Suggestion for a new classification of earthquakes according to the focal depth

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Summary. — In this paper the Author suggests to regard the lower limit of the category of the so-called shallow earthquakes identical with the level of the regional isostatic compensation and the upper limit of the so-called deep shocks identical with the Byerly-discontinuity.

Riassunto. — In questa nota l'A. suggerisce di identificare il limite inferiore della categoria dei così detti terremoti a profondita normale con il livello della superficie di compensazione isostatica e il limite superiore dei così detti terremoti profondi con la discontinuità di Byerly.

In the geophysical practice it is customary to classify the earthquakes into three different groups according to the depth of hypocenter. In accordance with this classifying we distinguish shallow, intermediate and deep shocks respectively. According to the classical division:

Table I.

Denomination	Limits of focal depth, km
Shallow	0– 70 (sometimes 0–60)
Intermediate	70–300
Deep	300–750

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Some authors, e. g. Ritsema (2) and Honda (3) used a somewhat different classifying than that of in Table I. On the 6th figure of Ritsema's paper we find the following division of shocks:

Table II.

Group	Limits of focal depth, km
I.	0–40
II.	40–130
III.	≥ 130

In his quoted paper Honda wrote the followings: " The earthquakes are classed here as shallow when the focal depth does not exceed 100 km, intermediate when it is from 100 km to 250 km, and deep when it exceeds 250 km ".

There is no particular geophysical reason to maintain further the classical division of earthquakes (see in Table I). *It seems to be more real if we connect the limits of focal depth with certain special geophysical levels in the Earth. Such levels may be the different discontinuities*; the Mohorovicic-surface, the Byerly- and Repetti-ones.

However here appears a rather great difficulty. As it is well-known, the depth of the Mohorovicic-discontinuity is varying from place to place in accordance with the regional relief of the surface and the rule of isostasy. Although there are many data of the Earth's crustal thickness, due to gravitational and seismical explorations, nevertheless the number of useful values is as the present too small for a theoretical world-wide investigation.

On the other hand the crustal thickness under oceanic territories is only 5-15 km or somewhat larger. If we connect the lower limit of the shallow shocks' category with the Mohorovicic-discontinuity, the greatest part of earthquakes over the oceanic territories (earlier pertaining to the *shallow* category), — would now belong into the group of the *intermediate* quakes. Hereby much of the regularities discovered concerning the shallow shocks all over the world would disappear. Naturally this were not desirable. *Therefore we suggest to regard the lower limit of the shallow shocks' category identical with the level of the regional isostatic*

compensation. According to the calculations of Gutenberg (4) the pressure between the surface and the depth of 50 km is as follows (See on Table III):

Table III.

Depth,	Pressure of column in bars			Pressure difference in bars		
km	*a*	*b*	*c*	*a–b*	*a–c*	*b–c*
0	770	0	0	770	770	0
6	2340	1550	590	790	1750	960
11	3650	2860	2000	790	1650	860
15	4700	3910	3300	790	1400	610
20	6010	5220	4920	790	1090	300
25	7320	6680	6530	640	790	150
30	8780	8140	8150	640	630	— 10
40	11700	11380	11390	320	310	— 10
50	14630	14620	14630	10	0	— 10

a) Pressure under a 3 km high mountain area;
b) pressure under continental lowlands;
c) pressure under a 6 km deep ocean.

It is to be seen that the difference of pressure in a depth of 50 km is almost zero. Therefore we may regard the depth of 50 km as the *level of regional isostatic compensation*.

In accordance with these considerations the suggested new classification of earthquakes regarding their focal depth is as follows:

Table IV.

Category	Limits of focal depth	km
S–RIC	Surface, – level of regional isostatic compensation	0–50
RIC–B	Level of regional isostatic compensation, – *Byerly*-discontinuity	51–413
B–R	*Byerly*-discontinuity, – *Repetti*-discontinuity	> 414

Table V.

Date	Lat. (or approximate location)	Long.	M	Type	Focal depth km	Earlier class
1896 Jan. 19	Central Honshu		8,1	S-RIC	normal	shallow
1896 March 4	?	?	8,3 ?	S-RIC ?	normal ?	shallow ?
1896 May 5	?	?	8,3 ?	S-RIC ?	normal ?	shallow ?
1896 June 15	NE Honshu		8,7	S-RIC	normal	shallow
1896 June 15	NE Honshu		8,5	S-RIC	normal	shallow
1896 June 15	NE Honshu		8,5	S-RIC	normal	shallow
1896 June 17	Central Honshu		8,5 ?	S-RIC	normal	shallow
1896 Aug. 31	NE Honshu		8,5	S-RIC	normal	shallow
1897 Febr. 7	40 N	140 E	8,3	S-RIC	normal	shallow
1897 Febr. 19	38 N	142 E	8,3	S-RIC	normal	shallow
1897 Febr. 19	38 N	142 E	8,3	S-RIC	normal	shallow
1897 May 28	E Mediterran		8,0 ?	RIC-B ?	?	intermediate ?
1897 June 12	26 N	91 E	8,7	S-RIC	25	shallow
1897 Aug. 5	38 N	143 E	8,7	S-RIC	normal	shallow
1897 Sept. 20	6 N	122 E	8,6	S-RIC	normal	shallow
1897 Sept. 21	6 N	122 E	8,7	S-RIC	normal	shallow
1897 Oct. 18	12 N	126 E	8,1	S-RIC	normal	shallow
1898 Apr. 22	39 N	142 E	8,3	S-RIC	normal	shallow
1898 June 29	?	?	8,3 ?	S-RIC	normal ?	shallow ?
1899 Jan. 24	17 N	98 W	8,4	S-RIC	normal	shallow
1899 Sept. 4	60 N	142 W	8,3	S-RIC	normal	shallow
1899 Sept. 10	60 N	142 W	8,6	S-RIC	normal	shallow
1900 Jan. 20	20 N	105 W	8,3	S-RIC	normal	shallow
1900 July 29	10 S	165 E	8,1	S-RIC	normal	shallow
1900 Oct. 9	60 N	142 W	8,3	S-RIC	normal	shallow

(Continuation)

Date	Lat. (or approximate location)	Long.	M	Type	Focal depth km	Earlier class
1900 Oct. 29	11 N	66 W	8,4	S-RIC	normal	shallow
1901 Aug. 9	22 S	170 E	8,4	S-RIC	normal	shallow
1901 Aug. 9	40 N	144 E	8,3	S-RIC	normal	shallow
1902 Apr. 19	14 N	91 W	8,3	S-RIC	normal	shallow
1902 Aug. 22	40 N	77 E	8,6	S-RIC	normal	shallow
1902 Sept. 22	18 N	146 E	8,1	S-RIC	normal	shallow
1902 Sept. 23	16 N	93 W	8,4	S-RIC	normal	shallow
1903 Jan. 4	20 S	175 W	8,0	RIC-B	400	deep
1903 Jan. 14	15 N	98 W	8,3	S-RIC	normal	shallow
1903 Febr. 27	8 S	106 E	8,1	S-RIC	normal	shallow
1903 June 2	57 N	156 W	8,3	RIC-B	100	intermediate
1903 Aug. 11	36 N	23 E	8,3	RIC-B	100	intermediate
1904 June 25	52 N	159 E	8,3	S-RIC	normal	shallow
1904 June 25	52 N	159 E	8,1	S-RIC	normal	shallow
1904 Aug. 27	64 N	151 W	8,3	S-RIC	normal	shallow
1904 Dec. 20	8 ½ N	83 W	8,3	S-RIC	normal	shallow
1905 Jan. 22	1 N	123 E	8,4	RIC-B	90	intermediate
1905 Apr. 4	33 N	76 E	8,6	S-RIC	normal	shallow
1905 July 9	49 N	99 E	8,4	S-RIC	normal	shallow
1905 July 23	49 N	98 E	8,7	S-RIC	normal	shallow
1906 Jan. 21	34 N	138 E	8,4	RIC-B	340	deep
1906 Jan. 31	1 N	81 ½ W	8,9	S-RIC	normal	shallow
1906 April 18	38 N	123 W	8,3	S-RIC	18	shallow
1906 Aug. 17	51 N	179 E	8,3	S-RIC	normal	shallow
1906 Aug. 17	33 S	72 W	8,6	S-RIC	normal	shallow

(Continuation)

Date	Lat. (or approximate location)	Long.	M	Type	Focal depth km	Earlier class
1906 Sept. 14	7 S	149 E	8,4	S-RIC	normal	shallow
1906 Dec. 22	43½ N	85 E	8,3	S-RIC	normal	shallow
1907 April 15	17 N	100 W	8,3	S-RIC	normal	shallow
1907 Oct. 21	38 N	69 E	8,1	S-RIC	normal	shallow
1908 March 26	18 N	99 W	8,1	RIC-B	80	intermediate
1909 March 13	31½ N	142½ E	8,3	RIC-B	80	intermediate
1909 July 7	36½ N	70½ E	8,1	RIC-B	230	intermediate
1910 April 12	25½ N	122½ E	8,3	RIC-B	200	intermediate
1910 June 16	19 S	169½ E	8,6	RIC-B	100	intermediate
1911 Jan. 3	43½ N	77½ E	8,7	S-RIC	normal	shallow
1911 June 15	29 N	129 E	8,7	RIC-B	160	intermediate
1911 Aug. 16	7 N	137 E	8,1	S-RIC	normal	shallow
1913 March 14	4½ N	126½ E	8,3	S-RIC	40	shallow
1913 Oct. 14	19½ S	169 E	8,1	RIC-B	230	intermediate
1914 Nov. 24	22 N	143 E	8,7	RIC-B	110	intermediate
1915 May 1	47 N	155 E	8,1	S-RIC	normal	shallow
1916 Jan. 13	3 S	135½ E	8,1	S-RIC	normal	shallow
1917 Jan. 30	56½ N	163 E	8,1	S-RIC	normal	shallow
1917 May 1	29 S	177 W	8,6	RIC-B	50-60	shallow
1917 June 26	15½ S	173 W	8,7	S-RIC	normal	shallow
1918 Aug. 15	5½ N	123 E	8,3	S-RIC	normal	shallow
1918 Sept. 7	45½ N	151½ E	8,3	S-RIC	normal	shallow
1918 Nov. 18	7 S	129 E	8,1	RIC-B	190	intermediate
1919 Jan. 1	19½ S	176½ W	8,3	RIC-B	180	inrermediate
1919 Apr. 30	19 S	172½ W	8,4	S-RIC	normal	shallow

(Continuation)

Date	Lat. (or approximate location)	Long	M	Type	Focal depth km	Earlier class
1919 May 6	5 S	154 E	8,1	S-RIC	normal	shallow
1910 June 5	23 ½ N	122 E	8,3	S-RIC	normal	shallow
1920 Sept. 20	20 S	168 E	8,3	S-RIC	normal	shallow
1920 Dec. 16	36 N	105 E	8,6	S-RIC	normal	shallow
1921 Nov. 15	36 ½ N	70 ½ E	8,1	RIC-B	215	intermediate
1922 Nov. 11	28 ½ S	70 W	8,4	S-RIC	normal	shallow
1923 Febr. 3	54 N	161 E	8,4	S-RIC	normal	shallow
1923 Sept. 1	35 ¼ N	139 ½ E	8,3	S-RIC	normal	shallow
1924 April 14	6 ½ N	126 ½ E	8,3	S-RIC	normal	shallow
1924 June 26	56 S	157 ½ E	8,3	S-RIC	normal	shallow
1926 June 26	36 ½ N	27 ½ E	8,3	RIC-B	100	intermediate
1927 May 22	36 ¾ N	102 E	8,3	S-RIC	normal	shallow
1928 March 9	2 ½ S	88 ½ E	8,1	S-RIC	normal	shallow
1928 Dec. 1	35 S	72 W	8,3	S-RIC	normal	shallow
1929 March 7	51 N	170 W	8,6	S-RIC	50	shallow
1929 June 27	54 S	29 ½ W	8,3	S-RIC	normal	shallow
1931 Oct. 3	10 ½ S	161 ¾ E	8,1	S-RIC	normal	shallow
1932 May 14	0 ½ N	126 E	8,3	S-RIC	normal	shallow
1932 June 3	19 ½ N	104 ¼ W	8,1	S-RIC	normal	shallow
1933 March 2	39 ¼ N	144 ½ E	8,9	S-RIC	normal	shallow
1933 Nov. 25	34 N	141 ½ E	8,25	S-RIC	normal	shallow
1934 Jan. 15	26 ½ N	86 ½ E	8,4	S-RIC	normal	shallow
1934 July 18	11 ¾ S	166 ½ E	8,1	S-RIC	normal	shallow
1935 Dec. 28	0	98 ¼ E	8,1	S-RIC	normal	shallow
1937 April 16	21 ½ S	177 W	8,1	RIC-B	400	deep

(Continuation)

Date	Lat. (or approximate location)	Long.	M	Type	Focal depth km	Earlier class
1938 Febr. 1	5¼ S	130½ E	8,6	S-RIC	normal	shallow
1938 Nov. 10	55½ N	158 W	8,7	S-RIC	normal	shallow
1939 Jan. 25	36¼ S	72¼ W	8,3	RIC-B	50-60	shallow
1939 April 30	10½ S	158½ E	8,1	S-RIC	50	shallow
1939 Dec. 21	0	123 E	8,6	RIC-B	150	intermediate
1940 May 24	10½ S	77 W	8,4	RIC-B	60	shallow
1941 June 28	12½ N	92½ E	8,7	RIC-B	60	shallow
1941 Nov. 25	37½ N	18½ W	8,4	S-RIC	normal	shallow
1942 May 14	0¾ S	81½ W	8,3	S-RIC	normal	shallow
1942 Aug. 6	14 N	91 W	8,3	RIC-B	50-60	shallow
1942 Aug. 24	15 S	76 W	8,6	RIC-B	60	shallow
1942 Nov. 10	49½ S	32 E	8,3	S-RIC	normal	shallow
1943 April 6	30¾ S	72 W	8,3	RIC-B	50-60	shallow
1943 May 25	7½ N	128 E	8,1	S-RIC	normal	shallow
1943 July 23	9½ S	110 E	8,1	RIC-B	90	intermediate
1944 Dec 7	33¾ N	136 E	8,3	S-RIC	normal	shallow
1945 Nov. 27	24½ N	63 E	8,3	S-RIC	normal	shallow
1946 Aug. 4	19¼ N	69 W	8,1	S-RIC	normal	shallow
1946 Dec. 20	32½ N	134½ E	8,4	S-RIC	normal	shallow
1948 Jan. 24	10½ N	122 E	8,3	S-RIC	normal	shallow
1949 Aug. 22	53¾ N	133¼ W	8,1	S-RIC	normal	shallow
1950 Aug. 15	28½ N	96½ E	8,7	S-RIC	normal	shallow
1950 Nov. 2	6½ S	129½ E	8,1	S-RIC	50	shallow
1950 Dec. 2	18¼ S	167½ E	8,1	RIC-B	60	shallow
1950 Dec. 9	23½ S	67½ W	8,3	RIC-B	100	intermediate

(Continuation)

Date	Lat. (or approximate location)	Long.	M	Type	Focal depth km	Earlier class
1952 March 4	42 ½ N	143 E	8,6	S-RIC	normal	shallow
1952 Nov. 4	52 ¾ N	159 ½ E	8,4	S-RIC	normal	shallow
1953 Nov. 25	34 N	141 ½ E	8,3	RIC-B	60	shallow
1955 Febr. 27	28 S	175 ½ W	8,0	S-RIC	normal	shallow
1957 March 9	51 ¼ N	176 ½ W	8,25	S-RIC	normal	shallow
1957 April 14	15 ½ S	173 W	8,0	S-RIC	normal	shallow
1957 Dec. 4	45 ½ N	99 ½ E	8,3	S-RIC	normal	shallow
1958 July 10	58 ½ N	136 W	8,0	S-RIC	normal	shallow
1958 Nov. 6	44 ½ N	148 ¾ E	8,7	RIC-B	75	intermediate
1959 May 4	52 ½ N	159 ½ E	8,25	RIC-B	60	shallow
1959 Sept. 14	28 ½ S	177 W	8,0	S-RIC	normal	shallow
1960 May 21	37 ½ S	73 ½ W	8,5	S-RIC	normal	shallow
.....	38 ¼ S	73 ¾ W	8,5	S-RIC	normal	shallow
.....	38 ½ S	74 ½ W	8,3	S-RIC	normal	shallow
June 20 (*)	45 ½ S	73 ¾ W	8,0	S-RIC	normal	shallow
1960 May 21 – June 20 (*)	37 ¾ S	73 W	8,25	S-RIC	normal	shallow
1960 May 22	39 ¾ S	74 ½ W	8,9	S-RIC	normal	shallow (**)
1963 Oct. 13	44 ¾ N	149 ½ E	8,0	RIC-B	60	shallow

(*) Great Chilean earthquake-sequence.
(**) According to *Rothé*.

Lastly, we show the new classification in the case of the greatest earthquakes ($M \geqslant 8{,}0$) between January 1896 and October 1963. The magnitude-data were determined by Gutenberg (5), Richter (6), Galanopoulos (7), Eaton (8), the Bulletin of the Seismological Society of America (9) and US Coast and Geodetic Survey (10) respectively.

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