

On the distribution of energy and number of earthquakes in accordance with the focal depth

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SUMMARY. — An investigation is presented here concerning the distribution of earthquake energy and number of shocks in accordance with the focal depth. The global distribution of these quantities according to the depth of hypocentres can be approached by an exponential curve between 0 and about 500 km under the Earth's surface.

RIASSUNTO. — Viene presentato dall'A., in questa nota, uno studio sulla distribuzione dell'energia dei terremoti e il numero di scosse nei confronti della profondità focale. La distribuzione nel mondo di queste quantità nei confronti della profondità ipocentrale, può essere rappresentata da una curva esponenziale compresa fra lo 0 e i 500 km al disotto della superficie della terra.

Ritsema (1) emphasized the importance of studies concerning the connection between strain- (or energy-)release and focal depth of earthquakes. In his quoted paper he mentioned that the strain-release/depth diagram of the Sunda Arc and the same diagram of the Earth as a whole show surprisingly similar characteristics in the period of 1904-1946.

This extraordinarily interesting recognition induced the author of the present paper to extend the investigations for a larger scale of time. Gutenberg and Richter (2,3) published the magnitude-data of the greatest shocks between 1896 and 1904; on the other hand the data of all shocks of magnitude 6,9 and over it are at our disposal from 1904 till about the middle of 1962, due partly to the common work of Gutenberg and Richter (4) and partly to the Bulletin of the Seismological Society of America (5). Altogether we have the data of 1389 earthquakes occurred between the beginning of 1896 and about the middle of 1962. We calculated the energy-release instead of the strain-release.

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Table I.

Magnitude depth, km	6,9	7,0	7,1	7,2	7,25	7,3	7,4	7,5	7,6	7,7	7,75	7,8
0-49	100	140	80	69	16	63	37	41	36	14	14	25
50-74	25	48	25	21	9	11	8	7	5	2	2	0
75-99	11	20	8	8	4	9	2	3	0	0	1	0
100-124	20	21	9	10	8	3	7	6	0	2	1	0
125-149	7	9	5	4	1	0	1	2	0	0	1	0
150-174	7	14	2	6	1	2	2	4	1	0	0	1
175-199	2	3	3	1	2	2	0	1	1	0	0	0
200-224	3	18	2	1	3	2	0	2	0	0	2	0
225-249	0	2	1	2	0	0	0	3	1	0	0	0
250-274	3	3	1	3	3	0	0	0	0	0	0	0
275-299	2	0	0	0	0	0	0	0	0	0	0	0
300-324	1	2	1	1	0	1	0	0	0	0	0	0
325-349	0	3	0	0	0	1	0	0	0	1	0	0
350-374	2	2	1	0	0	1	2	0	0	0	0	0
375-399	1	2	0	0	0	1	0	0	0	0	0	0
400-424	0	0	3	0	1	0	0	0	0	0	0	0
425-449	0	1	0	0	0	0	0	0	0	0	0	0
450-474	0	0	0	0	2	0	1	1	0	0	0	0
475-499	1	1	0	0	0	0	0	0	0	0	0	0
500-524	0	2	0	1	1	0	0	0	0	0	0	0
525-549	1	0	0	0	0	1	0	0	0	0	0	0
550-574	0	0	0	1	0	1	0	0	0	0	0	0
575-599	1	1	0	2	1	1	0	0	0	0	0	0
600-624	6	7	2	1	3	0	0	5	0	0	0	0
625-649	0	1	0	1	3	0	0	0	0	0	1	0
650-674	4	4	0	0	1	0	0	0	1	0	0	0
675-699	0	0	0	0	0	0	0	0	0	0	0	0
700-724	1	0	0	0	0	0	0	0	0	0	0	0
725-749	0	0	0	0	0	0	0	0	0	0	0	0
750-774	0	0	0	0	0	0	0	0	0	0	0	0
Total:	198	304	143	132	59	98	60	75	45	19	22	26

Table II.

Magnitude depth, km	7,9	8,0	8,1	8,2	8,25	8,3	8,4	8,5	8,6	8,7	8,8	8,9
0-49	49	5	20	0	3	39	13	6	8	9	0	3
50-74	5	0	3	0	1	4	1	0	3	1	0	0
75-99	2	0	2	0	0	1	1	0	0	1	0	0
100-124	1	0	0	0	0	4	0	0	1	1	0	0
125-149	0	0	0	0	0	0	0	0	0	0	0	0
150-174	1	0	0	0	0	0	0	0	1	1	0	0
175-199	1	0	1	0	0	1	0	0	0	0	0	0
200-224	2	0	1	0	0	1	0	0	0	0	0	0
225-249	0	0	2	0	0	0	0	0	0	0	0	0
250-274	0	0	0	0	0	0	0	0	0	0	0	0
275-299	0	0	0	0	0	0	0	0	0	0	0	0
300-324	0	0	0	0	0	0	0	0	0	0	0	0
325-349	1	0	0	0	0	0	1	0	0	0	0	0
350-374	1	0	0	0	0	0	0	0	0	0	0	0
375-399	0	0	0	0	0	0	0	0	0	0	0	0
400-424	0	1	1	0	0	0	0	0	0	0	0	0
425-449	0	0	0	0	0	0	0	0	0	0	0	0
450-474	0	0	0	0	0	0	0	0	0	0	0	0
475-499	0	0	0	0	0	0	0	0	0	0	0	0
500-524	0	0	0	0	0	0	0	0	0	0	0	0
525-549	0	0	0	0	0	0	0	0	0	0	0	0
550-574	1	0	0	0	0	0	0	0	0	0	0	0
575-599	0	0	0	0	0	0	0	0	0	0	0	0
600-624	2	0	0	0	0	0	0	0	0	0	0	0
625-649	0	0	0	0	0	0	0	0	0	0	0	0
650-674	1	0	0	0	0	0	0	0	0	0	0	0
675-699	0	0	0	0	0	0	0	0	0	0	0	0
700-724	0	0	0	0	0	0	0	0	0	0	0	0
725-749	0	0	0	0	0	0	0	0	0	0	0	0
750-774	0	0	0	0	0	0	0	0	0	0	0	0
Total:	67	6	30	0	4	50	16	6	13	13	0	3

Table III.

Depth, km	Number of shocks	Depth, km	Number of shocks
0- 49	790	400-424	6
50- 74	181	425-449	1
75- 99	73	450-474	4
100-124	94	475-499	2
125-149	30	500-524	4
150-174	43	525-549	2
175-199	18	550-574	3
200-224	37	575-599	6
225-249	11	600-624	26
250-274	13	625-649	6
275-299	2	650-674	11
300-324	6	675-699	0
325-349	6	700-724	1
350-374	9	725-749	0
375-399	4	750-774	0

Table IV

Depth, km	Total energy, 10^{20} ergs	Depth, km	Total energy, 10^{20} ergs
0- 49	3915110,9	400-424	16515,4
50- 74	485432,5	425-449	158,5
75- 99	178412,6	450-474	2488,0
100-124	254351,6	475-499	268,1
125-149	10265,5	500-524	1046,2
150-174	161739,9	525-549	588,2
175-199	38446,5	550-574	5174,7
200-224	50046,6	575-599	1807,0
225-249	23893,3	600-624	17480,7
250-274	3221,0	625-649	4195,9
275-299	219,2	650-674	7280,5
300-324	1465,4	675-699	0
325-349	34469,5	700-724	109,6
350-374	6992,5	725-749	0
375-399	905,2	750-774	0
Total energy: $5,222085 \cdot 10^{26}$ ergs.			

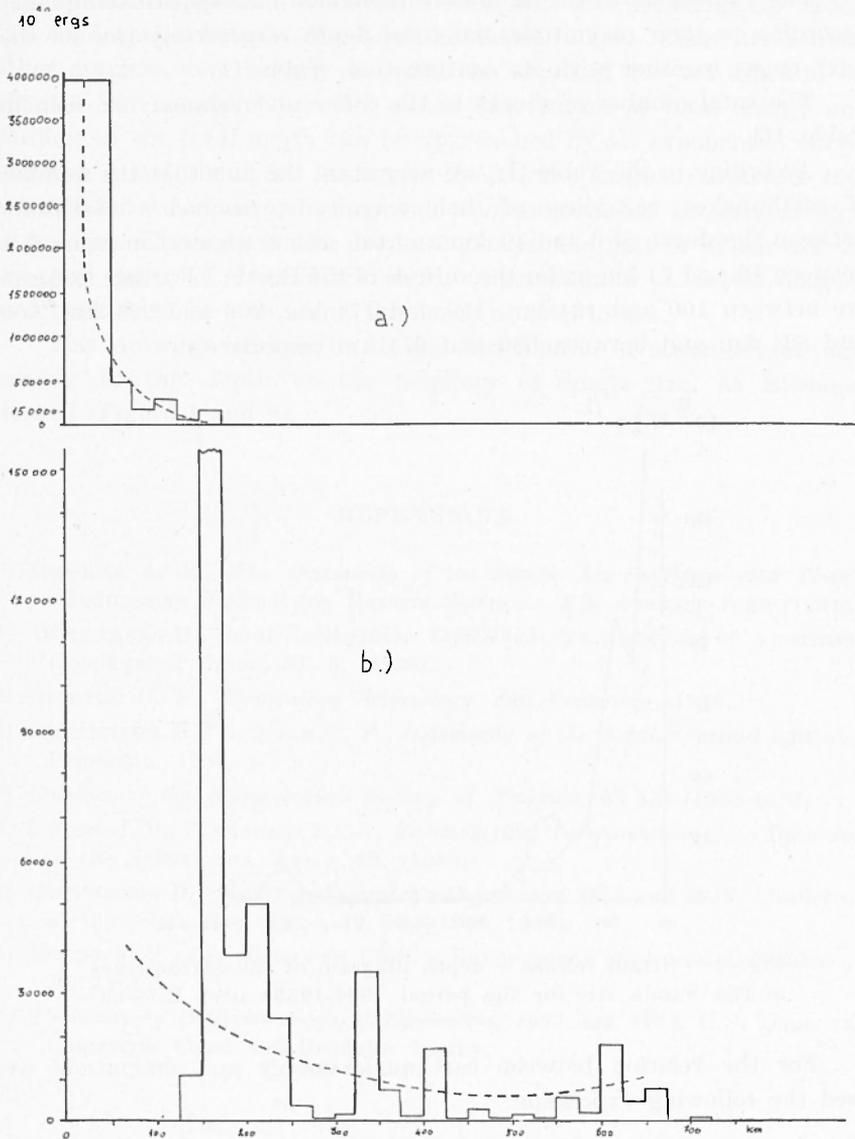


Fig. 1 - The distribution of earthquake-energy in accordance with the focal depth, between the period 1896-1963, all over the world, for shocks between magnitude range of 6.9-8.9 (according to the present author).

- a) between the depth of 0 and 175 km;
- b) between the depth of 125 and 750 km.

The Table I shows the number of the above mentioned earthquakes according to their magnitude and focal depth respectively (see on the next pages together with its continuation, Table II).

The total number of shocks in the different levels may be seen in Table III.

According to the Table III, we may state the fact that the number of earthquakes, regardless of their magnitude, reached a maximum between the depth of 0 and 49 km and the second greatest maximum is between 50 and 74 km under the surface of the Earth. Further maxima are between 100 and 124 km, 150 and 174 km, 200 and 224 km, 600 and 624 km and between 650 and 674 km respectively.

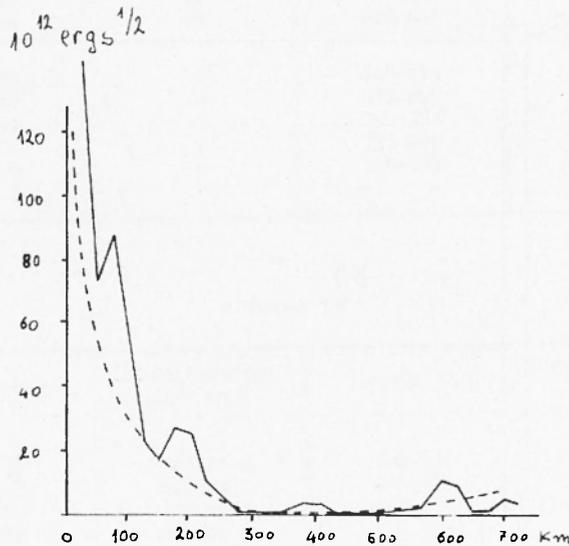


Fig. 2 - Strain release - depth diagram of the earthquakes of the Sunda Arc for the period 1904-1953, after Ritsena.

For the relation between earthquake-energy and magnitude we used the following expression:

$$\log E = 11 + 1,6 M$$

where E is the energy in ergs and M is the magnitude.

Using this formulæ, we got for the energy-distribution according to depth, the results of Table IV.

We state the fact that the total energy of shocks as a function of depth reached a maximal height between 0 and 49 km under the surface

and the second greatest maximum could be found immediately under this level, that is between the depth of 50 and 74 km. There are several other maxima, too, namely between the depth of 150-174 km and of 325-349 km respectively. The global distribution of total energy according to the focal depth can be approached by an exponential curve between 0 and about 500 km under the Earth's surface. Between 450 and 550 km we can experience a wide minimum-zone in the total energy of shocks. Throughout the deeper layers in the mantle of the Earth the total energy of shocks begin slowly to grow again. A newer, smaller maximum is to be seen about the depth of 600-675 km.

This drawing reminds us to the distribution of strain release according to the depth on the territory of Sunda Arc, as Ritsema showed (Figure 1 and 2).

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