	4	27.7	2	18.7
1180	3	09.7	2	59.2	2	36.2	5	29.6	5	21.5	4	29.9	2	19.9
1190	3	11.4	3	00.7	2	37.4	5	32.4	5	24.3	4	32.1	2	21.0
1200	3	13.0	3	02.2	2	38.7	5	35.2	5	27.0	4	34.3	2	22.2
1210	3	14.6	3	03.7	2	40.0	5	38.0	5	29.7	4	36.5	2	23.4
1220	3	16.2	3	05.2	2	41.3	5	40.7	5	32.4	4	38.7	2	24.5
1230	3	17.8	3	06.7	2	42.5	5	43.5	5	35.1	4	40.9	2	25.7
1240	3	19.4	3	08.2	2	43.8	5	46.3	5	37.8	4	43.1	2	26.9
1250	3	21.0	3	09.7	2	45.1	5	49.1	5	40.5	4	45.3	2	28.1
1260	3	22.6	3	11.2	2	46.4	5	51.9	5	43.2	4	47.5	2	29.3
1270	3	24.2	3	12.7	2	47.6	5	54.7	5	45.9	4	49.7	2	30.5
1280	3	25.8	3	14.2	2	48.9	5	57.5	5	48.6	4	51.9	2	31.7
1290	3	27.4	3	15.7	2	50.2	6	00.3	5	51.4	4	54.1	2	32.9
1300	3	29.0	3	17.2	2	51.5	6	03.1	5	54.1	4	56.3	2	34.1
1310	3	30.6	3	18.7	2	52.7	6	05.9	5	56.8	4	58.4	2	35.3
1320	3	32.3	3	20.3	2	54.0	6	08.7	5	59.5	5	00.6	2	36.4
1330	3	33.9	3	21.8	2	55.3	6	11.5	6	02.2	5	02.8	2	37.6
1340	3	35.5	3	23.3	2	56.6	6	14.3	6	04.9	5	05.0	2	38.8
1350	3	37.1	3	24.8	2	57.9	6	17.1	6	07.6	5	07.2	2	40.0
1360	3	38.7	3	26.3	2	59.1	6	19.8	6	10.3	5	09.4	2	41.1
1370	3	40.3	3	27.8	3	00.4	6	22.6	6	13.0	5	11.6	2	42.3
1380	3	41.9	3	29.3	3	01.7	6	25.4	6	15.7	5	13.8	2	43.5
1390	3	43.5	3	30.8	3	03.0	6	28.2	6	18.5	5	16.0	2	44.7
1400	3	45.1	3	32.3	3	04.2	6	31.0	6	21.2	5	18.2	2	45.9

APPENDIX 2, continued

Δ	Pgl		P*		Pn		Sgl		S*		Sn		Sgl-Pgl	
	km	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s
1410	3	46.7	3	33.8	3	05.5	6	33.8	6	23.9	5	20.4	2	47.1
1420	3	48.3	3	35.3	3	06.8	6	36.6	6	26.6	5	22.6	2	48.3
1430	3	49.9	3	36.8	3	08.1	6	39.4	6	29.3	5	24.8	2	49.5
1440	3	51.6	3	38.3	3	09.3	6	42.2	6	32.0	5	27.0	2	50.6
1450	3	53.2	3	39.8	3	10.6	6	45.0	6	34.7	5	29.2	2	51.8
1460	3	54.8	3	41.3	3	11.9	6	47.8	6	37.4	5	31.4	2	53.0
1470	3	56.4	3	42.8	3	13.2	6	50.6	6	40.1	5	33.6	2	54.2
1480	3	58.0	3	44.3	3	14.4	6	53.4	6	42.8	5	35.8	2	55.4
1490	3	59.6	3	45.9	3	15.7	6	56.2	6	45.6	5	38.0	2	56.6
1500	4	01.2	3	47.4	3	17.0	6	59.0	6	48.3	5	40.2	2	57.8

THE CATALOGUE. Earthquakes in Sweden 1951-1976

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No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1951								
1	Feb 21	18 45	63.8 N, 19.1 E (macr)		2.0	3	10	Vasterbotten. Not recorded.
			Felt: Bjurholm (Nordansjö, Långvik), Nordmaling (Bjertensjön)					
2	Oct 9		66.0 N, 17.9 E (macr)		2.0	3	10	Lappland. Not recorded.
			Felt: Arjeplog, Kuorekveik					
1952								
3	Dec 27	21 30	63.1 N, 18.3 E (macr)	$h_a = 9$	2.5	4	18	Ångermanland. Not recorded.
			Felt: Docksta, Drömme, Gavik (Nora), Häggviken, Mäja (Ullånger), Mjällom, Nordingrå, Salsåker, Ulvöhamn					
1953								
4	Mar 6	21 44 05.4	59.86 N, 11.11 E ± 0.8 (7)	$h_a = 50$ ± 0 (4)	3.9 ± 0.3 (2)	5	150	Akershus, Norway.
			Felt: Ågård, Åmål, Årjäng, Arvika, Bogen, Brunsberg, Brunskog, Bullaren, Charlottenberg, Dals-Ed, Ed, Edebäck, Glava, Gränssjön, Grums, Havstensund, Hjällsgård (Skee), Högsäter (Skillingmark), Karlstad, Koster, Krokstad, Krokstrand, Lönnhöjden (Gräsmark), Månserud, Norra Åsen (Holmedal), Olerud (Skillingmark), Östervallskog, Säffle, Strömstad, Sunne, Töcksfors, Torsby, Trättlanda (Blomskog), Vittensten (Eda) (also felt in Norway)					

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1953								
5	Sep 22	19 44 21.4 ± 0.4 (2)	61.40 N, 16.77 E (2)	24 \pm 1 (2) $h_a = 8$	3.0 \pm 0.4 (2)	4	15	Hälsingland. Felt: Bergvik, Söderhamn
6	Nov 11	22 30 03.7 ± 0.5 (2)	62.5 N, 17.0 E (macr)	$h_a = 21$	2.5 \pm 0.5 (2)	4	40	Medelpad. Felt: Kovland, Liden, Ljungaverken, Österbrån (Säbrån), Skallböle, Sundsvall
1954								
7	Oct 27	08 10 15.6 (2)	58.94 N, 14.64 E (2)	$h_a = 9$	2.5 (1)	4	17	Närke-Västergötland. Felt: Askersund, Finnerödja, Gårdsjö, Skyllberg, Snavlunda, St. Björstorp
1955								
8	May 24	21 10 (macr)	64.3 N, 20.7 E (macr)	$h_a = 15$	2.8	4	28	Västerbotten. Not recorded. Felt: Burträsk, Lövånger, Robertsfors, Storbrännan, Vebomark
9	Aug 30	15 21 15.4 ± 0.1 (2)	59.5 N, 13.6 E (2)	23 \pm 10 (6) $h_a = 17$	3.2 \pm 0.1 (2)	4	32	Värmland. Felt: Alster, Arnön (Våse), Deje, Forshaga, Gunnerud (Alster), Karlstad, Kil, Munkfors, Norsbron, Skoghall, Stömne, Värmlands-Hedås

THE CATALOGUE, continued

No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1955								
10	Nov 15	08 48 56.2 ± 0.4 (2)	58.3 N, 13.7 E (macr)	$h_a = 13$	2.8 (1)	4	25	Västergötland. Felt: Åsarp, Åsslätt, Broddetorp, Falköping, Fårdala, Gudhem, Källtorp, Kavlös, Skara, Skövde, Skultorp, Stenstorp, Tibro, Varnhem
11	Dec 5	00 00	58.2 N, 13.6 E (macr)	$h_a = 16$	2.3	3	17	Västergötland. Not recorded. Felt: Åsarp, Gate, Gudhem, Skövde, Skultorp, Varnhem
1956								
12	Jan 1	04 55 31.7 ± 0.4 (5)	61.4 N, 16.8 E (macr)	21 (3) $h_a = 13$	2.4 (1)	4	25	Hälsingland. Felt: Bollnäs, Florsberg, Glösbo, Granbo, Håviken (Söderala), Kilafors, Mo, Mobodarna, Mokorset, Nianfors, Norrala, Söderhamn, Strand (Skog)
13	Jan 21	01 51 05.4 ± 0.3 (3)	66.00 N, 17.27 E ± 5 (3)	25 ± 16 (3) $h_a = 23$	2.9 ± 0.0 (2)	4	44	Lappland. Felt: Ammarnäs, Arjeplog, Båtsjaur, Björkliden, Böckholm, Hemfjäll (Sorsele), Jutis, Mullholm, Slagnäs, Storvindeln, Svannäs

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1956								
14	Feb 15	03 50 10.0 ± 0.9 (2)	57.5 N, 13.4 E (macr)	10 (1) $h_a = 16$	2.3 (1)	4	31	Västergötland
Felt: Ambjörnarp, Anderstorp, Axelfors, Dalstorp, Gislaved, Gnosjö, Grimsås, Håksvik, Limmared, Nissafors, Reftete, Skeppared, Svenljunga, Tranemo, Uddebo, Vegby								
15	Jul 8	23 16 23.0 ± 0.9 (2)	58.1 N, 13.0 E (macr)		2.0 (1)		10	Västergötland.
Felt: Fåglavik, Herrljunga								
16	Jul 9	20 36	58.5 N, 13.6 E (macr)		2.0	3	10	Västergötland. Not recorded.
Felt: Klyftamon (Lerdala), Lövängen (Skärv), Valle, Varnhem								
17	Aug 26	08 09 56.7 ± 0.8 (3)	62.11 N, 16.72 E ± 5 (3)	22 \pm 4 (7) $h_a = 16$	3.3 \pm 0.1 (3)	4-5	38	Hälsingland.
Felt: Älgbohed, Annsjön (Bergsjö), Attmar, Bergsjö, Ejuråker, Delabo, Edeström (Bergsjö), Friggesund, Gnarp, Grånsfors, Hassela, Hedvigsfors, Jättendal, Matfors, Ramsjö, Sänningstjärn, Strömsbruk								
18	Aug 31	10 47 51.8 ± 0.5 (3)	65.56 N, 17.35 E ± 5 (3)	17 (1) $h_a = 9$	3.2 \pm 0.1 (3)	4	17	Lappland.
Felt: Örnäsudden, Sorsele, Vindel-Grannäs								

THE CATALOGUE, continued

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No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
	1957							
19	Jan 26	12 28 03.4 ± 0.8 (3)	64.54 N, 21.33 E (3)	3 ± 1 (2)	2.9 ± 0.1 (3)			Västerbotten.
20	Apr 10	20 03 48.1 ± 0.9 (4)	64.13 N, 20.56 E ± 3 (4)	27 ± 2 (2)	3.0 ± 0.2 (3)			Västerbotten.
21	Apr 11	08 05 29.8 ± 1.0 (4)	64.13 N, 20.56 E ± 4 (4)	25 (1)	2.8 ± 0.2 (3)			Västerbotten.
22	Jun 2	05 50	57.9 N, 14.8 E (macr)	$h_a = 9$	2.5	4	18	Småland. Not recorded.
		Felt: Adelöv, Aneby, Frinnaryd, Lommaryd, Marbäck, Ramfall (Torpa), Skärstad, Vireda, Ydre						
23	Sep 20	09 32 28.1 ± 1.5 (3)	66.77 N, 19.58 E (3)	17 ± 15 (3)	2.7 ± 0.0 (2)			Lappland.
24	Oct 10	20 20 44.7 ± 0.5 (3)	61.15 N, 14.85 E (3)	25 (1) $h_a = 32$	2.8 ± 0.4 (2)	3	34	Dalarna. Felt: Höljes, Örviken, Rörbäcksnäs, Tandö (Lima), Värmlands-Dalby (also felt in Norway)

MARKUS BÄTH

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
	1958							
25	Jan 19	01 52 13.5 ± 1.5 (3)	67.43 N, 23.72 E ± 0 (3)		3.2 ± 0.1 (2)			Norrbotten.
26	Jan 19	19 45 05.7 ± 0.6 (3) Felt: Nilivaara, Palo, Saittarova, Ullatti	67.11 N, 21.61 E ± 4 (3)	13 ± 10 (5) $h_a = 12$	2.9 ± 0.0 (2)	4	24	Lappland.
27	Feb 25	09 18 28.6 ± 1.6 (5)	62.07 N, 19.47 E ± 6 (5)		2.9 ± 0.2 (3)			Bothnian Bay.
28	Aug 28	23 12 10.3 ± 1.7 (5) Felt: Bodträskfors, Bredåker, Gransjö, Harads, Ljuså, Mårdudden, Sandtrask, Sörbyn, Svartlå	66.17 N, 21.34 E ± 6 (5)	21 ± 16 (8) $h_a = 9$	3.2 ± 0.2 (3)	5	28	Norrbotten.
29	Sep 17	06 22 42.7 ± 0.8 (3) Felt: Bronäs, Bya, Eskilsäter, Gaperhult, Götene, Grastorp, Kållandsö, Källby, Källtorp, Lidköping, Lundsbrunn, Lurö, Madångsholm, Råda, Salstad, Skara, Tådene, Torsö, Vara, Varnhem	58.47 N, 13.55 E ± 3 (3)	$h_a = 15$	3.2 ± 0.3 (4)	5	45	Västergötland.

THE CATALOGUE, continued

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No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
	1958							
30	Sep 29	13 40	56.6 N, 13.7 E (macr)	$h_a = 11$	2.9	4-5	25	Småland. Not recorded. Doubtful.
			Felt: Agunnaryd, Bölminge, Delary, Eneyrda, Göteryd, Hallaryd, Hamneda, Hinneryd, Hornsberg, Pjätteryd, Rante, Södra Ljunga, Strömsnasbruk, Torpa, Traryd, Vivljunga					
31	Oct 4	00 32 58.2 ± 0.9 (4)	64.35 N, 20.62 E ± 4 (4)	17 ± 7 (3) $h_a = 14$	2.8 ± 0.3 (3)	4	26	Vasterbotten.
			Felt: Åsträsk, Bodbysund, Bygdeträsk, Flarken, Innansjön, Kålabodaby, Lappvattnet, Storbrannan, Vebomark					
32	Dec 19	00 50 26.9 ± 3.2 (6)	66.36 N, 13.20 E ± 11 (6)	17 ± 16 (24) $h_a = 37$	4.7 ± 0.2 (4)	6	170	Nordland, Norway. I_0 and r estimated.
			Felt: Ammarnäs, Borgafjäll, Gardvik, Håkakot, Hemavan, Jäckvik, Jutis, Långsjöby, Medelefors, Ripfjäll, Slussfors, Storuman, Tarnaby, Umfors, Umnäs, Vilhelmina (felt strongest in Norway)					
33	Dec 19	07 56 16.5 ± 4.0 (6)	66.36 N, 13.20 E ± 11 (6)	11 ± 9 (16)	4.5 ± 0.3 (4)			Nordland, Norway.
			Felt: Ammarnäs, Håkakot, Hemavan, Högsta, Jutis, Mjölkbäcken, Tarnaby, Umfors, Umnäs (felt strongest in Norway)					

MARKUS BÄTH

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1959								
34	Aug 18	16 28 32.3 ± 0.9 (3)	57.90 N, 11.48 E ± 2 (3)		3.0 ± 0.1 (3)			Bohuslän.
35	Nov 3	07 38 58.4 ± 1.3 (4)	59.52 N, 15.86 E ± 4 (4)	$h_a = 9$	2.8 ± 0.3 (3)	5	26	Västmanland. Felt: Ängen, Arboga, Åsby, Aspånge, Baggbron, Bergtorpet, Bernshammar, Bro, Ekeby, Ekebybro, Ekorrtorp (Heden), Enbo, Gisslarbo, Grönö, Hamre, Hed, Hedströmmen, Himmeta, Holmen, Jönsarbo, Karmansbo, Kindbro, Kolbäck, Kolsva, Krampen, Lyftinge, Malmön, Näverkärret, Östtuna, Södra Skogen, Solmyra, Sör-Berga, Stjärnvik, Vahlsta, Vallby, Valskog, V. Skedvi, Virsbo
1960								
36	Mar 16	14 35	58.4 N, 12.0 E (macr)	$h_a = 12$	2.4	3-4	17	Bohuslän. Not recorded. Doubtful. Felt: Ängebacken, Forshälla, Grohed, Kleva-Orust, Ljungskil, Myckleby, Ramseröd, Ryr, Skredsvik, Stillingsön, Uddevalla
37	Oct 15	06 19 35.4 ± 1.8 (3)	64.23 N, 19.39 E ± 8 (5)	24 ± 10 (4)	3.0 ± 0.1 (4)			Västerbotten.

THE CATALOGUE, continued

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No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1960								
38	Oct 20	11 50 12.4 ± 1.9 (4)	56.36 N, 13.30 E ± 7 (4)	$h_a = 23$	2.8 ± 0.3 (4)	4	44	Skåne. Felt: Åsbo-Össjö, Åsljunga, Eket, Eljalt, Färingtofta, Hulshult, Hyllstofta, Klippan, Oderljunga, Ö. Ljungby, Örke lljunga, Perstorp, Riseberga, Röke, Spången (2 km east of Ljungbyhed), Stidsvig, Toboda (Våxtorp), Visseltofta
1961								
39	Feb 17	03 21 49.3 ± 0.6 (5)	65.18 N, 24.23 E ± 4 (5)	28 ± 15 (9)	3.7 ± 0.1 (5)			Bothnian Bay. Felt in Finland
40	Apr 4	11 48 49.6 ± 1.2 (6)	56.95 N, 13.29 E ± 5 (4)		2.7 ± 0.4 (4)	3	10	Småland. Felt: Hyltebruk, Landeryd, Rydöbruk, Västbo, Yaberg (Höljeryd) (macroseismic information probably incomplete)
1962								
41	Mar 15	00 33 30.9 ± 1.8 (4)	65.52 N, 22.39 E ± 6 (4)	27 ± 18 (6)	2.5 ± 0.1 (3)			Bothnian Bay.

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THE CATALOGUE, continued

No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1962								
42	May 17	13 09 37.5 ± 0.3 (6)	65.66 N, 21.43 E (3)		3.1 ± 0.2 (3)			Norrbotten.
43	Jun 28	22 35 40.8 ± 0.4 (4)	60.93 N, 17.18 E ± 5 (4)	14 ± 5 (5)	2.6 ± 0.1 (4)			Gastrikland.
44	Jul 5	21 45	62.5 N, 15.9 E (macr)	$h_a = 7$	2.1	3-4	10	Medelpad. Not recorded.
Felt: Borgsjöbyn								
45	Sep 28	17 22 01.7 ± 0.6 (6)	64.52 N, 20.54 E ± 4 (8)	17 ± 15 (13) $h_a = 25$	3.8 ± 0.3 (6)	4-5	60	Vasterbotten. Felt: Åkullsjön, Ånaset, Arnberg, Åstråsk, Bastutråsk, Bjurträsket, Bodbysund, Boliden, Burträsk, Bygdetråsk, Bygdsiljum, Byske, Drängemark, Ekträsk, Finnforsfallet, Finnträsk, Granliden, Granö, Gravmark, Gummark, Hjoggböle, Högdalsås, Holmträsk, Innansjön, Innervik, Jörn, Kåge, Kålabodaby, Kalvträsk, Klutmark, Kvarnbysund, Lappvattnet, Lövånger, Lubboträsk, Melsliden, Norreträsk, Norsjö, Norsjö-Vallen, Österjörn, Överklinten, Rödåsel, Rörviken, Skellefteå, Skråmträsk, Stavatrask, Storbrännan, Svartnäs, Västanträsk, Vebomark, Vindeln, Yttersjön

THE CATALOGUE, continued

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No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1962								
46	Oct 16	17 55 56.3 ± 0.3 (3)	64.55 N, 20.52 E (3)		2.6 \pm 0.2 (4)			Västerbotten.
47	Oct 18	10 35 48.0 ± 1.9 (6)	60.87 N, 11.34 E ± 6 (6)	25 \pm 16 (14) $h_a = 32$	4.2 \pm 0.4 (5)	6	145	Hedmark, Norway. I_0 and r estimated. Felt: Amnerud, Aspberget, Bastuknappen, Bjurberget, Bogen, Bograngen, Charlottenberg, Edeback, Eksharad, Heden, Järpliden, Kärrbackstrand, Klaråsen, Likenäs, Lima, Limesforsen, Loffstrand, Malung, Malungsfors, Mårbacken, Medskogen, Norra Finnskoga, Östra Näsberget, Röjdåfors, Rörbäcksnäs, Sälen, Skillingsfors, Sörsjön, Stället, Syslebäck, Torgåsmon, Torsby, Uggleheden, Vägsjöfors, Venjan (also felt in Norway)
48	Dec 15	03 48 35.6 ± 1.5 (6)	67.51 N, 14.22 E ± 6 (6)	21 \pm 19 (11)	4.5 \pm 0.2 (5)	6	235	Nordland, Norway. I_0 and r estimated. Felt: Amarnäs, Arjeplog, Aspнас, Jäckvik, Långudden, Lycksele, Merkinas, Porjus, Randijaur, Sadvaluspen, Sorsele, Tarnaby, Tjåmotis, Umfors (also felt in Norway)
1963								
49	Jan 14	12 00	65.5 N, 21.4 E (macr)	$h_a = 5$	2.1	4	10	Norrbottnen. Not recorded. Doubtful. Felt: Alterdalen, Altersbruk, Backträsk, Holmträsk

THE CATALOGUE, continued

No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
	1963							
50	Jun 19	17 00 19.8 ± 1.3 (4)	56.27 N, 11.74 E ± 4 (4)		3.0 ± 0.3 (4)			Kattegatt.
51	Aug 5	13 15	61.2 N, 17.3 E (macr)	$h_a = 10$	2.6	4	20	Hälsingland. Not recorded. Doubtful. Felt: Hå, Ljusne, Östanbo, Sandarne, Skallgårdssund, Söderhamn, Stenö, Storzjungfrun, Sunnäsbruk
52	Oct 3	02 05 32.4 ± 0.4 (6)	64.90 N, 22.26 E ± 5 (6)	29 ± 19 (3)	2.9 ± 0.4 (4)			Bothnian Bay.
53	Oct 11	16 39 43.3 ± 1.4 (5)	58.55 N, 13.13 E ± 4 (5)	23 (1) $h_a = 14$	3.0 ± 0.3 (4)	4	26	Västergötland. Felt: Götene, Kållandsö, Kvanum, Lidköping
54	Oct 29	18 28 33.0 ± 1.7 (5)	65.91 N, 21.42 E ± 4 (5)	20 ± 13 (7)	3.0 ± 0.4 (4)			Norrbotten. Felt: see following earthquake

THE CATALOGUE, continued

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No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1963								
55	Oct 29	18 28 36.8 ± 1.6 (4)	65.91 N, 21.42 E ± 4 (5)	22 \pm 9 (3) $h_a = 9$	3.2 \pm 0.3 (5)	5-6	35	Norrbotten Felt: Ängesbyn, Avaheden, Boden, Brännberg, Degerberget, Gransjö, Gunnarsbyn, Häggan, Hedsvedjan, Hundsjö, Ljuså, Norra Bredåker, Norriån, Orrbyn, Sävast, Skogså, Slumpberget, Södra Bredåker, Svartbjörnsbyn, Ubbyn, Vändträsk
56	Nov 2	22 54 56.4 ± 0.8 (5)	57.04 N, 11.85 E ± 0 (5)	29 \pm 13 (3)	2.9 \pm 0.1 (4)			Kattegatt.
1965								
57	Jan 23	11 09 38.2 ± 1.1 (11)	64.95 N, 23.34 E ± 3 (11)	14 \pm 15 (11)	3.4 \pm 0.1 (6)			Bothnian Bay.
58	Feb 23	13 55 34.1 ± 0.4 (4)	64.73 N, 20.56 E ± 3 (5)	13 \pm 2 (2)	2.4 \pm 0.3 (5)			Västerbotten. Doubtful.
1966								
59	Apr 12	17 29 48.0 ± 0.4 (3)	61.45 N, 16.63 E (3)		2.1 \pm 0.2 (2)			Hälsingland.

MARKUS BÄTH

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1966								
60	Apr 22	18 36 21.7 ± 0.5 (6)	58.34 N, 14.18 E ± 2 (6)	28 ± 19 (3)	2.7 ± 0.1 (5)			Västergötland.
61	Sep 9	16 01 23.9 ± 0.8 (5)	58.45 N, 14.07 E ± 3 (5)	14 ± 24 (4)	2.6 ± 0.2 (4)			Västergötland.
62	Oct 14	16 08 22.3 ± 0.4 (6)	65.24 N, 22.51 E ± 2 (3)		2.5 ± 0.1 (3)			Bothnian Bay.
1967								
63	Jan 4	04 44 18.9 ± 1.5 (6)	68.00 N, 20.63 E ± 8 (7)	28 (1) $h_a = 15$	3.2 ± 0.3 (4)	4-5	35	Lappland. Felt: Jukkasjärvi, Kalixfors, Kiruna, Kurravaara, Övre Sopperö, Rensjön
64	Feb 4	15 34 54.6 ± 1.3 (14)	59.50 N, 13.35 E ± 4 (14)	23 ± 10 (22) $h_a = 20$	3.4 ± 0.3 (7)	5-6	75	Värmland. Felt: Åmål, Åmotfors, Arvika, Åtorp, Bäckalund, Björktjärn, Björneborg, Bogen, Brattforshyttan, Deje, Forshaga, Granbergsdal, Gråsmark, Grums, Gustavsfors, Hagfors, Hällefors, Karlsdal, Karlskoga, Karlstad, Kil, Klingevi, Kristinehamn, Lakene, Långserud, Lekvattnet, Lesjöfors, Lindfors, Linneback, Maggeby, Mårbacken, Molkom, Munkfors, Nykroppa, Olsäter, Ölserud, Östmark, Östra Ämtervik, Persberg, Råda, Ransäter, Saffle, Segmon, Skattkärr, Skived, Skoghäll, Stavnäs, Storfors, Sunne, Torrskog, Torsby, Ulvsby, Värmlandsbro, Värmlands-Hedås, Värmskog, Vase, Västra Ämtervik, Västra Skymnäs, Visnum

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1967								
65	Apr 10	05 14 33.7 ± 1.7 (11)	65.23 N, 22.65 E ± 5 (11)	16 ± 17 (16)	3.1 ± 0.3 (5)			Bothnian Bay.
66	Apr 13	08 46 16.1 ± 2.1 (12)	68.32 N, 20.76 E ± 7 (12)	29 ± 14 (13)	3.4 ± 0.1 (7)			Lappland.
67	Apr 13	09 03 46.5 ± 1.7 (12)	63.23 N, 18.99 E ± 6 (13)	10 ± 13 (10) $h_a = 16$	3.3 ± 0.3 (7)	4	30	Ångermanland. Felt: Alfredshem, Bjästa, Docksta, Domsjöverken, Gideå, Högländ, Hörnett, Husum, Järved, Kroksta, Moliden, Nolaskog, Örnsköldsvik, Översjöala, Sidensjö, Själevad, Skagsudde, Skeppsmalm, Sundåsen, Svedjeholmen
68	Apr 14	15 57 17.4 ± 0.8 (5)	58.34 N, 13.91 E ± 4 (6)		2.6 ± 0.1 (3)			Västergötland.
69	May 24	16 14 24.3 ± 1.3 (5)	67.49 N, 21.00 E ± 5 (5)		2.5 ± 0.1 (3)			Lappland.
70	Jun 8	08 50 57.6 ± 1.2 (5)	65.40 N, 24.13 E ± 6 (3)		2.8 ± 0.4 (2)			Bothnian Bay.
71	Jun 13	13 44 55.3 ± 0.4 (5)	65.12 N, 24.31 E ± 3 (3)		2.3 ± 0.2 (3)			Bothnian Bay.

THE CATALOGUE, continued

No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1967								
72	Jun 24	15 01 48.3 ± 0.5 (6)	60.88 N, 15.00 E ± 2 (4)		2.3 ± 0.2 (4)			Dalarna.
73	Aug 16	22 44 51.3 ± 1.0 (7)	59.24 N, 13.41 E ± 4 (7)	30 ± 13 (4) $h_a = 16$	2.6 ± 0.4 (6)	4	30	Lake Vänern. Felt: Alster, Forshaga, Högboda, Hynboholm, Kil, Skåre, Skoghall, Ulvsby
74	Aug 24	23 11 54.6 ± 0.7 (4)	64.86 N, 21.24 E ± 3 (4)		2.4 ± 0.2 (4)			Vasterbotten.
75	Oct 9	13 29 21.7 ± 0.5 (6)	65.44 N, 22.27 E ± 2 (4)		2.5 ± 0.1 (3)			Bothnian Bay.
76	Oct 19	08 55 35.8 ± 0.5 (5)	62.43 N, 17.10 E ± 0 (4)		2.5 ± 0.1 (3)			Medelpad.
77	Oct 22	07 43 13.0 ± 0.4 (5)	61.84 N, 14.42 E ± 6 (5)		2.3 ± 0.3 (4)			Härjedalen.
78	Nov 29	09 25 23.7 ± 0.6 (4)	60.69 N, 17.61 E ± 7 (6)	28 ± 8 (5) $h_a = 4$	2.7 ± 0.3 (5)	4-5	(10)	Uppland. Felt: Furuvik, Fyrtornet, Skutskar

THE CATALOGUE, continued

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No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1967								
79	Nov 30	11 47 14.5 ± 1.0 (8)	59.04 N, 13.74 E ± 4 (8)	15 ± 7 (5)	2.9 ± 0.3 (7)			Lake Vänern. Probably a smaller aftershock 3.3 sec later.
80	Dec 4	04 59 05.9 ± 0.7 (3)	66.64 N, 23.31 E ± 3 (3)		2.4 ± 0.1 (2)			Norrbotten.
81	Dec 18	09 54 07.7 ± 0.5 (3)	60.56 N, 16.56 E (3)		1.9 ± 0.2 (3)			Gästrikland.
1968								
82	Feb 6	01 27 32.0 ± 1.7 (8)	57.33 N, 12.33 E ± 6 (8)	$h_a = 16$	2.4 ± 0.2 (6)	4	31	Halland. Felt: Åkulla, Ålekulla, Björketorp, Fotskäl, Frillesås, Himle, Horred, Kungsäter, Långås, Öjersås, Rolfstorp, Skällinge, Torestorp, Varberg, Våröbacka, Veddige
83	Mar 12	07 32 35.6 ± 1.2 (9)	58.65 N, 13.67 E ± 7 (9)	13 ± 13 (9) $h_a = 12$	3.1 ± 0.2 (6)	4	23	Västergötland. Felt: Björsäter, Ekby, Forshem, Frösve, Gösäter, Götene, Hällekis, Jula, Lerdala, Lugnås, Lugnsäter, Mariestad, Odensåker, Tidavad, Timmersdala, Torsö, Ullervad, Utby

MARKUS BATH

THE CATALOGUE, continued

No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1968								
84	Mar 28	03 42 00.1 ± 0.9 (5)	60.59 N, 15.93 E ± 4 (5)	16 \pm 10 (10) $h_a = 14$	2.8 \pm 0.3 (5)	4-5	33	Dalarna. Felt: Åshammar, Bengtsheden, Boda, Borgårdet, Enviken, Grycksbo, Hillersboda, Hofors, Jädraås, Järbo, Långshyttan, Linghed, Lumsheden, Svärdejö, Torsåker
85	Jun 1	04 50 17.1 ± 1.0 (4)	68.41 N, 20.79 E ± 7 (5)	22 \pm 13 (5)	2.6 \pm 0.3 (5)			Lapland.
86	Jun 1	20 29 59.4 ± 0.2 (4)	63.39 N, 21.30 E ± 2 (4)		2.3 \pm 0.2 (4)			Bothnian Bay.
87	Jun 13	04 49 58.1 ± 1.2 (6)	64.41 N, 20.67 E ± 4 (6)	14 \pm 14 (5)	2.6 \pm 0.1 (5)			Västerbotten.
88	Sep 1	14 25 45.3 ± 0.9 (4)	66.31 N, 22.47 E ± 4 (4)		2.5 \pm 0.1 (4)			Norrbottn.
89	Sep 1	16 07 45.2 ± 0.5 (3)	66.31 N, 22.47 E ± 4 (4)		2.4 \pm 0.1 (4)			Norrbottn.

THE CATALOGUE, continued

No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
	1968							
90	Sep 3	22 35 17.1 ± 0.9 (9)	58.45 N, 14.00 E ± 3 (10)	12 \pm 14 (10) $h_a = 14$	3.2 \pm 0.2 (7)	5-6	50	Västergötland. Felt: Axvall, Beateberg, Blikstorp, Börstig, Broddetorp, Falköping, Folkabo, Furubacken, Götene, Gudhem, Härlunda, Herrljunga, Hjo, Holmestad, Hova, Husaby, Jula, Kållandsö, Karlsborg, Kvanum, Lerdala, Lugnås, Lundsbrunn, Mariestad, Moholm, Mölltorp, Sandhem, Säter, Skara, Skövde, Skultorp, Stenstorp, Tibro, Tidaholm, Tidän, Timmersdala, Töreboda, Ulvåker, Undenas, Vårgårda, Varing, Varnhem, Varsås, Vinninga
91	Sep 4	17 09 15.6 ± 1.6 (14)	66.86 N, 23.86 E ± 6 (13)	13 \pm 9 (14) $h_a = 14$	3.3 \pm 0.3 (6)	3-4	20	Norrbottn. Felt: Pello, Rantajarvi
92	Oct 11	19 23 07.4 ± 0.9 (4)	59.53 N, 12.75 E ± 3 (4)		2.6 \pm 0.6 (2)			Värmland.
93	Oct 12	15 52 22.8 ± 0.3 (5)	66.85 N, 17.51 E ± 2 (3)		2.1 \pm 0.1 (2)			Lappland.
94	Dec 6	14 29 07.0 (3)	58.07 N, 11.88 E (3)		2.1 \pm 0.2 (2)			Bohuslän.
95	Dec 25	15 28 20.9 ± 1.5 (4)	68.19 N, 20.70 E ± 6 (4)		2.7 \pm 0.2 (3)			Lappland.

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
		1969						
96	Feb 5	12 09 39.3 ± 0.4 (4)	58.60 N, 13.66 E ± 2 (3)		2.3 ± 0.1 (3)			Västergötland.
97	Feb 13	18 04 03.6 ± 0.8 (6)	59.39 N, 12.85 E ± 4 (5)		2.5 ± 0.3 (4)			Värmland.
98	Feb 14	12 25 39.6 ± 0.9 (4)	58.61 N, 15.06 E ± 3 (3)		2.2 ± 0.0 (2)			Östergötland.
99	Feb 15	04 31 20.0 ± 1.2 (5)	65.21 N, 22.86 E ± 4 (5)		2.3 ± 0.5 (3)			Bothnian Bay.
100	Jun 19	23 59 07.7 ± 0.9 (5)	67.63 N, 19.47 E ± 4 (5)	32 (1)	2.5 ± 0.2 (2)			Lappland.
101	Jul 4	22 28 53.0 ± 2.4 (10)	67.74 N, 19.40 E ± 8 (10)	17 ± 17 (9)	2.9 ± 0.2 (5)			Lappland.
102	Jul 20	07 00 53.4 ± 1.4 (10)	66.95 N, 22.89 E ± 5 (10)	23 ± 8 (3)	2.7 ± 0.3 (4)			Norrbottn.

THE CATALOGUE, continued

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No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1969								
103	Aug 15	19 44 52.9 ± 0.6 (7)	65.63 N, 22.00 E ± 2 (3)	18 \pm 6 (4)	2.2 \pm 0.6 (3)			Norrbotten.
104	Sep 12	10 54 58.4 ± 1.1 (4)	66.78 N, 15.87 E ± 5 (3)		2.0 \pm 0.2 (3)			Lappland.
105	Sep 17	09 37 39.8 ± 1.3 (5)	64.66 N, 21.60 E ± 5 (5)	3 (1)	2.2 \pm 0.5 (2)			Västerbotten.
106	Nov 30	08 29 36.6 ± 1.6 (7)	65.40 N, 22.83 E ± 6 (7)		2.2 \pm 0.1 (3)			Bothnian Bay.
1970								
107	Jan 5	11 46 28.9 ± 0.5 (6)	58.00 N, 11.64 E ± 4 (3)	11 \pm 7 (3)	2.4 \pm 0.2 (3)			Bohuslän.
108	Mar 24	14 04 28.7 ± 0.6 (4)	59.02 N, 13.22 E ± 0 (4)	4 \pm 4 (2)	2.6 \pm 0.2 (4)			Värmland.
109	Mar 24	15 58 35.9 ± 0.4 (4)	59.02 N, 13.22 E ± 0 (4)	11 (1)	2.2 \pm 0.2 (3)			Värmland.

MARKUS BÄTH

THE CATALOGUE, continued

No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
		1970						
110	Mar 27	19 53 37.1 ± 1.3 (7)	64.99 N, 20.87 E ± 5 (7)	22 \pm 1 (2)	2.3 \pm 0.4 (2)			Västerbotten.
111	Mar 28	07 28 05.5 ± 1.2 (5)	67.30 N, 23.58 E ± 5 (5)	13 \pm 11 (5)	2.4 \pm 0.4 (2)			Norrbotten.
112	Apr 3	15 56 52.2 ± 0.9 (5)	57.95 N, 11.50 E ± 0 (3)	11 \pm 3 (2)	2.2 \pm 0.3 (2)			Bohuslän.
113	Apr 10	09 58 54.7 ± 0.4 (4)	58.60 N, 12.60 E (2)		2.3 \pm 0.4 (2)			Dalsland.
114	May 4	21 27 29.3 ± 0.9 (6)	68.14 N, 20.76 E ± 3 (6)	1 (1)	2.2 \pm 0.1 (2)			Lappland.
115	May 12	14 14 11.2 ± 1.0 (12)	60.95 N, 12.79 E ± 4 (12)		3.0 \pm 0.1 (6)			Dalarna-Värmland.
116	May 24	00 22 02.1 ± 1.2 (9)	59.83 N, 13.52 E ± 4 (9)		2.5 \pm 0.4 (6)			Värmland.

THE CATALOGUE, continued

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No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1970								
117	Jun 14	15 38 13.3 ± 0.6 (3)	61.98 N, 17.50 E (3)		1.7 \pm 0.2 (3)			Halsingland.
118	Jun 14	17 33 49.9 ± 1.3 (13)	65.11 N, 22.13 E ± 4 (13)	15 \pm 14 (17)	2.6 \pm 0.2 (5)			Bothnian Bay.
119	Aug 12	19 28 43.3 ± 0.3 (8)	61.47 N, 16.25 E ± 2 (8)	10 \pm 11 (6) $h_a = 7$	2.8 \pm 0.2 (6)	5	21	Halsingland. Felt: Arbrå, Bollnas, Koldemo, Lottefors, Norra Kyrkbyn, Norranget, Simeå, Skeppstabadet, Trönödal, Vallsta
120	Sep 11	22 35 55.7 ± 0.7 (10)	65.64 N, 22.45 E ± 3 (5)	14 \pm 4 (3)	2.4 (1)			Norrbotten.
121	Sep 24	02 30 47.8 ± 0.2 (5)	66.71 N, 23.11 E ± 0 (3)		2.1 (1)			Norrbotten.
122	Sep 28	04 17 57.6 ± 0.5 (5)	60.13 N, 14.72 E ± 2 (3)		1.7 \pm 0.3 (3)			Dalarna.

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
		1970						
123	Oct 2	15 16 21.4 ± 0.2 (4)	58.28 N, 17.22 E ± 0 (3)		2.3 ± 0.3 (3)			Östergötland.
124	Oct 14	11 44 53.8 ± 0.7 (5)	58.64 N, 13.57 E ± 4 (4)		2.3 ± 0.2 (3)			Västergötland. Doubtful.
125	Nov 20	09 30 45.6 ± 0.5 (6)	61.73 N, 17.34 E ± 2 (3)		2.4 ± 0.3 (3)			Hälsingland.
126	Nov 20	09 32 47.8 ± 0.5 (6)	61.73 N, 17.34 E ± 2 (3)		2.4 ± 0.3 (3)			Hälsingland.
127	Dec 31	18 24 08.6 ± 0.8 (8)	64.40 N, 21.08 E ± 3 (6)		2.3 ± 0.1 (3)			Västernorrland.
		1971						
128	Jan 4	12 02 39.5 ± 0.6 (5)	58.64 N, 13.57 E ± 2 (3)		1.9 ± 0.4 (3)			Västergötland. Doubtful.
129	Apr 14	13 48 44.7 ± 0.3 (3)	63.48 N, 18.92 E (3)		1.9 ± 0.4 (3)			Ångermanland.

THE CATALOGUE, continued

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No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1971								
130	Apr 17	08 05 00.5 ± 1.1 (12)	67.95 N, 23.14 E ± 4 (13)	13 ± 12 (18)	2.9 ± 0.1 (4)			Norrbotten.
131	Apr 20	23 33 35.6 ± 1.1 (12)	64.38 N, 20.92 E ± 4 (12)	17 ± 11 (18) $h_a = 29$	2.9 ± 0.2 (6)	4	55	Västerbotten. Felt: Ånäset, Bjurfors, Bodbysund, Bureå, Burträsk, Bygdsiljum, Flarken, Granliden, Gravmark, Hällnäs, Innansjön, Lappvattnet, Ljusvattnet, Lövänger, Lövsäle, Överklinten, Robertsfors, Sävarberg, Sikeå, Skellefteå, Storsävarträsk
132	Apr 29	15 29 51.3 ± 0.3 (4)	58.35 N, 11.95 E ± 0 (3)		2.1 ± 0.2 (2)			Bohuslän.
133	Jul 10	04 12 14.1 ± 1.2 (7)	58.38 N, 13.28 E ± 5 (5)		2.3 ± 0.2 (4)			Västergötland.
134	Jul 28	23 24 53.7 ± 1.4 (11)	62.13 N, 17.31 E ± 5 (11)	7 ± 16 (13) $h_a = 8$	2.8 ± 0.3 (6)	4-5	20	Medelpad-Hälsingland. Felt: Årskog, Galtström, Gnarp, Kvissleby, Njurunda, Nolby, Skatan, Skrängstabodarna
135	Aug 27	07 16 30.6 ± 0.4 (4)	62.94 N, 17.84 E ± 2 (3)		2.2 ± 0.1 (3)			Ångermanland.

MARKUS BATH

THE CATALOGUE, continued

No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
	1971							
136	Sep 7	02 41 28.8 ± 1.2 (5)	61.37 N, 16.91 E ± 4 (5)	22 \pm 12 (14) $h_a = 8$	2.4 \pm 0.2 (4)	4	15	Hälsingland.
		Felt: Ljusne, Marmaverken, Sandarne, Söderala, Söderhamn						
137	Sep 10	11 04 06.3 ± 0.9 (5)	66.56 N, 16.65 E (3)		2.3 \pm 0.3 (3)			Lappland.
138	Sep 11	14 16 23.7 ± 0.8 (9)	58.79 N, 12.73 E ± 3 (7)		2.6 \pm 0.1 (5)			Dalsland.
139	Sep 14	16 54 35.3 ± 0.7 (7)	65.52 N, 22.35 E ± 4 (5)		2.2 \pm 0.3 (2)			Norrbotten.
140	Oct 5	11 56 12.6 ± 0.2 (5)	62.80 N, 17.92 E ± 0 (3)		2.5 \pm 0.2 (3)			Ångermanland.
141	Oct 6	07 42 48.0 ± 1.1 (9)	62.74 N, 18.16 E ± 5 (4)	(0)	2.3 \pm 0.1 (3)			Ångermanland. Doubtful.
142	Oct 7	09 33 07.5 ± 0.9 (14)	58.54 N, 12.83 E ± 4 (9)		2.8 \pm 0.1 (4)			Västergötland.

THE CATALOGUE, continued

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No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1971								
143	Nov 25	13 46 48.8 ± 0.6 (14)	66.91 N, 22.58 E ± 2 (5)	15 \pm 10 (12)	2.8 \pm 0.3 (2)			Norrbotten.
1972								
144	Mar 6	16 03 02.7 ± 0.7 (13)	64.89 N, 20.66 E ± 3 (7)	13 \pm 5 (4)	2.2 \pm 0.3 (3)			Västerbotten.
145	Apr 19	00 18 29.8 ± 0.4 (3)	62.68 N, 16.98 E (3)		2.0 \pm 0.1 (4)			Medelpad.
146	Jun 12	04 31 31.2 ± 1.3 (13)	60.07 N, 14.57 E ± 5 (13)	4 \pm 5 (7) $h_a = 10$	2.7 \pm 0.2 (6)	5	30	Dalarna. Felt: Filipstad, Fredriksberg, Gäddsjöberg, Grängesberg, Gravendal, Hällefors, Hörken, Långban, Lesjöfors, Nordmarkshyttan, Rämnen, Tyfors
147	Jun 21	11 37 16.1 ± 0.8 (3)	58.79 N, 13.70 E (2)		2.3 \pm 0.1 (2)			Västergötland.
148	Aug 1	17 52 23.5 ± 0.9 (10)	62.01 N, 20.86 E ± 3 (6)		1.6 (1)			Bothnian Bay.

MARKUS BATH

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1972								
149	Aug 20	02 52 35.8 ± 0.7 (12)	61.86 N, 17.06 E ± 3 (12)	14 \pm 8 (17) $h_a = 11$	3.0 \pm 0.1 (5)	4-5	26	Hälsingland. Felt: Bergsjö, Gnarp, Harmånger, Hassela, Jättendal, Stocka, Strömsbruk
150	Sep 25	02 55 34.9 ± 0.8 (8)	58.91 N, 13.93 E ± 3 (4)	10 \pm 6 (3)	2.3 \pm 0.2 (3)			Västergötland.
151	Oct 25	13 17 28.4 ± 0.6 (6)	58.53 N, 11.19 E ± 2 (3)		2.3 \pm 0.1 (2)			Bohuslan.
152	Dec 16	10 09 26.6 ± 0.7 (11)	63.61 N, 19.84 E ± 4 (12)	19 \pm 14 (4) $h_a = 17$	2.5 \pm 0.2 (5)	3-4	25	Ångermanland. Felt: Holmsund, Hörnefors, Nordmaling, Norrbyn, Norrbyskär
1973								
153	Jan 11	12 36 00.3 ± 0.6 (7)	65.24 N, 22.83 E ± 2 (5)		1.8 (1)			Bothnian Bay.
154	Feb 13	00 05 11.9 ± 1.1 (14)	66.01 N, 18.24 E ± 4 (14)	17 \pm 7 (12) $h_a = 21$	3.2 \pm 0.3 (5)	4-5	50	Lappland. Felt: Arjeplog, Jutis, Mellanström, Radnijsaur

THE CATALOGUE, continued

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No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1973								
155	Apr 11	05 01 35.4 ± 0.7 (15)	58.76 N, 13.38 E ± 4 (16)	23 \pm 15 (31) $h_a = 24$	3.8 \pm 0.1 (6)	5-6	90	Lake Vänern. Felt: Anten, Ärtemark, Askersund, Berg, Billingsfors, Dals Långed, Daretorp, Eggby, Fagersanna, Finnerödja, Gårdsjö, Götene, Hova, Karlsborg, Kristinehamn, Lidköping, Lundsbrunn, Mariestad, Moholm, Mölltorp, Pålsboda, Ryd, Säffle, Säter, Säware, Skara, Skövde, Skultorp, Steneby, Timmersdala, Töreboda, Vadsbo, Vänersborg, Vårgårda, Vargön, Varnhem, Vårsås
156	Apr 17	06 17 56.0 ± 0.7 (12)	68.11 N, 20.06 E ± 4 (12)	3 \pm 9 (15) $h_a = 8$	3.0 \pm 0.3 (5)	4-5	20	Lappland. Felt: Kiruna, Lombolo, also at places 20 km NW of Kiruna
157	Apr 25	02 17 08.0 ± 0.7 (5)	61.69 N, 17.56 E (3)	20 \pm 1 (2)	2.3 \pm 0.3 (3)			Hälsingland.
158	Apr 25	19 32 38.2 ± 0.5 (4)	58.80 N, 12.92 E (3)		2.3 \pm 0.3 (3)			Lake Vänern.
159	May 30	15 37 23.4 ± 0.8 (6)	60.00 N, 14.92 E ± 3 (4)		2.2 \pm 0.2 (5)			Västmanland.

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THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
		1973						
160	Jun 7	11 22 57.3 ± 1.1 (5)	58.82 N, 12.80 E ± 4 (5)		2.4 ± 0.2 (4)			Lake Vänern.
161	Jul 2	04 07 09.7 ± 1.3 (4)	56.20 N, 12.70 E ± 5 (3)		2.1 ± 0.2 (3)			Skåne.
162	Jul 22	04 02 53.7 ± 0.7 (7)	58.23 N, 13.66 E ± 2 (7)	19 ± 19 (6) $h_a = 12$	2.8 ± 0.3 (5)	4-5	28	Västergötland. Felt: Broddetorp, Dala, Ekedalen, Falköping, Göteve, Gudhem, Hangelösa, Högstena, Kvanum, Ottravad, Sätuna, Skövde, Stenstorp, Vångaby, Vartofta
163	Jul 26	16 14 09.5 ± 0.7 (5)	58.82 N, 12.88 E ± 0 (3)		2.4 ± 0.1 (2)			Lake Vänern.
164	Aug 22	12 30 02.2 ± 0.9 (4)	58.61 N, 13.72 E (3)		1.9 ± 0.3 (2)			Västergötland.
165	Aug 29	18 03 37.6 ± 0.2 (4)	59.73 N, 16.07 E ± 0 (4)		1.8 ± 0.4 (2)			Västmanland.
166	Oct 6	00 41 13.7 ± 1.1 (13)	64.95 N, 20.63 E ± 5 (13)	0 ± 7 (8)	2.2 ± 0.2 (3)			Västerbotten. Doubtful.

THE CATALOGUE, continued

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No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1973								
167	Oct 6	08 36 15.7 ± 0.2 (7)	58.52 N, 11.40 E ± 0 (3)	15 \pm 4 (3)	2.0 \pm 0.3 (3)			Bohuslan.
168	Oct 25	12 22 59.1 ± 0.2 (3)	58.81 N, 11.90 E (2)		1.5 (1)			Dalsland.
169	Nov 15	14 46 37.3 ± 1.5 (6)	58.40 N, 14.25 E ± 8 (4)		1.9 \pm 0.4 (2)			Västergötland.
170	Nov 26	21 45 35.3 ± 0.6 (14)	62.94 N, 18.29 E ± 3 (14)	6 \pm 14 (22) $h_a = 6$	3.1 \pm 0.2 (5)	5	17	Ångermanland. Felt: Mjällom, Noraström, Nordingrå, Torrom, Vallen
171	Dec 30	09 26 15.8 ± 0.4 (5)	61.35 N, 16.83 E ± 2 (3)	(0)	2.2 \pm 0.2 (4)			Hälsingland. Doubtful.
1974								
172	Jan 13	18 27 04.9 ± 0.9 (8)	63.56 N, 17.20 E ± 3 (5)		2.2 \pm 0.1 (5)			Ångermanland.

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
		1974						
173	Feb 5	22 34 01.2 ± 0.4 (5)	58.10 N, 14.33 E ± 2 (5)	$h_a = 18$	2.3 ± 0.3 (5)	4	35	Lake Vättern.
			Felt: Härja, Kättilstorp, Slutarp, Tidaholm, Vreten					
174	Feb 18	11 24 57.7 ± 0.5 (4)	58.58 N, 13.80 E ± 3 (3)		2.0 ± 0.1 (2)			Västergötland.
175	Mar 2	17 16 19.3 ± 1.1 (9)	60.81 N, 17.27 E ± 4 (9)	7 ± 7 (12)	2.2 ± 0.2 (3)			Gästrikland.
176	Mar 6	20 40 35.8 ± 1.5 (7)	65.93 N, 23.14 E ± 5 (7)		1.9 ± 0.1 (2)			Norrbottnen.
177	Mar 26	12 19 16.3 ± 1.6 (9)	61.44 N, 14.71 E ± 5 (4)	13 ± 9 (3)	2.5 ± 0.2 (4)			Dalarna.
178	May 21	16 51 18.5 ± 1.0 (12)	58.27 N, 12.70 E ± 4 (12)	22 ± 14 (21) $h_a = 12$	3.5 ± 0.1 (6)	5	35	Västergötland. Felt: Aspelund (14 km north of Sjövik), Bjarke, Essunga, Falköping, Floby, Gråstorp, Gudhem, Helås, Mörlanda, Nossebro, Stora Mellby, Trollhättan, Uoby, Vara, Vårgårda

THE CATALOGUE, continued

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No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1974								
179	Jun 4	23 13 49.1 ± 0.9 (18)	62.41 N, 17.26 E ± 4 (18)	11 \pm 10 (30) $h_a = 11$	3.5 \pm 0.3 (6)	5-6	40	Medelpad. Felt: Alnö, Bergsåker, Fränsta, Indal, Kovland, Matfors, Mosjön, Nedansjö, Njurunda, Ortviken, Skäggssta, Skönsberg, Söråker, Stavreviken, Stöde, Sundsvall, Svartvik, Timrå, Torp, Torpshammar, Viskan
180	Jun 8	14 33 55.2 ± 0.5 (8)	59.16 N, 12.67 E ± 2 (5)		2.3 \pm 0.4 (4)			Värmland-Dalsland.
181	Jun 30	14 38 52.2 ± 1.0 (10)	68.12 N, 20.39 E ± 3 (6)	13 \pm 4 (2)	2.6 \pm 0.4 (4)			Lapland.
182	Jul 5	16 19 51.2 ± 0.4 (5)	57.39 N, 12.30 E ± 2 (5)		2.8 \pm 0.3 (5)			Halland.
183	Jul 21	08 32 41.1 ± 0.8 (8)	67.60 N, 22.24 E ± 3 (4)	16 \pm 0 (2)	2.1 \pm 0.2 (2)			Lapland-Norrbottn.
184	Sep 12	00 31 15.0 ± 1.2 (10)	66.18 N, 21.94 E ± 4 (10)	$h_a = 13$	2.5 \pm 0.1 (5)	4-5	30	Norrbottn. Felt: Gunnarsbyn, Niemisel, Norriån, Sörbyn (refers also to the following earthquake)

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THE CATALOGUE, continued

No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
	1974							
185	Sep 12	00 32 00.4 ± 1.2 (8)	66.18 N, 21.94 E ± 4 (8)		2.4 ± 0.3 (3)			Norrbotten.
		Felt: see the preceding earthquake						
186	Sep 24	11 22 11.8 ± 0.6 (3)	58.59 N, 13.44 E ± 3 (3)		2.0 ± 0.4 (2)			Västergötland.
187	Sep 27	17 36 38.4 ± 0.9 (13)	64.33 N, 20.52 E ± 3 (13)	13 ± 14 (16)	2.9 ± 0.2 (6)			Västerbotten.
188	Oct 21	04 22 22.4 ± 0.3 (4)	61.90 N, 17.59 E ± 0 (4)		2.2 ± 0.1 (3)			Hälsingland.
189	Oct 28	21 56 29.5 ± 0.5 (7)	57.38 N, 12.33 E ± 2 (5)	9 ± 3 (2) $h_a = 15$	2.6 ± 0.2 (5)	4-5	36	Halland. Felt: Åsa, Askim, Berghem, Björketorp, Fjärås, Floda, Fotskäl, Frillesås, Göteborg, Horred, Hysena, Istorp, Jonsered, Kinna, Kungsäter, Kungsbacka, Mølndal, Onsala, Öxnevalla, Partille, Pixbo, Ringhals, Särö, Skene, Södra Mark, Tölö, Ullared, Vallda, Varberg, Veddige
190	Nov 27	14 39 26.1 ± 0.4 (5)	58.83 N, 11.88 E ± 2 (3)		2.4 ± 0.1 (3)			Dalsland.

THE CATALOGUE, continued

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No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1974								
191	Dec 1	19 35 56.1 ± 1.2 (11)	68.06 N, 19.86 E ± 4 (11)	35 \pm 10 (7) $h_a = 17$	3.2 \pm 0.3 (4)	4-5	40	Lappland. Felt: Årosjokk, Fjällnäs, Jukkasjärvi, Kalixfors, Kiruna, Kurravaara, Luossavaara, Rensjön
192	Dec 9	19 08 23.8 ± 0.6 (7)	66.17 N, 23.41 E ± 2 (7)	11 \pm 12 (4)	2.1 \pm 0.1 (2)			Norrbotten.
1975								
193	Jun 17	15 28 45.7 ± 1.2 (6)	64.44 N, 20.96 E (3)		2.0 \pm 0.6 (2)			Västerbotten.
194	Jun 18	23 45 52.0 ± 0.5 (4)	64.83 N, 20.28 E ± 3 (3)	(0)	2.0 \pm 0.3 (2)			Västerbotten. Doubtful.
195	Jul 5	17 37 55.7 ± 1.5 (5)	64.49 N, 20.94 E ± 5 (5)		2.1 \pm 0.2 (4)			Västerbotten.
196	Aug 11	18 28 10.5 ± 1.1 (15)	67.40 N, 22.35 E ± 4 (15)	15 \pm 13 (31) $h_B = 15$	3.8 \pm 0.3 (6)	5	45	Norrbotten. Felt: Anttis, Erkheikki, Junosuando, Kangosfors, Masugnsbyn, Merasjärvi, Pajala, Saittarova, Tärendö, Vettasjärvi

MARKKUS BÄTH

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
		1975						
197	Aug 28	17 21 38.9 ± 0.9 (9)	63.95 N, 21.12 E ± 4 (8)		1.9 ± 0.3 (2)			Vasterbotten.
198	Aug 29	04 42 21.7 ± 0.8 (8)	65.85 N, 24.11 E ± 3 (8)	10 ± 9 (8) $h_a = 11$	2.4 ± 0.4 (3)	4	22	Norrbotten. Felt: Haparanda, Kärrbäck, Mattila, Nikkala, Sävis, Seskarö
199	Oct 8	18 21 22.9 ± 0.8 (7)	61.93 N, 17.70 E ± 1 (4)		2.2 ± 0.2 (4)			Hälsingland.
200	Oct 29	07 45 47.4 ± 0.7 (8)	64.52 N, 20.81 E ± 0 (4)	14 ± 8 (4)	2.0 (1)			Vasterbotten.
201	Nov 11	11 25 12.5 ± 0.4 (4)	58.60 N, 13.81 E (3)		2.0 ± 0.1 (3)			Vastergötland.
202	Dec 1	13 05	65.8 N, 23.6 E (macr)	$h_a = 16$	2.8	4	30	Norrbotten. Not recorded. Doubtful. Felt: Båtskärensås, Haparanda, Kalix, Karlsborgsverken, Nikkala, Sävis, Sangis, Seskarö, Storöhamn, Torneå (weaker shocks reported felt on Dec 2 at 08 55 and 15 00 GMT)

THE CATALOGUE, continued

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No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1975								
203	Dec 13	15 29 54.7 ± 0.9 (9)	66.88 N, 22.51 E ± 3 (9)	14 \pm 13 (4) $h_a = 13$	2.7 \pm 0.2 (4)	4	25	Norrbotten. Felt: Kainulasjärvi, Tärendö
1976								
204	Jan 4	15 08 33.0 ± 0.7 (13)	64.36 N, 20.67 E ± 3 (13)	30 \pm 8 (2)	2.4 \pm 0.2 (4)			Västerbotten.
205	Mar 12	23 22 18.7 ± 0.9 (14)	61.31 N, 17.18 E ± 3 (14)	14 \pm 11 (19) $h_a = 29$	3.1 \pm 0.2 (6)	4-5	70	Hälsingland. Felt: Arbrå, Bergvik, Bollnäs, Edsbyn, Elgnäs, Forsa, Forsby (just north of Gävle), Granberg, Gruvberget, Iggesund, Kilafors, Landafors, Ljusne, Los, Lottefors, Mohed, Mokorset, Norrsundet, Rengsjö, Rimsbo, Söderhamn, Stråttjärä, Svabensverk, Vansäter
206	Mar 16	06 27 08.5 ± 0.6 (9)	58.68 N, 13.41 E ± 3 (6)	5 \pm 0 (2) $h_a = 16$	2.6 \pm 0.1 (4)	3-4	23	Västergötland. Felt: Björsäter, Hällekis, Lugnås, Tidån

MARKUS BÄTH

THE CATALOGUE, continued

No	Date	Origin time GMT	Epicenter lat, long	Depth h, km	Magnitude M_L	Intensity I_0	Radius r, km	Remark
1976								
207	Mar 29	14 14 38.4 ± 1.2 (12)	59.92 N, 12.62 E ± 4 (12)	14 \pm 12 (10) $h_a = 21$	3.1 \pm 0.3 (5)	4-5	50	Värmland. Felt: Åmotfors, Arvika, Bogen, Bortan, Charlottenberg, Eda, Edane, Gettjärn, Gråsmark, Gunnarskog, Helgebodafors, Högboda, Högerud, Jössefors, Lekvattnet, Lenungshammar, Lysvik, Mangskog, Mitandersfors, Rackstad, Rottneros, Sätergård, Skillingsfors, Sulvik, Sunne, Torsby, Tvällen, Västerrottna, Vitsand (also felt in Norway)
208	Apr 3	21 39 36.2 ± 0.8 (8)	67.97 N, 23.54 E ± 3 (5)	16 \pm 1 (2)	1.8 (1)			Norrbottnen.
209	Apr 9	11 19 39.5 ± 0.8 (7)	64.72 N, 22.72 E ± 4 (6)		1.6 (1)			Bothnian Bay.
210	Apr 30	12 53 52.2 ± 1.0 (12)	64.40 N, 21.20 E ± 4 (12)	15 \pm 10 (22) $h_a = 14$	2.8 \pm 0.4 (5)	5	42	Västerbotten. Felt: Ånäset, Bjuröklubb, Bjurön, Bodan, Bodbysund, Brände, Bureå, Bursiljum, Burträsk, Bygdsiljum, Byske, Drängsmark, Edet, Fjällbyn, Flarken, Gummark, Hjoggböle, Hökmark, Kålaboda, Kallviken, Lappvattnet, Lövvånger, Mångbyn, Mårtensboda, Mjödvattnet, Nolbyn, Nysåtra, Övre Bäck, Ragvaldsträsk, Robertsfors, Sjöbotten, Skäran, Skellefteå, Skelleftehamn, Uppersjöbäcken, Vallen, Vebomark

THE CATALOGUE, continued

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No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1976								
211	Jul 3	07 26 01.4	58.45 N, 13.87 E	1 ± 7 (3)	2.7 ± 0.2 (5)	4	20	Västergötland.
		± 1.1 (16)	± 4 (9)	$h_a = 10$				
		Felt: Axvall, Eggby, Locketorp, Skara, Skövde, Stenstorp						
212	Aug 17	05 35 53.8	62.85 N, 17.76 E	9 ± 11 (25)	3.2 ± 0.3 (6)	5	55	Ångermanland.
		± 0.9 (14)	± 3 (14)	$h_a = 18$				
		Felt: Björkäbruk, Bollstabruk, Bredsäter, Forsed, Graninge, Härnösand, Klockestrand, Kramfors, Långsele, Lugnvik, Lunde, Nordingrå, Öst-Nyland, Ramvik, Sanna, Sollefteå, Ullånger, Vibyggerå, Viksjö, Ytterlännäs						
213	Aug 17	22 32 49.1	65.68 N, 22.49 E	6 ± 8 (5)	2.3 ± 0.3 (4)			Norrbottnen.
		± 0.8 (10)	± 3 (10)					
214	Aug 22	15 15 14.3	67.96 N, 22.95 E	8 ± 5 (2)	1.9 ± 0.6 (2)			Lappland.
		± 0.8 (10)	± 3 (6)					
215	Aug 25	21 24 28.3	58.95 N, 15.10 E	7 ± 10 (13)	2.8 ± 0.2 (5)	4-5	45	Närke.
		± 0.8 (10)	± 3 (10)	$h_a = 19$				
		Felt: Åmmeberg, Åsbro, Askersund, Aspabruk, Finnerödja, Garphyttan, Hallsberg, Hasselfors, Hjortkvarn, Karlsborg, Kumla, Laxå, Narlunda, Odensbacken, Pålshoda, Rönneshytta, Sköllersta, Tjällmo, Viby, Vretstorp, Zinkgruvan						

THE CATALOGUE, continued

No	Date	Origin time	Epicenter	Depth	Magnitude	Intensity	Radius	Remark
		GMT	lat, long	h, km	M_L	I_0	r, km	
1976								
216	Sep 3	04 28 00.6	58.45 N, 13.87 E	8 ± 12 (19)	3.6 ± 0.1 (6)	5	70	Vastergötland.
		± 1.0 (13)	± 4 (13)	$h_a = 23$				
		Felt: Älgarås, Alingsås, Axvall, Baltak, Bankeryd, Blidsberg, Borgunda, Brevik, Broddetorp, Falköping, Flakeberg, Götene, Grästorp, Grolanda, Gudhem, HÄrlunda, Hjo, Holmestad, Jönköping, Karlsborg, Kvänum, Laxå, Lerdala, Lidköping, Lugnås, Lundsbrunn, Mariestad, Moholm, Sandhem, Skara, Skärv, Skövde, Skultorp, Stenstorp, Stenungsund, Stöpen, Svanskog, Tibro, Tidaholm, Tidån, Timmeredala, Töreboda, Ulvåker, Udenäs, Vara, Våring, Varnhem, Vårsås, Vedum, Vinninga						
217	Sep 7	15 21 57.0	59.63 N, 13.40 E	7 ± 5 (3)	2.7 ± 0.4 (5)	4	24	Värmland.
		± 0.9 (9)	± 4 (9)	$h_a = 12$				
		Felt: Deje, Edane, Fagerås, Östra Ämtervik, Västra Ämtervik						

Note added in proofreading:

1976

Jul 12	03 29 50	62.8N, 18.2E			2.2 (2)			Ångermanland.
	(5)	(4)						

EPICENTER AND MAGNITUDE INDEX

Each region comprises one degree latitude and one degree longitude. For example, region 5612 means latitudes 56.00 to 56.99 N and longitudes 12.00 to 12.99 E. The reference numbers of earthquakes are those used in the main catalogue.

Region	Magnitude	M_L	2.6-3.0	≤ 2.5
	≥ 3.1			
5611			50	
5612				161
5613			30, 38, 40	
5711			34, 56	112
5712			182, 189	82
5713				14
5714				22
5811				94, 107, 132, 151, 167, 168, 190
5812	178		138, 142	36, 113, 158, 160, 163
5813	29, 83, 155, 216		10, 53, 68, 162, 206, 211	11, 15, 16, 96, 124, 128, 133, 147, 150, 164, 174, 186, 201
5814	90		60, 61	7, 169, 173
5815			215	98
5817				123
5911	4			
5912	207		92	97, 180
5913	9, 64		73, 79, 108, 217	109, 116
5915			35	
5916				165
6011	47			
6012			115	
6014			146	122, 159
6015			84	72
6016				81
6017			43, 78	175
6114			24	77, 177
6116			5, 119	12, 59, 136, 171
6117	205		51, 149	117, 125, 126, 157, 188, 199

Region	Magnitude	M_L		
	≥ 3.1		2.6-3.0	≤ 2.5
6215				44
6216	17			145
6217	179, 212		134	6, 76, 135, 140
6218	170			141
6219			27	
6220				148
6317				172
6318	67			3, 129
6319				1, 152
6321				86, 197
6419			37	
6420	45		8, 20, 21, 31, 46, 87, 131, 187	58, 110, 144, 166, 193, 194, 195, 200, 204
6421			19, 210	74, 105, 127
6422			52	209
6423	57			
6517	18			
6521	42, 55		54	49
6522	65		118	41, 62, 75, 99, 103, 106, 120, 139, 153, 213
6523			202	176
6524	39		70	71, 198
6613	32, 33			
6615				104
6616				137
6617			13	2, 93
6618	154			
6619			23	
6621	28			184, 185
6622			102, 143, 203	88, 89
6623	91			80, 121, 192
6714	48			
6719			101	100
6721			26	69
6722	196			183, 214
6723	25		130	111, 208
6819	191			
6820	63, 66		85, 95, 156, 181	114

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