SEISMICITY OF NORWAY IN RELATION TO COSMIC CONDITIONS

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TAMRAZYAN, G. P.: Seismicity of Norway in relation to cosmic conditions. *Norsk Geologisk Tidsskrift*, Vol. 49, pp. 81-86. Oslo 1969.
Correlations between the earthquakes in Norway 1900-1950 and cosmic conditions suggest that earthquakes are triggered by cosmic conditions.

This paper considers the distribution of earthquakes in Norway in connection with cosmic conditions. Considered here are earthquakes of magnitude $M \geq 3$ from 1900-1950 (data from Båth 1956). Within these 50 years more than 140 earthquakes were registered (Fig. 1). Comparatively strong earthquakes (magnitude $M \geq 4.5$) during this period are shown in Table 1.

The strong earthquake in Norway on 23rd October 1904 had a magnitude of $M=6.5$ and the quantity of energy released was 3.5×10^{21} erg. All the

Table 1. Strong earthquakes ($M \geqq 4.5$) in Norway 1900-1950

Date	Greenwich Mean Time (hours, minutes)	Latitude N	Longitude E	Magnitude M	Synodic age of the earthquake (days, hours)	Reduced anomalistic age of the earthquake (days)
September 4, 1902	9 00	65.5	11.0	4.5	2 15	7.0
October 23, 1904	10 27	59.2	10.5	6.5	13 18	15.2
November 18, 1904	2 30	59.6	11.5	4.7	10 23	13.0
February 6, 1905	17 10	62.0	5.0	4.7	2 17	14.1
January 14, 1907	13 03	65.5	11.0	5.2	0 18	1.9
January 27, 1907	4 58	65.5	11.0	5.4	13 11	14.2
June 29, 1907	20 00	60.0	8.1	4.5	19 06	4.1
June 30, 1908	4 53	67.3	14.3	4.8	1 23	13.3
August 24, 1911	21 48	60.0	5.2	4.9	1 06	3.3
July 19, 1913	15 50	64.0	8.0	4.9	16 01	12.9
August 4, 1913	7 38	61.4	5.8	5.2	2 06	0.8
September 11, 1913	2 34	67.5	13.5	5.0	10.19	9.9
April 10, 1918	0 26	61.4	6.5	4.9	28 21	0.1
September 6, 1920	4 46	66.9	14.0	4.5	23.17	25.3
May 23, 1929	18 36	57.5	7.4	4.9	14 14	12.6
May 29, 1929	23 31	57.7	7.3	4.7	20 19	18.6
March 11, 1938	16 08	61.9	4.2	5.2	9 10	0.3
October 9, 1939	10 09	58.0	7.6	4.6	26 03	26.0
November 26, 1942	3 09	59.9	6.4	4.8	17 13	15.0

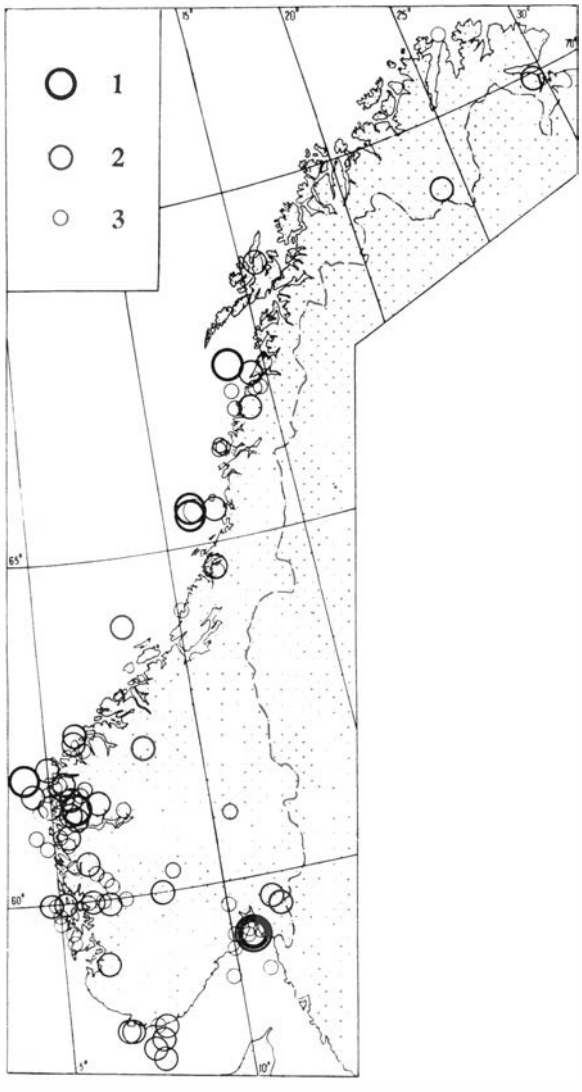

Fig. 1. Earthquakes in Norway 1900-1950.
Earthquake magnitudes (M):
1) 5.0-5.4 or more;
2) 4.0-4.9;
3) 3.5-3.9.

other earthquakes taken together released only 3.7×10^{20} erg, which is almost 10 times less. In order not to obscure the picture of the distribution of seismic energy of all earthquakes in Norway, this strong earthquake (M=6.5) is excluded from the following statistical account.

As seen in Table 2, the 41 earthquakes with magnitude M=4.0-5.4 released slightly more than 96 % of the energy of all earthquakes recorded in Norway 1900–1950. The remaining 100 earthquakes with magnitude M=3.0-3.9 released less than 4 % of the total seismic energy in the region. The energy released by earthquakes of lesser magnitude (M<3) is insignificant. On the whole, 41 strong earthquakes form the seismic picture of the region. The synodic age of an earthquake is the time interval (in days) between

Table 2. Distribution of earthquakes and their energy in Norway during 1900-1950

Magnitude	Number of earthquakes	Summary energy, in %
5.0-5.4	5	59.2
4.5-4.9	13	30.6
4.0-4.4	23	6.5
3.5-3.9	50	3.1
3.0-3.4	50	0.6
Total	141	100.0

the date of the earthquake and the last new Moon; it is determined by taking the average duration of the synodic month as 29.6 days. The anomalistic age of the earthquake is the time interval (in days) between the date of earthquake and the previous Moon's passage through its perigee. The duration of the reduced anomalistic age is determined by taking the average duration of an anomalistic month as 27.6 days. To convert the current anomalistic month into the reduced one a correction is introduced (sometimes up to dozens of hours).

This shows the important role of lunar phases (the relative location of the Earth, the Moon and the Sun) in the distribution of seismic energy released in this region during the lunar month. The strong earthquake with M=6.5, for example, falls in the interval between the 9th and 18th day of the synodic month (this earthquake occurred on the 13.7th day of the synodic month).

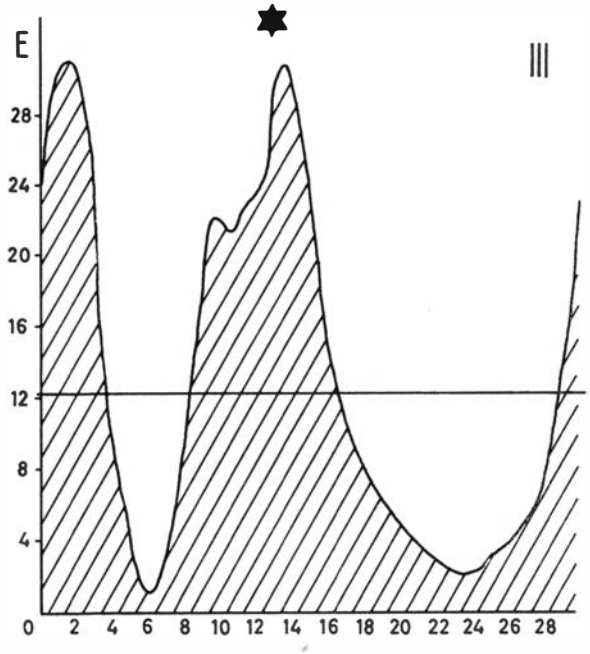

Fig. 2. Energy of earthquakes in Norway during 1900-1950 as a function of average age. Days of the average synodic month are represented on the abscissa. Curve shows the change in seismic energy (E. $\times 10^{18}$ ergs) by twice-sliding three-days period; the earthquake of magnitude M=6.5 is marked with an asterisk.

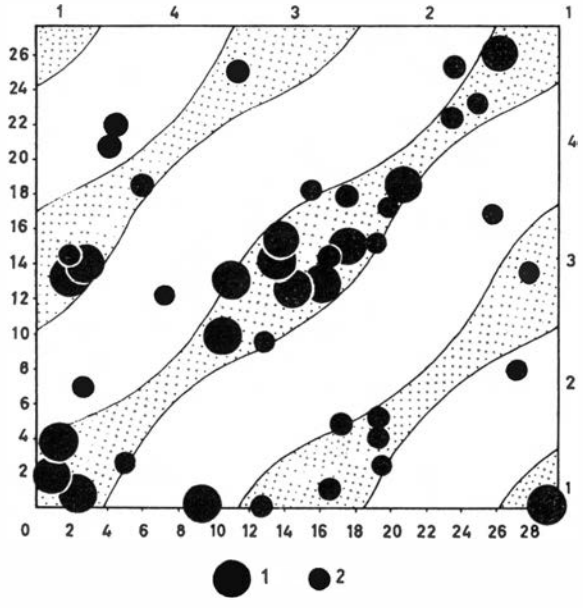

Fig. 3. Distribution of strong earthquakes ($M \geqq 4$) in Norway during 1900-1950 as a function of average synodic and reduced anomalistic age. Days of the average synodic month are on the abscissa. Days of the reduced anomalistic month on the ordinate. Circles designate earthquakes. Earthquake magnitudies: 1) 4.6-5.4 or more; 2) 4.0-4.5.

The distribution of seismic energy as a function of synodic and reduced anomalistic age is shown in Fig. 3. As can be seen, plots of most strong earthquakes (with magnitude $M \geq 4.0$) in Norway fall in narrow zones elongated in a direction extending from the left lower corner to the right upper corner of the diagram.

In the seismically active zones 32 earthquakes (with magnitude $M \geq 4$) occurred, whereas in the seismically passive belts only 10 earthquakes occurred. If the number of earthquakes in the seismically passive belts (numbers 2 and 4) is recalculated to one hundred percent, then the seismically active zones (numbers 1 and 3) show an increase of 32 % (Table 3).

Especially interesting is the distribution of earthquake energy (Table 3). In seismically active zones the release of seismic energy increased fully 5 times (534 %) as much as it did in seismically passive belts. This is

Table 3. Distribution of strong earthquakes ($M \geqq 4.0$) in Norway 1900-1950 and their energy in seismically passive belts and seismically active zones

Belt, zone	Seismically passive belt		Seismically active zone		Seismically passive belts	Seismically active zones	In the active zones as compared to the passive belts, %
No. (belt, zone)	2	4	1	3	2+4	1+3	
No. of earthquakes	5	5	21	11	10	32	320
Energy of earthquakes:							
$\times 10^{18}$ ergs	12.6	43.5	270.9	28.9	56.1	299.8	534
%	3.5	12.3	76.1	8.1	15.8	84.2	534

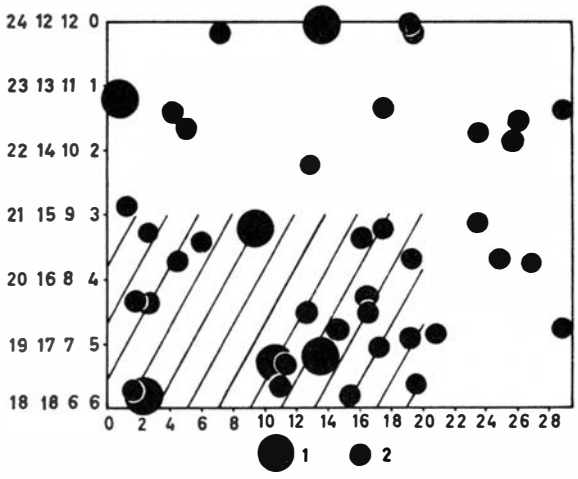

Fig. 4. Distribution of earthquakes in Norway by hours of the reduced lunar days (counted out from the moment of upper culmination of the Moon) and simultaneously in connection with their synodic age (1900-1950). Earthquake magnitudes (M):
1) 5.0-5.4 and more;
2) 4.0-4.9.

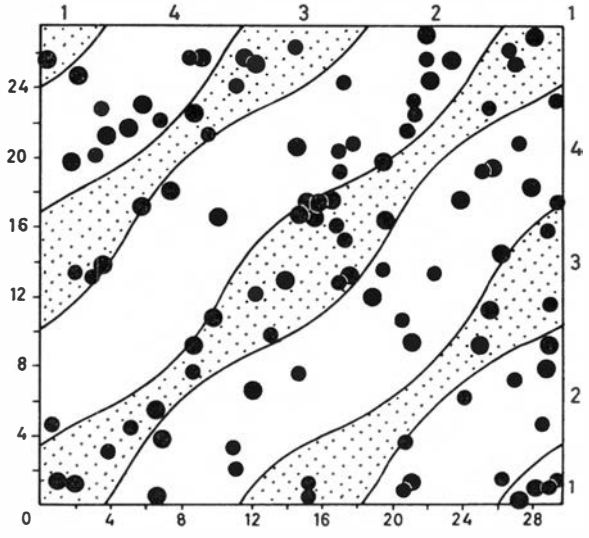

Fig. 5. The distribution (1900-1950) of weak earthquakes in Norway depending on the synodic and the reduced anomalistic age. Magnitudes of the earthquakes:
3.0-3.4 (Small circles);
3.5-3.9 (large circles).

especially obvious for the first seismically active zone, where the energy of the earthquakes exceeded that of earthquakes in the seismically passive zone 6-20 times.

The increase of several hundred percent in energy released by earthquakes as related to the variation of values of the tide-generating forces is a visual and indisputable demonstration of a genetic connection between seismic activity and tide-forming forces (Tamrazyan 1967).

On the other hand, the distribution of numerous weak earthquakes (with magnitude M=3.0-3.9), whose energy comprises only ca. 4 percent of the total seismic energy released in Norway, reveals practically no priority accumulation related to the synodic and the reduced anomalistic months

(Fig. 5). They are distributed, as a whole, almost evenly. But it is not these weak, although numerous, earthquakes that establish the seismic regime of any country. The seismic character of different regions is created by strong earthquakes. An analogous picture is also found in other regions (Tamrazyan 1966). Distribution of earthquakes as related to local lunar time and their synodic age is shown in Fig. 4. The increase in the number of earthquakes and especially in their energy shown in the lower left part of Fig. 4 is striking. Here, in comparison with the rest of the Figure, the frequency of the earthquakes is 2 times greater and their energy is 5 times greater.

The above correlations testify to the effect of cosmic conditions in triggering energy released at earthquake foci.

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16 March 1968

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