KBS TEKNISK RAPPORT

21

Earthquakes of Sweden 1891–1957 1963–1972

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KÄRN - BRÄNSLE - SÄKERHET

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EARTHQUAKES OF SWEDEN

1891 - 1957

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The objective of this report is to present a general brief description of seismic activity in Sweden. Geographical distribution of epicentres, seismicity, magnitudes of Swedish earthquakes and their relation to source dimensions are included. Macroseismic observations from 1891-1957 and instrumental data from 1963-1972, altogether 182 earthquakes, are used.

1. Macroseismic observations 1891-1957

For the time period 1891-1950 the relevant seismic information is taken from a paper by Båth (1956), entitled "An earthquake catalogue for Fennoscandia for the years 1891-1950", hereafter called the Catalogue. In the present report only Swedish earthquakes (adjacent waters included) with magnitudes $M \geq 3$ have been used. 101 such events are given in the Catalogue. The magnitude limit refers to the recommendation made in the Catalogue. No consideration is made with respect to the varying accuracy of epicentral location given in the Catalogue. Thus, some few of the epicentres used may show location error of 100 km or larger.

The time interval of 60 years covered by the Catalogue has been extended up to 1957 by utilizing data of Sahlström and Båth (1958). Since magnitudes are not given maximum intensity, I_0, and area of perceptibility, which they present for 14 Swedish earthquakes, are converted to the released energy, E, by using the formula (see Båth, 1954)

$$\log E = 9.6 + 3.2 \log r - 1.6 \log (10^{\frac{I_0 - 2}{3}} - 1) + 1.1 I_0 \qquad (1)$$

where r is radius of the circular (assumed) area of perceptibility. The desired magnitude, M, is then obtained from (see Båth, 1954)

$$\log E = 12 + 1.8 M \qquad (2)$$

Calculated magnitudes and approximate epicentral locations are given in Table I. To homogenize the data again only events with magnitudes $M \geq 3$ (9 in number) are employed.

1.1 Geographic distribution of epicentres

A map of all the 110 selected epicentres covering the time period 1891-1957 and with magnitudes $M \geq 3$ is shown in Fig. 1. The largest earthquake from this ensemble is the event of March 9, 1909 which has a magnitude $M = 5$ and occurred in the northern Gulf of Bothnia. Swedish earthquakes beneath the sea from this time interval are rather scarce, 12 in number. This may be due to the macroseismic origin of data. Note also that 7 of the off-shore events are rather large, with magnitudes $M \geq 4$.

The map gives an indication of areas with higher seismic activity. These are especially the south-western Sweden including also the southern Baltic Sea and the eastern coastal area along the Gulf of Bothnia. A diffuse seismic area may be traced in northern Norrland. Generally speaking, southern part of the country shows higher activity when compared with the northern part. Areas with practically no seismic activity are broadly the western part of the country, say, north of 61°N and the area of south-eastern Sweden.

The map in Fig. 1 provides no information on focal depth. As follows from the discussion of Båth (1954) the mean depth of Fennoscandian earthquakes is about 25 km. Majority of Swedish events occur between 5 and 35 km depth.

1.2 Seismicity

By seismicity we mean the seismic energy released by earthquakes per certain area and certain time interval. Seismic energy is calculated from equation (2), where M is the magnitude given in the Catalogue, for events 1891-1950, or the magnitude calculated according to equations (1) and (2), for events 1951-1957. When estimating the energy, multiple shocks reported on several places in the Catalogue were considered as single earthquakes. This simplification has only marginal effect on the determination of seismicity considered here. Seismicity estimates are made firstly for the whole territory of Sweden and secondly for the southern Sweden, here the portion of the territory south of 60°N latitude. Table II comprises the energy release corresponding to five different magnitude ranges. It follows from the table that large events contribute significantly to the total seismicity, whereas small events, say, with $M < 4$ have practically negligible effect. For the period 1891-1957, more than 60 % of the total seismicity of Sweden originates in southern Sweden.

In Table III we present the mean seismic energy, E', released per year. The available period of observation 1891-1957 is sampled by 10 years long time intervals (period 1951-1957 being an exception) and E' is determined within each interval. Calculations are carried out for both the whole Sweden and the southern Sweden. From the table, it is clear that E' is strongly time dependent. Note that e.g. during decades 1901-1910 and 1911-1920 seismicity differs by a factor of 30, for both areas investigated. Increase of the sampling interval up to 20 and 30 years provides somewhat more time-stable results. Since an estimation of a representative time interval is by no means the purpose of the present report, we emphasize that results presented refer to the period 1891-1957. Any extrapolation beyond the limits of this period must be done with utmost caution.

1.3 Magnitude-frequency relationship

During the period 1891-1957 there were 110 earthquakes ($M \geq 3$) reported from Sweden and 66 from southern Sweden. This means that in average there was one earthquake every 0.6 year in Sweden and one every year in southern Sweden. Mean return periods, T(M), for magnitude M defined as

$$T(M) = \frac{\text{period of observation}}{\text{number of events}} \qquad (3)$$

are listed in Table IV, for four different magnitude ranges and for the total magnitude range considered. Data given in the table may be utilized to describe the seismicity in terms of magnitude-frequency relationships. It is known that the logarithm of the number of events, N_c, of a given magnitude decreases linearly with the magnitude, i.e.

$$\log N_c = a - bM \qquad (4)$$

where a, b are constants. We calculated N_c at 0.5 magnitude steps starting at 3.2, in correspondence with the sampling used in Table IV. Straight lines, estimating a and b, are fitted by least squares. Data for the whole Sweden and for southern Sweden have been treated separately. The resulting linear relations are

$$\log N_c = 4.69 \pm 0.44 - (0.87 \pm 0.10)\ M \tag{5}$$

for Sweden 1891-1957, $3.0 \leq M \leq 5.5$ and

$$\log N_c = 3.36 \pm 0.30 - (0.57 \pm 0.08)\ M \tag{6}$$

for southern Sweden 1891-1957, $3.0 \leq M \leq 4.9$.

2. Instrumental observations 1963-1972

During the first years of the 1960's the seismic network in Sweden expanded, so that it was possible to locate regional events from Swedish seismograph readings. The seismic activity in Sweden, during the above stated ten years, recorded by Swedish modern seismographs and further analyzed from records of these instruments, occasionally with the aid of Finnish and Norwegian readings, is tabulated (Table V) and mapped (Fig. 2) below.

Epicentral coordinates and origin times have been recalculated according to the travel-time tables in Båth (1971). The tables were not available for the routine bulletin work for most of these ten years. Therefore, present focal parameters differ somewhat from those given in the Seismological bulletins (1963-1972). Coordinates are given with an accuracy of ±10 km and times with an accuracy of ±1 sec. To obtain a consistent material only events located with the help of three or more stations have been included. Therefore, some events, the locations of which are found in the monthly bulletins, are not included in the table. Many additional small-size events occurring during these ten years have been recorded at one or two stations only and have therefore been impossible to locate. Such events are here not considered. Table V contains 93 events.

Magnitudes, M_L, are calculated according to Båth et al. (1976). Only maximum trace amplitudes equal to or larger than 0.20 mm are regarded as sufficiently reliable to be used for magnitude calculations. For each event the number of stations used for the magnitude calculation is noted in the table. In some cases this number is zero, so that no magnitude is available. The magnitude accuracy is estimated to be ±0.2 units. Seismic energy is estimated from (see Båth et al., 1976)

$$\log E = 12.30 + 1.27\ M_L \tag{7}$$

Since E(M)-relationships presented are simplifications of true dependences, equations (2) and (7) should not be combined in order to convert M into M_L and vice versa. Instead, a preliminary formula of Båth (personal communication) is recommended

$$M \simeq 1 + M_L \tag{8}$$

The notation "uncertain location" in the comments of Table V implies inconsistency in data, so that an accurate location solution is not obtainable. "Near-surface" indicates the appearance of Rg-waves. These events have occurred within the uppermost two kilometers of the crust. This notation is sometimes followed by "possibly explosion", "probably explosion" or "probably explosion or rockburst". Events which have one of the last two notations are not included in the map in Fig. 2, neither are events with magnitudes $M_L < 2.0$. The map contains 73 events separated into three magnitude groups. Largest earthquakes from this time period have magnitudes $M_L = 3.4$.

The accumulated seismic wave energy for the mapped events is calculated according to formula (7) for all of Sweden and southern Sweden, and for various magnitude ranges. The results are given in Table VI. It is found that during the ten years the seismic wave energy released in southern Sweden is 26 % of that released in all of Sweden. This is in disagreement with the energy distribution based on the macroseismic data. Also the total energy released between 1963 and 1972 is far less than energy released during the decades between 1891 and 1957.

The geographic distribution of instrumentally determined epicentra differs somewhat from that given in Secion 1. A belt with higher seismic activity starts at the area of lake Vänern and extends in the NE direction to the northern Gulf of Bothnia. Another distinct active region can be seen in the northern Norrland. The aseismic areas resemble more or less those determined from macroseismic data.

At present, instrumental data are available only for a relatively short time interval of 10 years. Consequently, no statistical processing has been applied.

3. Source dimensions

By source dimensions we mean the fault length, L, the fault width (or depth extent), W, and the fault displacement (or total offset), D. For a given source mechanism, e.g. for strike-slip movement, it is reasonable to expect close relation between the source dimensions and the total energy emitted by the seismic source. The energy is related with magnitude by known and fairly simple formulae. Much effort has been invested to find linear dependences between magnitude and the logarithm of the source dimensions or their combination. The attempts become rather difficult when approaching low magnitudes. This is due especially to the fact that theoretical and/or empirical dimensions obtained for weak earthquakes can hardly be examined by accurate field measurements. Besides the magnitude limitations, number of difficulties appears when estimating in situ the source dimension. The fault may terminate in an inaccessible area, surface (visible) displacement differs from that at depth, the depth extent is usually difficult to estimate etc. Concluding, source dimensions of small earthquakes determined from magnitudes should be considered as first approximations only. Errors of 100 % and more are rather likely to occur.

Below, we summarize empirical results presented by Chinnery (1969). Strike-slip movement source and magnitude range 3.4-8.3 are assumed. In the low-magnitude range $3.4 \leq M \leq 6.4$, Chinnery used 9 Californian events. For the three source dimensions the following least-squares fits have been recommended

$$M_L = 1.32 \log D + 4.27 \tag{9}$$

$$M_L = 0.97 \log LD - 1.51 \tag{10}$$

$$M_L = 0.79 \log LDW - 4.74 \tag{11}$$

In Table VII there are given L, D and W for four different magnitudes. Note that M_L magnitudes are regionally dependent. Equations (9)-(11) when applied to Swedish earthquakes provide most likely overestimated D, DL, LDW. This is due to the different crustal attenuation in California (sedimentary rocks) and in Sweden (granitic rocks). Thus, using M_L magnitudes of Swedish events in equations (9)-(11) we obtain source-dimensions which may be considered as the upper limits of true values.

4. Acknowledgements

The present report has been prepared at the Seismological Institute, Uppsala, according to the request of the KBS, specified in detail by Mr. Anders Bergström. Our colleague, Daniel Lindström drew the maps.

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Seismological bulletin, Uppsala, 1963-1972.

TABLE I

Date, approximate location and magnitudes ($M \geq 3$) of Swedish earthquakes 1951-1957

Date	Epicentral area approx. coordinates	Magnitude M
1953, Nov. 11	Sundsvall area 62.4°N, 17.3°E	3.5
1955, May 24	Burträsk 64.5°N, 20.7°E	3.1
Aug. 30	Deje 59.6°N, 13.5°E	3.3
Nov. 15	Falbygden-Skara-Tibro 58.3°N, 13.3°E	3.1
1956, Jan. 1	Mo-Glösbo-Norrala 61.2°N, 17.1°E	3.1
Jan. 21	Arjeplog 66.1°N, 18.0°E	3.5
Feb. 15	Tranemo 57.5°N, 13.3°E	3.2
Aug. 26	Bergsjö-Hassela 62.1°N, 16.8°E	3.5
1957, Oct. 10	Värmland-Dalarna 60.7°N, 13.4°E 1)	3.1

1) Instrumental determination (see Sahlström and Båth, 1958)

TABLE II

Number of earthquakes, N, and energy released during 1891-1957

Magnitude M	Sweden N	Energy ergs	Southern Sweden N	Energy ergs
3.0-3.4	52	3.8×10^{19}	32	3.3×10^{19}
3.5-3.9	33	1.5×10^{20}	17	8.1×10^{19}
4.0-4.4	20	6.6×10^{20}	13	4.7×10^{20}
4.5-4.9	4	1.2×10^{21}	4	1.2×10^{21}
5.0-	1	1.0×10^{21}	-	-
3.0-5.0	110	3.0×10^{21}	67	1.8×10^{21}

TABLE III

Number of earthquakes, N, and seismic energy, E', released per year

Time interval	Sweden N	E' ergs	Southern Sweden N	E' ergs
1891-1900	11	1.0×10^{19}	6	8.7×10^{18}
1901-1910	21	2.2×10^{20}	15	1.1×10^{20}
1911-1920	21	7.1×10^{18}	12	3.3×10^{18}
1921-1930	18	3.3×10^{19}	15	2.9×10^{19}
1931-1940	17	2.5×10^{19}	7	1.7×10^{19}
1941-1950	13	9.3×10^{18}	8	7.6×10^{18}
1951-1957	9	1.3×10^{18}	3	2.6×10^{17}

TABLE IV

Number of events, N, and mean return periods, T(M)

Magnitude M	Sweden N	Sweden T(M) years	Southern Sweden N	Southern Sweden T(M) years
3.0-3.4	52	1.3	32	2.1
3.5-3.9	33	2.0	17	3.9
4.0-4.4	20	3.4	13	5.2
4.5-4.9	4	16.8	4	16.8
3.0-5.0	110	0.6	66	1.0

TABLE V

Swedish earthquakes 1963-1972, instrumental determination

Event number	Date y m d	Origin time h m s	Location lat. °N	long. °E	Magnitude M_L	Number of stations used for magnitude calculation	Comments
1	63 01 19,	19 54 08	59.8	15.3	2.4	3	*
2	63 10 03,	02 05 32	64.7	23.0	3.0	3	
3	63 10 11,	16 39 44	58.3	13.3	2.9	6	
4	63 10 29,	18 28 35	65.8	21.9	3.1	3	G
5	63 11 02,	22 54 57	57.1	12.1	2.9	3	
6	65 01 23,	11 09 41	64.9	23.9	3.4	4	
7	65 02 23,	13 55 38	64.7	20.9	2.5	3	
8	65 05 06,	10 02 46	60.0	14.5	2.8	1	A
9	66 06 22,	00 50 38	66.9	18.8	2.2	1	
10	66 10 14,	16 08 25	65.2	22.6	2.7	3	
11	67 01 04,	04 44 18	67.9	21.0	3.1	4	
12	67 02 04,	15 34 56	59.5	13.3	3.3	4	
13	67 04 10,	05 14 37	65.1	22.9	3.1	5	
14	67 04 13,	08 46 19	68.1	20.8	3.4	6	
15	67 04 13,	09 03 48	63.2	18.9	3.3	6	
16	67 05 24,	16 14 26	67.5	21.1	2.1	1	
17	67 06 08,	08 51 00	65.2	24.6	2.6	2	
18	67 06 19,	19 30 01	59.2	14.5	-	0	**
19	67 06 24,	15 01 51	60.8	15.0	2.1	3	
20	67 08 16,	22 44 51	59.3	13.3	2.6	5	
21	67 08 24,	23 11 57	64.8	21.3	2.4	2	
22	67 10 19,	08 55 38	62.4	17.1	2.5	3	
23	67 10 22,	07 43 14	61.7	14.1	2.5	4	
24	67 11 29,	09 25 27	60.6	17.7	2.8	2	
25	67 11 30,	11 47 17	59.0	13.6	3.0	6	
26	67 12 04,	04 59 08	66.6	23.4	2.2	2	
27	67 12 18,	09 54 08	60.7	16.8	2.0	3	F
28	68 02 06,	01 27 33	57.3	12.4	2.4	3	
29	68 03 12,	07 32 41	58.6	13.5	3.0	5	
30	68 03 28,	03 42 02	60.5	16.0	2.8	3	
31	68 06 01,	04 50 17	68.3	20.7	2.3	1	
32	68 06 13,	04 50 00	64.4	20.8	2.7	5	
33	68 06 14,	17 49 34	55.9	13.9	2.1	2	**

TABLE V (cont.)

Event number	Date y m d	Origin time h m s	Location lat. °N	long. °E	Magnitude M_L	Number of stations used for magnitude calculation	Comments
34	68 08 07,	12 33 46	58.6	14.6	2.0	1	C
35	68 09 03,	22 35 19	58.5	13.8	3.1	5	H
36	68 09 04,	17 09 17	66.9	23.7	3.3	7	
37	68 09 08,	17 23 47	67.9	19.4	2.2	1	
38	68 09 08,	17 24 24	67.9	19.4	-	0	
39	68 10 11,	19 23 10	59.6	12.9	1.9	1	
40	68 10 12,	15 52 24	66.8	17.5	2.2	2	
41	68 12 25,	15 28 20	68.2	20.3	2.5	2	
42	69 02 13,	18 04 05	59.4	13.1	2.5	4	
43	69 02 13,	23 30 05	60.1	15.0	2.1	1	*
44	69 03 07,	21 33 10	60.1	15.0	2.3	2	*
45	69 06 19,	20 35 05	60.5	16.6	2.3	2	**
46	69 06 19,	23 59 11	67.6	19.8	2.2	1	
47	69 07 04,	22 28 54	67.6	19.4	2.9	4	
48	69 10 05,	14 57 01	60.6	17.8	2.5	2	**
49	70 03 24,	14 04 29	59.0	13.1	2.7	3	
50	70 03 24,	15 58 36	59.0	13.1	2.2	1	
51	70 03 28,	07 28 09	67.3	23.6	2.1	2	
52	70 05 12,	14 14 13	61.0	12.8	3.0	6	
53	70 05 24,	00 22 02	59.8	13.7	2.4	4	
54	70 06 14,	16 24 05	65.2	21.9	2.0	1	
55	70 06 14,	17 33 52	65.1	22.1	2.8	4	
56	70 08 12,	19 28 46	61.5	16.4	2.8	5	
57	70 09 28,	04 17 59	60.1	14.7	1.7	2	
58	70 10 02,	15 16 22	58.3	17.3	2.6	3	I
59	70 11 20,	09 30 49	61.6	17.6	2.4	2	C
60	70 11 20,	09 32 51	61.6	17.6	2.2	3	C
61	71 03 27,	11 30 44	59.9	15.3	1.3	1	*
62	71 04 01,	12 00 32	59.2	15.7	-	0	**
63	71 04 17,	08 05 03	67.8	22.6	2.8	5	
64	71 04 20,	23 33 37	64.3	20.8	2.9	4	
65	71 04 29,	15 29 43	58.8	13.0	2.0	2	F
66	71 06 03,	12 31 41	59.4	16.1	-	0	**
67	71 07 08,	11 05 37	55.7	13.5	1.8	2	**
68	71 07 10,	04 12 13	58.3	13.2	2.4	4	

TABLE V (cont.)

Event number	Date y m d	Origin time h m s	Location lat. °N	long. °E	Magnitude M_L	Number of stations used for magnitude calculation	Comments
69	71 07 28,	23 24 54	62.1	17.3	2.9	5	D
70	71 08 04,	12 09 50	62.4	17.3	2.1	2	
71	71 08 27,	07 16 29	62.9	17.9	2.0	2	
72	71 09 07,	02 41 37	61.2	17.0	2.6	2	
73	71 09 10,	11 04 06	66.6	16.4	2.1	2	
74	71 09 11,	14 16 25	58.9	12.8	2.5	4	
75	71 09 14,	16 54 32	65.5	22.5	2.1	1	
76	71 10 05,	11 56 15	62.9	17.9	2.5	1	
77	71 10 06,	07 42 49	62.6	18.0	2.1	2	D
78	71 10 07,	09 33 08	58.6	13.0	2.7	3	
79	71 11 25,	13 46 50	66.8	22.1	2.7	2	
80	72 02 05,	18 31 45	60.0	15.2	1.8	2	*
81	72 03 06,	16 03 04	64.9	20.5	1.8	1	
82	72 04 19,	00 18 30	62.6	17.2	2.2	2	
83	72 06 12,	04 31 33	60.1	14.5	2.7	4	G
84	72 07 03,	15 04 16	58.9	14.3	1.9	1	B
85	72 08 12,	05 36 15	60.1	15.0	2.0	2	*
86	72 08 13,	06 29 50	60.1	15.0	2.1	2	*
87	72 08 20,	02 52 35	61.9	16.8	2.9	2	
88	72 09 04,	00 26 33	57.1	18.4	2.3	2	
89	72 09 25,	02 55 34	58.9	13.7	2.5	1	
90	72 10 13,	01 28 34	67.2	20.5	2.2	3	E
91	72 10 13,	01 28 56	67.2	20.5	2.6	4	E
92	72 12 16,	10 09 27	63.5	19.7	2.6	4	
93	72 12 19,	21 12 57	59.8	15.1	2.5	1	*

Comments: * = Near-surface event, probably explosion or rockburst (not mapped in Fig. 2)

** = Near-surface event, probably explosion (not mapped in Fig. 2)

A = Near-surface event, possibly explosion or rockburst

B = Near-surface event, possibly explosion

C = Possibly explosion

D = Near-surface event

E = Rockburst at the Malmberget iron ore mines

F = Uncertain location

TABLE V (cont.)

Comments: G = Possibly 2 events, 3 sec apart

H = Possibly 2 events, 4 sec apart, the 2nd one somewhat stronger

I = Possibly 2 events, a few sec apart

TABLE VI

Number of earthquakes, N, and energy released during 1963-1972

Magnitude M_L	Sweden N	Sweden Energy ergs	Southern Sweden N	Southern Sweden Energy ergs
2.0-2.4	28	3.6×10^{16}	7	1.1×10^{16}
2.5-2.9	32	18.1×10^{16}	9	4.7×10^{16}
3.0-3.4	13	29.6×10^{16}	4	7.4×10^{16}
2.0-3.4	73	51.3×10^{16}	20	13.2×10^{16}

TABLE VII

Earthquake magnitude and source dimensions

Magnitude M_L	Displacement D cm	Fault length L km	Fault width W km
3.5	0.3	5.6	1.8
4.0	0.6	7.7	2.4
4.5	1.5	10.5	3.2
5.0	3.6	14.4	4.1

Figure captions

Fig. 1. Locations and magnitudes of Swedish earthquakes for the period 1891-1957. Macroseismic determinations.

Fig. 2. Locations and magnitudes of Swedish earthquakes for the period 1963-1972. Instrumental determinations.

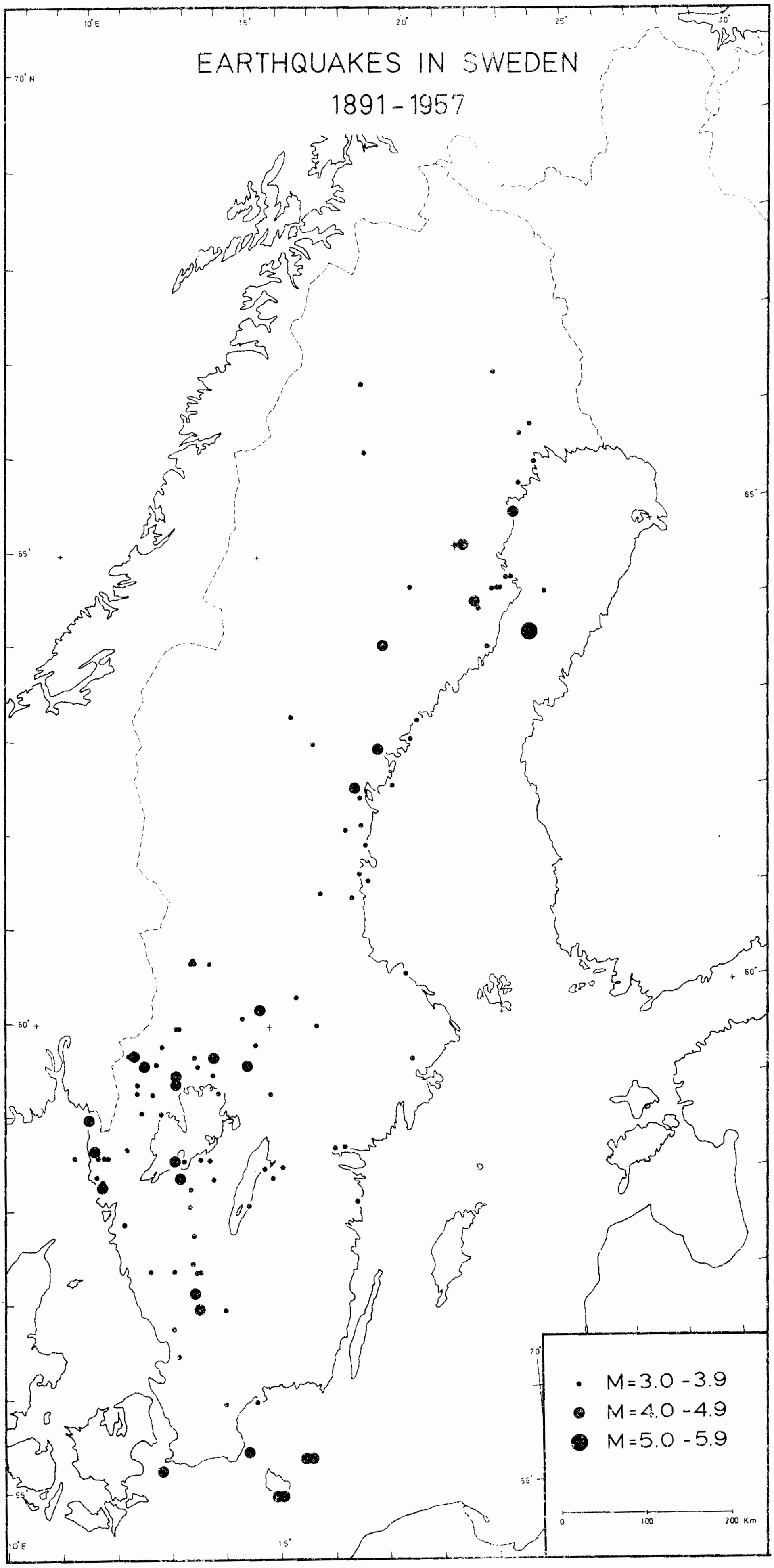

Fig. 1. Locations and magnitudes of Swedish earthquakes for the period 1891-1957. Macroseismic determinations.

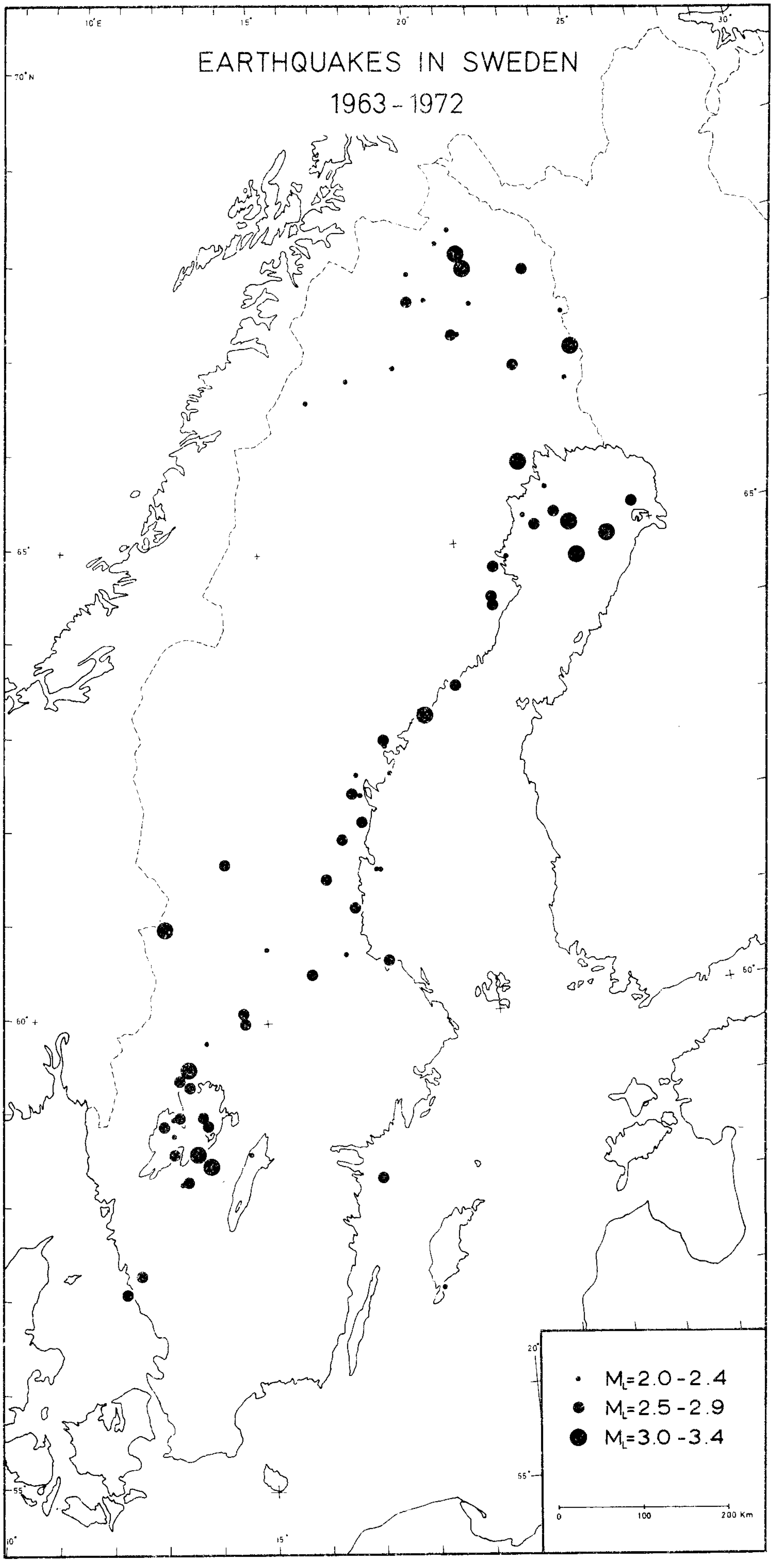

Fig. 2. Locations and magnitudes of Swedish earthquakes for the period 1963-1972. Instrumental determinations.

<u>Förteckning över tekniska rapporter</u>

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Nils Kjellbert
AB Atomenergi 77-04-05

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Sven Knutsson och Roland Pusch
Högskolan i Luleå 77-04-15

03. Deponering av högaktivt avfall i borrhål med buffertsubstans
A Jocobsson och R Pusch
Högskolan i Luleå 77-05-27

04. Deponering av högaktivt avfall i tunnlar med buffertsubstans
A Jacobsson, R Pusch
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Roland Blomqvist
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Ulf Lindblom
Hagconsult AB 77-02-28

07. Resteffekt för KBS del 1
Litteraturgenomgång Del 2 Beräkningar
K Ekberg, N Kjellbert, G Olsson
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08. Utlakning av franskt, engelskt och kanadensiskt glas med högaktivt avfall
Göran Blomqvist
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09. Diffusion of soluble materials in a fluid filling a porous medium
Hans Häggblom
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10. Translation and development of the BNWL-Geosphere Model
Bertil Grundfelt
Kemakta Konsult AB 77-02-05

11. Utredning rörande titans lämplighet som korrosionshärdig kapsling för kärnbränsleavfall
Sture Henriksson
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12. Bedömning av egenskaper och funktion hos betong i samband med slutlig förvaring av kärnbränsleavfall i berg
Sven G. Bergström
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Lars Rombén
Cement och Betonginstitutet 77-06-22

13. Urlakning av använt kärnbränsle (bestrålad uranoxid) vid direktdeponering
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14. Influence of cementation on the deformation properties of bentonite/quartz buffer substance
R. Pusch
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15. Orienterande temperaturberäkningar för slutförvaring i berg av radioaktivt avfall
Rapport 2
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16. Översikt av utländska riskanalyser samt planer och projekt rörande slutförvaring
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19. Studier av neotektonisk aktivitet i mellersta och norra Sverige, flygbildsgenomgång och geofysisk tolkning av recenta förkastningar
Robert Lagerbäck
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20. Tektonisk analys av södra Sverige
Vättern - Norra Skåne
Kennert Röshoff
Erik Lagerlund
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21. Earthquakes of Sweden 1891-1957
1963-1972
Ota Kulhânek
Rutger Wahlström
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22. The influence of rock movement on the stress/strain situation in tunnels or bore holes with radioactive conisters embedded in a bentonite/quartz buffer mass.
Roland Pusch
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23. Water uptake in a bentonite buffer mass.
A model study.
Roland Pusch
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24. Beräkning av utlakning av vissa fissionsprodukter och aktinider från en cylinder av franskt glas.
Göran Blomqvist
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