International Seismological Centre
Ref-2613

Manila Observatory.- Philippine Islands.
Seismological Bulletin, No. 1, a. January, 1911.

No.	Date	Character.	Instrument and Component	Beginning P. h. m. s.	Beginning S. h. m. s.	Beginning L. h. m. s.	Maximum range of motion Hour h. m. s.	A mm.	T s.	F h. m.	Remarks.
1	1	I_u	V.	18 27 26	18 38 26	18 51 44	18 58 09	0.01	14.4	19 30	
			H. NNW	18 27 26	18 37 29	18 50 59	18 58 14	.02	16.5	19 22	
			H. WSW	18 27 26	18 37 41	18 50 54	18 58 13	.06	13.8	19 25	
2	4	III_u	V.	7 34 24	7 41 50	7 50 16	7 58 28	.31	14.4	9 30	Vertical Component 0.05 mm. Earthquake in Turkestan.
			H. NNW	7 34 24	7 41 20	7 51 25	8 00 17	3.13	13.2	9 35	
			H. WSW	7 34 24	7 41 34	7 51 25	7 58 21	2.60	13.8	9 46	
3	4	I	H. NNW	17 41 48						18 25	
			H. WSW	17 41 48						18 26	
4	5	II_d	V.	7 51 30		7 51 54	7 52 08	1.50	2.4	7 59	V. C. 1.12 mm.
	6	At 20h 30m Egke., III at Catbalogan (W of Samar).									
5	7	I_v	V.	4 42 08		4 42 56	4 43 00	.02	2.4	4 46	V. C. 0.01 mm. Egke., IV in northern part of Luzon.
6	7	II_r	V.	10 19 10	10 23 44	10 28 51	10 37 04	.06	10	11 57	V. C. 0.01 mm.
			H. NNW	10 19 13	10 23 37	10 28 53	10 33 00	1.35	8.1	11 52	
			H. WSW	10 19 13	10 23 54	10 28 08	10 37 09	1.51	9.6	12 06	
7	8	I	V.	17 06 13						17 12	V. C. 0.01 mm.
			H. NNW	17 06 13						17 15	
			H. WSW	17 06 13						17 17	
8	10	I_d	V.	16 24 04		16 24 17	16 24 46	.32	2.4	16 28	V. C. 0.12 mm.
9	11	I	V.	0 35 23						1 04	
			H. WSW	0 35 37						1 08	
10	16	I_r	V.	16 55 51	16 59 22	17 04 24	17 07 38	.03	10.8	17 34	
			H. NNW	16 55 52	16 59 29	17 04 31	17 08 16	.13	8.4	17 34	
			H. WSW	16 55 52	16 59 40	17 04 43	17 07 40	.45	9.0	17 47	

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No.	Date	Character.	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour.	Maximum range of motion A	Maximum range of motion T	F	Remarks
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
			V.	6 57 34		6 59 42	7 00 12	.06	2.4	7 22	V. C. 0.01 mm. Eqke., V in the
11	17	I_v	H. NNW	6 57 37		6 59 42	7 00 27	.16	7.2	7 16	northeastern part of Mindanao.
			H. WSW	6 57 37		6 59 19	7 00 37	.28	7.8	7 22	
	19	At 1h 30m Eqke., IV at Sarangani (S of Mindanao)									
12	19	I_d	V.	11 04 43		11 04 57	11 04 59	.17	2	11 09	V. C. 0.05 m m.
			V.	13 47 20		13 49 19	13 53 11	.02	2.8	14 06	Eqke. III at Butuan (N of Min-
13	19	I_v	H. NNW	13 47 24		13 49 19	13 52 47	.04	8.4	14 07	danao).
			H. WSW	13 47 24		13 49 35	13 52 46	.14	7.8	14 37	
	22	At 23h 20m Eqke., IV at Sarangani (S of Mindanao).									
14	24	I_d	V.	3 04 39		3 04 59	3 05 11	.03	2.2	3 06	V. C. 0.01 m m.
			V.	8 47 24						9 27	
15	25	I_r	H. NNW	8 47 24						9 22	
			H. WSW	8 47 24						9 28	
			V.	4 57 07						5 02	
16	27	I	H WSW	4 57 08			5 01 11	.03	6	5 10	
	28	At 4h 30m Eqke., IV at Sarangani (S of Mindanao).									

M. Saderra M.

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No.	Date	Character.	Instrument and Component	Beginning P.	Beginning S.	Beginning L.	Maximum range of motion Hour	A	T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
	8	I_v	V.	3 11 26		3 11 34	3 11 39	0.04	1.8	3 14	V.C. 0.03 mm. Intensity I. Origin Taal volcano.
	8	I_v	V.	9 15 38						9 17	
	8	I_v	V.	9 23 34		9 23 39	9 23 53	.03	1.6	9 25	V.C. 0.01 mm. Int. I.
	8	I_v	V.			12 11 38				12 13	V.C. 0.01 mm. Int. I
	8	I_v	V.	14 05 10		14 05 15	14 06 06	.15	2.4	14 08	V.C. 0.11 mm. Int. II
	8	I_v	V.	14 12 39						14 14	Intensity I.
	8	I_v	V.	20 54 20						20 56	Intensity I.
	8	I_v	V.	23 20 04						23 23	Intensity I.
	8	I_v	V.	23 37 08						23 41	Intensity. I.
	9	I_v	V.	0 17 07						0 24	Intensity I.
	9	I_v	V.	1 02 48						1 05	Intensity I.
	9	I_v	V.	2 33 47						2 36	Intensity I.
	9	I_v	V.	2 39 15						2 41	Intensity I.
	9	I_v	V.	2 50 09						2 51	Intensity I.
	9	I_v	V.	6 19 44						6 22	Intensity I.
	9	I_v	V.	8 41 58						8 45	Intensity II.
	9	I_v	V.	10 16 02						10 18	Intensity I.
	9	I_v	V.	13 43 30						13 45	Intensity I. V.C. 0.01 mm.
	9	I_v	V.	15 01 49			15 03 13	.09	2.4	15 05	Intensity I.

Origin Taal volcano.

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No.	Date	Character.	Instrument and Component.	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
	9	I_v	V.	16 54 21						16 56	Intensity I.
	9	I_v	V.	18 01 16		18 01 46	18 02 16	.18	2.4	18 04	Intensity I. V. C. 0.01 mm.
	9	I_v	V.	23 59 37						0 01	Intensity I.
	10	I_v	V.	0 28 14		0 28 20	0 29 12	.18	2.4	0 31	Intensity II. V. C. 0.07 mm.
	10	I_v	V.	3 22 02		3 22 09	3 22 36	.30	2.4	3 25	Intensity II. V. C. 0.21 mm.
	10	I_v	V.	6 42 52						6 45	Intensity I. V. C. 0.02 mm.
	10	I_v	V.	11 06 45						11 09	Intensity I.
	10	I_v	V.	14 41 47						14 44	Intensity I.
	10	I_v	V.	22 00 43						22 04	Intensity I. V. C. 0.02 mm.
	10	I_v	V.	22 08 09						22 10	Intensity I.
	11	I_v	V.	8 08 32						8 10	Intensity I. V. C. 0.01 mm.
	11	I_v	V.	18 31 05						18 33	Intensity I.
	12	I_v	V.	0 05 16						0 7	Intensity I. V. C. 0.01 mm.
	12	I_v	V.	23 58 31						0 0	Intensity I.
	13	I_v	V.	4 58 05		4 58 11	4 58 28	.06	2.4	5 0	Intensity I. V. C. 0.02 mm.

Origin: Taal volcano

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No.	Date	Character.	Instrument and Component	Beginning. P	S	L	Maximum range of motion. Hour	A	T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s	h. m.	
17	14	I_d	V.			10 42 48	10 43 09	.05	2.4	10 45	V. C. 0.01 mm.
18	15	II_v	V.	18 04 03		18 04 14	18 05 27	1.50	2.4	18 17	V. C. 1.30 m m. Earthquake, IV.
			H. NNW	18 04 03		18 04 15	18 04 48	2.69	8.1	18 20	south Luzon and north Min-
			H. WSW	18 04 03		18 04 15	18 05 13	3.80	8.4	18 25	doro.
19	15	I_d	V.			17 28 39				17 32	V. C. 0.01 mm.
20	15	I_d	V.	21 33 10		21 33 19	21 33 58	.16	2.4	21 35	V. C. 0.13 mm.
	16	At 9h 45m Eqke., II at Dumaguete (Negros Oriental).									
21	18	I_d	V.			1 37 54	1 37 56	.05	2.4	1 40	V. C. 0.01 mm.
22	18	I_d	V.	11 34 18		11 34 44	11 35 01	.53	2.4	11 37	V. C. 0.05 mm.
23	19	I_d	V.			1 23 43	1 23 52	.02	2.4	1 26	V. C. 0.01 mm.
24	19	II_r	V.	2 50 12	2 57 07	3 05 04	3 14 52	.04	11.6	3 58	Eqke. at Lahore (British India).
			H. NNW	2 50 12	2 57 00	3 05 00	3 14 53	.37	13.2	4 00	
			H. WSW	2 50 12	2 56 55	3 05 07	3 15 21	.48	11.4	4 14	
25	20	I_d	V.	13 45 30		13 45 40	13 46 04	.44	2.4	13 54	V. C. 0.22 mm.
26	20	I_d	V.			20 15 08				20 17	V. C. 0.01 mm.
27	21	I_d	V.			0 22 07	0 22 09	.03	2.4	0 24	V. C. 0.01 mm.
28	21	II_d	V.	4 32 11		4 32 20	4 32 58	1.68	2.4	4 39	V. C. 0.81 mm.
29	21	I_d	V.	17 29 46		17 30 00	17 30 18	.25	2.4	17 36	V. C. 0.13 mm.
30	22	I_d	V.			5 16 19	5 16 22	.03	2.4	5 18	V. C. 0.01 mm.

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No.	Date	Character.	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
31	23	Id	V.	8 39 01		8 39 13	8 39 21	.07	2.4	8 42	V. C. 0.04 mm.
32	23	Id	V.	9 24 43		9 24 52	9 25 15	.04	2.4	9 27	V. C. 0.02 mm.
33	23	II	V.	19 17 21						20 48	
			H. NNW	19 17 24						20 48	
			H. WSW	19 17 24						21 11	
34	25	I	V.			8 56 26				9 42	
			H. WSW			8 56 26				9 27	
35	25	I	V.	22 05 28		22 05 38	22 05 49	.06	2.4	22 09	V. C. 0.01 mm.

M. Saderra M.

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Seismological Bulletin, No. 3, a. March, 1911.

No	Date	Character.	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion. Hour	A	T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s	mm.	s.	h. m.	
36	1	I_d	V.			2 03 43	2 03 53	0.02	2.4	2 06	Vertical Component 0.01 mm.
37	1	I_v	H. WSW	13 16 00		13 16 48	13 17 00	.06	2.4	13 25	V. C. 0.03 mm. Earthquake, IV at Laoag (NW of Luzon).
38	1	I_d	V.	23 52 19		23 52 29	23 52 34	.06	2.4	23 54	V. C. 0.03 mm.
39	2	I_d	V.	4 33 11		4 33 22	4 33 28	.04	2.4	4 35	V. C. 0.01 mm.
40	3	I_d	V.	1 25 08		1 25 36	1 26 18	.07	2.4	1 27	
41	6	I_d	V.	14 31 06		14 31 18	14 31 37	.16	2.4	14 37	V. C. 0.13 mm.
42	7	II_v	H. NNW	1 32 25		1 34 31	1 36 32	1.97	8.1	2 20	V. C. 0.10 mm. Eqke., IV at Butuan (N of Mindanao).
			H. WSW	1 32 25		1 34 21	1 37 52	1.72	8.1	2 42	
43	9	I_v	V.	13 05 10		13 07 09	13 08 06	.10	2.4	13 52	V. C. 0.02 mm. Eqke., III in the Central Mindanao.
			H. NNW	13 05 08		13 07 08	13 07 43	.28	7.8	13 43	
			H. WSW	13 05 08		13 07 04	13 08 23	.44	9	14 00	
	10	At 3^h Eqke. IV at Cebu (E of Cebu I.)									
44	11	I_d	V.			0 12 57	0 13 15	.01	2.4	0 16	V. C. 0.01 mm.
45	11	I_d	V.	8 37 19		8 37 49	8 37 55	.06	2.4	8 40	V. C. 0.04 mm.
46	11	I_r	V	11 22 50	11 28 27	11 33 04	11 34 02	.01	15.6	12 08	
			H. NNW	11 22 50	11 28 31	11 33 06	11 34 12	.07	9	12 16	
			H. WSW	11 22 50	11 28 24	11 33 05	11 33 56	.13	8.4	12 33	
47	12	I_d	V.	2 53 21		2 53 44	2 53 50	.28	2.4	2 56	V. C. 0.06 mm.
	13	At 2^h Eqke., III at Batangas (S of Luzon).									

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No.	Date	Character	Instrument and Component.	Beginning P	Beginning S	Beginning L	Maximum range of motion. Hour	A	T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
48	13	II_v	V.	17 37 39		17 38 02	17 38 19	1.70	2.4		V. C. 1.12 mm. Eqke., III at Nueva Caceres (SE of Luzon).
			H. NNW	17 37 39		17 38 05	17 38 18	.71	7.2		
			H. WSW	17 37 39		17 38 05	17 39 09	.58	9.6		
49	13	I_v	V.	17 48 13		17 48 39	17 48 43	.23	2.4		V. C. 0.09 mm. Eqke., III at Nueva Caceres (SE of Luzon).
50	13	I_v	V.	17 52 56		17 53 21	17 53 34	1.30	2.4	18 28	V. C. 0.28 mm. Eqke., III at Nueva Caceres (SE of Luzon).
			H. NNW	17 52 56		17 53 21	17 53 38	.25	7.5	18 11	
			H. WSW	17 52 56		17 53 21	17 53 56	.25	8.1	18 30	
	13	At $18^h 53^m$ Eqke., III at Nueva Caceres (SE of Luzon).									
51	13	II_v	V.	20 49 40		20 50 08	20 50 42		2.4	21 10	V. C. 1.05 mm. Eqke., III at Paracale (SE of Luzon).
			H. NNW	20 49 41		20 50 07	20 51 00	.37	6.9	21 07	
			H. WSW	20 49 41		20 50 07	20 50 37	.42	8.1	21 14	
52	13	I_d	V.			22 25 39	22 25 43	.03	2.4	22 28	V. C. 0.01 mm.
53	13	I	V.		22 40 13					23 10	
			H. WSW		22 40 13					23 07	
54	14	I_d	V.	9 57 30		9 57 38	9 57 41	.05	2.4	9 59	V. C. 0.01 mm.
55	15	II_d	V.	17 53 00		17 53 19	17 53 35	.20	2.4	17 57	V. C. 0.09 mm.
56	16	I_d	V.	14 16 42		14 17 05	14 17 07	.05	2.4	14 20	V. C. 0.02 mm.
57	16	I_d	V.	20 42 02		20 42 29	20 42 32	.58	2.4	20 50	V. C. 0.20 mm.
58	17	I_d	V.	15 26 25		15 26 36	15 26 44	.05	2.4	15 28	V. C. 0.01 mm.

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No.	Date	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
59	17	II_v	V.	21 45 20		21 45 29	21 46 36	.34	2.4	21 51	V. C. 0.17 mm. Egke., III at Balanga (SW of Luzon).
60	18	I_d	V.	5 25 35		5 25 51	5 25 57	.11	2.4	5 28	V. C. 0.02 mm.
	20	At 19h 56m Egke., at Tacloban (NE of Leyte).									
61	21	I_d	V.	7 04 44		7 04 53	7 04 59	.05	2	7 07	V. C. 0.05 mm.
			V.	11 21 26						11 53	V. C. 0.02 mm.
62	24	I	H. NNW	11 21 28						11 50	
			H. WSW	11 21 28						12 05	
			V.	17 44 33		17 48 44				18 02	
63	27	I	H. NNW	17 44 33		17 48 38	17 50 34	.06	8.7	18 04	
			H WSW	17 44 33		17 48 41	17 50 42	.19	8.4	18 12	
64	28	I_d	V.	23 06 17		23 06 34	23 07 32	.19	2.4	23 11	V. C. 0.13 mm.
65	29	I_d	V.	12 18 59		12 19 15	12 19 23	.26	2.4	12 24	V. C. 0.05 mm.

M. Saderra M.

Manila Observatory.- Philippine Islands.
Seismological Bulletin No. 4, a. April, 1911.

No.	Date.	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
			V.	6 06 13						6 30	
			H. NNW	6 06 13		6 10 11				6 28	
66	1	I_r	H. WSW	6 06 13		6 10 17	6 12 42	.15	9	6 37	
			W. E.	6 06 13		6 10 20	6 11 40	.01	6	6 20	
			V.			10 20 55	10 21 39	.02	2.4	10 36	Vertical Component 0.01 mm.
			H. WSW			10 20 56	10 21 31	.06	9	10 39	
67	1	I	W. N			10 21 09	10 22 14	.02	6	10 35	
			W. E			10 21 09	10 22 05	.03	5.6	10 36	
			V.	9 05 40						9 19	V. C. 0.01 mm.
68	3	I	H. WSW	9 05 40		9 09 36	9 09 55	.03	9.3	9 20	
			W. E	9 05 40		9 09 36	9 09 46	.03	6.6	9 19	
	3	At 22h Earthquake, II at Surigao (NE of Mindanao).									
69	4	I_d	V.	3 06 01		3 06 14	3 06 42	.01	2.4	3 09	
70	4	I_d	V.	22 45 49		22 46 01	22 46 16	.02	2	22 48	V. C. 0.01 mm.
71	7	I_d	V.			5 09 30	5 09 34	.01	2.4	5 11	V. C. 0.01 mm.
72	7	I_d	V.			13 33 46	13 34 15	.06	2.4	13 37	V. C. 0.02 mm.
	7	At 14h 25m Eqke., III at Batangas (S of Luzon).									
			V.	14 53 52						15 39	
73	7	I_r	H. NNW	14 53 52						15 20	
			H. WSW	14 53 51	14 59 06	15 03 09	15 06 37	.10	8.4	15 53	

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No.	Date.	Character.	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
74	7	I_d	V.	18 05 48		18 06 12	18 06 21	.30	2.4	18 11	V. C. 0.06 mm.
	10	At 16h 52m Eqke., V at Surigao (NE of Mindanao).									
75	11	I	V.	3 02 13						3 27	
			H. WSW	3 02 10						3 36	
			W. E	3 02 11						3 36	
76	11	I	H. WSW	21 41 14						22 06	
			W. N	21 41 20						22 20	
			W. E	21 41 20						22 18	
77	13	I_r	V.	8 54 22		8 58 34	8 59 05	.02	6.4	9 23	Eqke., III at Guam (Marianas Islands).
			H. NNW	8 54 27		8 58 20	8 59 11	.11	7.2	9 15	
			H. WSW	8 54 26		8 58 44	9 01 59	.14	7.8	9 30	
			W. N	8 54 22		8 58 18	8 59 00	.05	4.2	9 32	
			W. E	8 54 22		8 58 55	9 01 24	.04	6.4	9 38	
78	14	II_v	V.	20 12 12		20 12 29	20 13 00	1.80	2.2	20 24	V. C. 2.02 mm. Eqke., III at Batangas (S of Luzon).
79	15	I_d	V.	8 25 06		8 25 12	8 25 17	.03	2.4	8 28	V. C. 0.02 mm.
80	15	I	V.		20 04 35					20 24	
			H. WSW		20 04 16					20 33	
81	17	I_d	V.	3 20 53		3 21 19	3 21 42	.40	2.4	3 26	V. C. 0.22 mm.
	18	At 1h 36m Eqke., III at Guam (Marianas Islands).									

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April, 1911.

No.	Date	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m	
82	19	I_u	V.	2 24 43	2 34 06	2 45 15	2 57 34	.01	13.6	3 32	
			H. wsw	2 24 49	2 33 50	2 45 05	2 56 22	.06	15.6	3 41	
83	19	I	H. wsw			22. 22 19				23 02	
84	22	I_d	V.	4 42 26		4 42 35	4 42 49	.22	2.4	4 47	V. C. 0.12 mm.
85	24	I_v	V.	15 55 06		15 55 13	15 55 31	.09	2.4	15 59	V. C. 0.04 mm. Eqke., III at Batangas (S of Luzon)
86	28	I	V.			18 11 24				18 55	V. C. 0.01 mm.
			H. NNW			18 11 21				18 54	
			H. WSW			18 11 21				19 06	
			W. E			18 11 24				19 00	
87	29	I	V.			2 45 55				3 00	
			H. NNW			2 45 58				3 01	
			H. WSW			2 45 59				3 11	
			W. N			2 46 00				2 49	

W. = Wiechert seismograph, 1000 kilograms. N = N-S component; E = E-W component. Period 7 seconds. Magnif. 98. Damping 4:1.

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No.	Date	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
	1	At $17^h\,13^m\,30^s$ Earthquake, IV at Butuan (N of Mindanao)									
88	2	I_d	V.	2 35 06		2 35 14	2 35 23	0.03	2.4	2 39	Vertical Component 0.01 mm.
89	2	I_d	W. N	21 53 34		21 53 57	21 54 00	.02	2.2	21 55	
	3	At $11^h\,54^m\,20^s$ Eqke., II at Vigan (NW of Luzon).									
			V.	21 34 00		21 38 15	21 41 04	.01	8.8	22 01	
			H. NNW	21 34 00		21 38 02	21 41 01	.08	7.5	22 02	
90	4	I	H. WSW	21 33 59		21 38 32	21 41 33	.19	8.7	22 19	
			W. N	21 34 16		21 39 06	21 40 34	.01	10.8	21 54	
			W. E	21 34 18		21 38 24	21 41 16	.03	12.8	22 04	
	5	At $3^h\,54^m\,05^s$ Eqke., III at Butuan (N of Mindanao).									
			V.	7 45 23	7 48 34						
			H. NNW	7 45 23	7 48 47						
91	5	II_r	H. WSW	7 45 23	7 48 08						
			W. N	7 45 23	7 48 22						
			W. E	7 45 23							
			V.	7 52 04	7 55 12	7 57 23	7 59 25	.02	17.6	9 06	
			H. NNW	7 51 51	7 54 57	7 59 21	7 59 55	.19	9.6	9 20	
92	5	II_r	H. WSW	7 52 01	7 55 15	7 59 53	8 01 31	.29	9.6	9 58	
			W. N	7 52 00	7 54 36	7 58 07	7 59 18	.76	13.2	9 22	
			W. E	7 52 09	7 54 49	7 58 44	8 00 54	.80	12	9 15	

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No.	Date	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion. Hour	A	T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	m m.	s.	h. m.	
93	7	I_d	V.	18 17 26		18 17 37	18 17 44	.03	2.4	18 19	V. C. 0.01 m m.
94	8	I_d	V.	5 44 34		5 44 46	5 45 18	.18	2.4	5 50	V. C. 0.09 m m.
	11	At 1h 57m 30s Eqke., III at Butuan (N of Mindanao).									
			V.	9 32 02		9 33 31	9 33 50	.03	32	9 46	Eqke., III at Santo Domingo (Batanes Islands).
			H. NNW	9 32 03		9 33 23	9 33 32	.06	5.1	9 43	
95	12	I_v	H. WSW	9 32 03		9 33 40	9 34 03	.05	8.1	9 49	
			W. N	9 32 02		9 33 24	9 33 31	.01	5	9 45	
			W. E	9 32 02		9 33 30	9 33 33	.01	4	9 42	
			V.	11 22 04		11 22 12	11 23 17	2.40	2.4	11 58	V. C. 2.50 m m. South Zambales Range.
			H. NNW	11 22 08		11 22 16	11 23 28	5.30	5.4	12 05	
96	13	II_v	H. WSW	11 22 08		11 22 16	11 22 40			12 20	
			W. N	11 22 05		11 22 10	11 23 08	3.17	4	12 06	
			W. E	11 22 05		11 22 12	11 23 32	2.04	2.8	12 18	
97	14	I_d	V.			20 54 37	20 54 49	.02	2.4	20 57	
			V.	0 45 42			0.46 22	.04	2.4	0 50	
98	15	I_r	H. NNW	0 45 44						0 53	
			H. WSW	0 45 44			0 46 32	.02	8.7	1 04	
			W. N	0 45 48			0 46 12	.01	2.6	0 51	
99	15	I_v	V.	1 38 23		1 39 21	1 39 48	.32	2.4	1 46	V. C. 0.02 m m.
			W. N	1 38 28		1 39 28	1 40 56	.02	5.2	1 47	

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No.	Date.	Character	Instrument and component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm	s.	h. m.	
100	18	I_v	V.	14 12 46		14 13 03	14 13 13	.30	2.4	14 19	V. C. 0.26 mm. Felt at Antipolo.
			W. N	14 12 40		14 12 57	14 13 10	.14	5	14 19	Origin near the Pacific coast
			W E	14 12 40		14 12 57	14 13 16	.13	4	14 20	E of Manila.
101	21	I	V.			23 18 01				23 26	
			H. NNW			23 18 14				23 27	
			H. WSW			23 18 14				23 32	
102	23	I_d	V.	20 55 25		20 55 49	20 56 02	.05	2.4	20 59	V. C. 0.01 mm.
			W. N	20 55 24		20 55 46	20 56 03	.01	2	21 00	
103	24	I	V.		6 59 07					7 16	
			H. WSW		6 59 09					7 19	
			W. E		6 59 00					7 18	
104	24	I	H. NNW	11 53 52		11 57 10	11 59 28	.05	8.1	12 08	
			H. WSW	11 53 40		11 56 31	11 58 40	.05	8.4	12. 14	
105	24	I_d	V.	15 34 01		15 34 18	15 34 46	.40	2.4	15 39	V. C. 0.11 mm.
			W. E	15 34 00		15 34 14	15 34 17	.07	4.2	15 39	
106	24	I	V.	20 40 28		20 43 50	20 44 16	.01	11.2	20 58	
			H. NNW	20 40 30		20 43 58				20 57	
			H. WSW	20 40 22		20 43 51	20 45 48	.24	9.3	21 05	
			W. N	20 40 26		20 44 00	20 45 48	.04	10	21 05	
			W. E	20 40 30		20 43 00	20 44 06	.04	10.4	21 02	

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No.	Date	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A.	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
107	28	I_d	V.	12 39 11		12 39 28	12 39 38	.34	2.4	12 45	V. C. 0.18 mm mm.
108	28	II_v	V.	17 47 34		17 47 50	17 48 33	2.20	2.2	18 42	V. C. 1.90 mm mm. tope., III near western coast of Zambales.
			H. NNW	17 47 34		17 47 50	17 48 34	1	8	18 10	
			H WSW	17 47 34		17 47 50	17 48 31	.99	10	18 21	
109	28	I	V.	19 18 48		19 19 36	19 19 50	.08	2.4	19 25	V. C. 0.02 mm mm.
			H. NNW			19 19 32				19 26	
			H. WSW			19 19 31				19 26	
110	29	I	V.			3 23 17				3 27	
			H. WSW			3 23 40				3 34	
111	31	I	V.			11 43 16				11 51	
			H. NNW			11 43 16				11 57	
			H. WSW			11 43 16				11 58	
			W. N			11 43 17				11 57	
			W. E			11 43 17				11 55	
112	31	I	V.			21 53 01				22 13	
			H. NNW			21 52 00				22 18	
			H. WSW			21 52 00				22 36	
			W. N			21 52 10				22 17	

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No.	Date	Character	Instrument and Component.	Beginning P	S	L	Maximum range of motion Hour	A	T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
113	2	I_d	V.			21 24 35	21 24 37	0.05	2.4	21 27	Vertical Component 0.01 mm.
114	2	I	H. WSW	12 39 25						12 56	
			V.	23 41 30		23 42 13	23 42 47	.37	2.4	0 06	V. C. 0.07 mm. Eqke., III southeastern Luzon.
			H. NNW	23 41 30		23 42 12	23 44 00	.69	7.8	0 23	
115	2-3	II_v	H. WSW	23 41 30		23 42 05	23 44 01	.82	8.1	0 45	
			W. N	23 41 24		23 42 07	23 43 43	.22	6.8	0 10	
			W. E	23 41 24		23 42 07	23 44 26	.13	6.4	23 57	
			V.	21 48 04		21 48 40	21 48 53	.73	2.4		V. C. 0.08 mm. Eqke., III northwestern Visayas.
116	3	II_v	W. N	21 48 03		21 48 37	21 48 46	.07	2.8		
			W. E	21 48 03		21 48 34	21 48 44	.09	3.6		
			V.	21 51 13			21 53 00	.12	2.4	22 02	V. C. 0.01 mm. Eqke., III, NE Leyte Island.
117	3	I_v	W. N.	21 51 12		21 52 00	21 52 05	.04	2.6	22 01	
			W. E	21 51 12		21 52 02				22 01	
118	4	I	H. WSW	4 31 20						5 08	
	4	At $7^h 51^m 12^s$ Eqke., III at Cuyo (Cuyo Island).									
			V.	17 39 55		17 41 34	17 42 46	.04	2.4	17 56	Eqke., III at Butuan (N Mindanao).
119	5	I_v	H. WSW	17 39 55		17 41 40	17 42 52	.07	6.6	18 01	
			W. E	17 39 51		17 41 43				17 51	
120	5	I_d	V.			19 19 07	19 19 12	.04	2.4	19 21	
	7	At $2^h 47^m$ Eqke., III at Calapan (NE Mindoro).									

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No.	Date	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	A	T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
121	7	III_u	V.	19 24 00	19 38 34	19 53 00	20 29 27	.03	19.2	21 40	Mexico.
			H. NNW	19 24 00	19 37 50	19 51 21	20 29 14	.08	18.6	21 29	
			H. WSW	19 24 00	19 38 00	19 51 23	20 28 00	.13	18	21 40	
			W. N	19 24 12	19 38 10	19 51 24	20 28 07	.02	18.8	21 50	
			W. E	19 24 07	19 38 13	19 53 01	20 29 28	.07	16.8	21 51	
122	8	I_v	V.	2 48 39		2 49 30	2 49 57	.42	2.4	2 54	V. C. 0.02 mm. Eqke., IV Panay I.
			W. N	2 48 36		2 49 35	2 49 50	.08	2.4	2 54	
			W. E	2 48 38		2 49 36	2 49 52	.06	2.4	2 54	
123	8	I_d	V.	11 46 42		11 46 52	11 48 19	1.06	2.4	12 02	V. C. 0.95 mm.
124	11	I_d	V.	22 32 00		22 32 08	22 32 11	.02	2.4	22 33	V. C. 0.01 mm.
125	12	I_d	V.	2 05 26		2 05 36	2 06 05	.08	2.4	2 09	V. C. 0.09 mm.
	13	At 3h 34m Eqke., III at Tacloban (NE of Leyte).									
126	13	I_d	V.	4 29 00		4 29 10	4 29 48	.04	2.4	4 31	V. C. 0.02 mm.
127	14	I_d	V.	20 56 01		20 56 19	20 56 21	.11	2.4	20 59	V. C. 0.01 mm.
128	15-16	III_v	V.	22 29 32		22 30 31				0 55	V. C. 0.92 mm. Felt with the intensity III and II in northeastern Luzon.
			H. WSW	22 29 32		22 30 28				1 24	
			W E	22 29 40		22 30 43				1 27	
129	17	II_r	V.	13 13 35	13 17 16	13 19 54	13 21 04	.03	14.4	13 54	
			H. WSW	13 13 33	13 17 02	13 19 54	13 30 31	.64	8.4	14 32	
			W. N	13 13 20	13 17 01	13 20 06	13 21 28	.12	11.2	14 30	

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No.	Date	Character	Instrument and Component	Beginning P h. m. s.	Beginning S h. m. s.	Beginning L h. m. s.	Maximum range of motion Hour h. m. s.	Maximum range of motion A mm.	Maximum range of motion T s.	F h. m.	Remarks
	19	At 20h 02m Eqke., II at Santo Domingo (Batanes Islands).									
	19	At 21h 24m 30s Eqke., II at Santo Domingo (Batanes Islands).									
130	19-20	I	W. N	23 40 32						0 02	
131	20	I_d	V.	22 43 13		22 43 25	22 43 38	.05	2.4	22 45	V. C. 0.01 mm.
132	22	I	H. WSW	8 13 07		8 15 51	8 17 34	.13	7.8	8 35	
			W. N	8 13 05		8 15 54	8 16 48	.03	5.2	8 33	
133	23	II_v	V.	3 27 23		3 27 32	3 27 54	1.70	2.4	3 40	V. C. 0.48 mm. Eqke., IV, southern coast Luzon.
			W. N	3 27 23		3 27 34	3 28 43	1.19	4.8	3 40	
134	26	II	V.	16 37 17		16 39 03	16 39 09	.72	2.4		V. C. 0.02 mm.
135	26	I	H. WSW	17 05 47		17 07 30	17 08 00	.25	9	17 34	V. C. 0.01 mm.
136	26	I	W. N	17 38 48						18 08	
	27	At 8h 06m 20s Eqke., III at Butuan (N Mindanao)									
137	27	I	H. WSW		12 12 47					12 27	
	27	At 12h 22m Eqke., III at Baguio (NW Luzon).									
138	28	I_d	V.	2 19 53		2 20 21	2 20 23	.18	2.4	2 22	V. C. 0.03 mm.
139	28	I_d	V.	2 31 15		2 31 52	2 32 00	.04	2.4	2 34	
140	28	I	H. WSW	15 23 29						15 52	
141	29	I	H. WSW		1 56 58					2 28	
	29	At 4h 04m Eqke., III at Baguio (NW Luzon).									

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SEISMOLOGICAL BULLETIN FOR JULY, 1911

By Rev. MIGUEL SADERRA MASÓ, S. J.,
Assistant Director of the Weather Bureau.

EARTHQUAKES FELT IN THE PHILIPPINES.

3, 0h 9m 57s.* Nueva Caceres (SE of Luzon). Oscillatory earthquake. Direction NNE–SSW, intensity III, Duration 5 seconds.

7, 18h 47m. Laoag (NW of Luzon). Earthquake of force II.

16, 4h 38m. Tacloban (NE of Leyte). Oscillatory earthquake. Direction ENE–WSW, intensity III, duration 6 seconds.

19, 11h 30m. Sarangani (S of Mindanao). Earthquake of intensity II

22, 4h 36m. Zamboanga and Basilan. Oscillatory earthquake of force IV direction of shocks SW–NE, duration 8 seconds.

24, 11h 36m. Sarangani (S of Mindanao). Earthquake of intensity III.

25, 12h 15m. San Fernando, Union (NW of Luzon). Oscillatory earthquake, direction WSW–ENE, intensity III, duration 3 seconds.

28, 6h 30m. Sarangani (S of Mindanao). Earthquake of force II.

30, 18h 2m. Baguio (W of Luzon). Oscillatory earthquake of intensity III, lasting 5 seconds; direction of shocks NNE–SSW.

NOTE.—The earthquake which occurred in Mindanao on July 12, together with its repetitions and aftershocks during July and August, will be found discussed at the end of this Bulletin.

*The intensity of earthquakes is given in the notation known as the scale of De Rossi-Forel. The time is stated as indicated by the seismographs at the Central Observatory whenever the disturbance has been registered by them. This fact is denoted by an asterisk (*). Otherwise the time is that noted by the observers who sent the notice. All time indications are in the official time of the Archipelago, which is that of the one hundred and twentieth meridian east of Greenwich.

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indicios, que suelen preceder á los grandes paroxismos volcánicos, y así ponerse á salvo de sus estragos. También presentaremos algunos datos sobre su relación con las lluvias y la presión atmosférica. Comenzaremos por las más antiguas, remontándonos por orden de fechas hasta nuestros días.

II. ERUPCIONES.

1707, 1716, 1731. Volcán Taal.—De estas erupciones más antiguas apenas existen datos acerca de la manera como principiaron, y mucho menos pormenores algunos de los temblores y ruidos precursores, si los hubo. La de 1707 se verificó principalmente en el cono llamado Binintiang Malaqui, y las de 1716 y 1731 en el lago mismo al E del cono principal, donde una serie de explosiones arrojó tantas piedras y arena que se formó un islote. Con la primera coincidieron grandes terremotos ó "*conmociones de la tierra.*"

1749. Volcán Taal, 11 de Agosto.—Según refiere el P. Buencuchillo, testigo ocular de esta erupción, vió, como á las once de la noche, antes de acostarse, un resplandor ó luz algo abultada en la cumbre del volcán: la erupción comenzó hacia las 3 de la madrugada siguiente, con fuertes detonaciones. Durante lo más fuerte de la erupción hubo terremotos muy intensos que abrieron muchas y grandes grietas; después continuaron sintiéndose temblores de poca intensidad durante varios meses. No parece sin embargo que hubiese ninguno precursor. Esta erupción duró unas tres semanas con intermitencias más ó menos largas.

1754. Volcán Taal, del 15 de Mayo al 1 de Diciembre.—Á esta formidable y larguísima erupción ó mejor dicho, serie de erupciones, no consta precediesen temblores de tierra, ruidos subterráneos ú otros indicios, aunque los hubo muy intensos junto con las muchas explosiones. El citado P. Buencuchillo, testigo de vista y autor de una minuciosa relación, dice que el volcán comenzó entre 9 y 10 de la noche á bramar de improviso y á despedir formidables llamas, etc. Sin embargo como los productos de las primeras explosiones cayeron solamente sobre la isla y el lago que la circunda la gente de los pueblos vecinos tuvo tiempo de alejarse; por manera que tan solo se citan 12 víctimas.

1766. Volcán Mayon, 20 de Julio.—Apareció la cúspide del cono completamente incandescente, viéndose descender hacia el Este una gran corriente de lava durante 6 días consecutivos. No se mencionan los daños causados; ni tampoco se dice nada de temblores de tierra, ni de ruidos precedentes á la erupción.

1800. Volcán Mayon, Octubre.—Apenas se sabe otra cosa de esta erupción, sino que el volcán arrojó, "*como siempre había acostumbrado*", gran cantidad de piedras, arenas, y cenizas, las cuales causaron muchos daños y muertes en los pueblos de Budiao y Cagsaua, que se hallaban sentados en la vertiente S del volcán.

1808. Volcán de Taal, Marzo.—De esta erupción no quedan más noticias que las generales de su existencia, y de los daños que causó en la isla y en los pueblos vecinos, sin pormenores algunos.

1814. Volcán Mayon, 1 de Febrero.—Es esta la más grande erupción del volcán de Albay, de que hay memoria en los anales de Filipinas. No la precedieron más señales precursoras que varios temblores de tierra durante el día precedente. "El 31 de Enero," escribe el Franciscano, P. F. Aragoneses, Párroco de Guinobatan, "sentimos algunos pequeños temblores, pero apenas hicimos caso de ellos, respecto de haber sido éstos allí muy frecuentes desde el horroroso terremoto de Octubre de 1811. Por la noche aumentaron los temblores; á las 2 de la mañana (1 de Febrero) sentimos uno más fuerte que los experimentados hasta entonces: volvió á repetir á 4^{h} y desde esta hora casi fueron continuos hasta que comenzó la erupción."

"Amaneció el Martes y apenas había yo visto en Camarines una mañana más serena y apacible y un horizonte más despejado. Noté sin embargo que los cerros más inmediatos al volcán estaban cubiertos de una neblina que yo creí ser humo de alguna casa

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que aquella noche se había quemado. Dieron las 8h de aquella mañana fatal á cuya hora el volcan comenzó á arrojar de repente una espesa columna de piedras, arena y cenizas que con la mayor velocidad se elevó en un momento á lo más alto de la atmósfera, á cuya vista quedamos sorprendidos y llenos del más grande pavor, y más cuando notamos que á toda prisa se iba cubriendo la falda del volcán. Jamás habíamos visto una semejante erupción: desde luego nos llegamos á persuadir de que un grande arroyo de fuego se venía sobre nosotros y nos iba á consumir, así que nos pusimos en precipitada fuga." Cagsaua, donde se hallaba el autor de las últimas precedentes líneas, está á unos 10 kilómetros al SSE del volcán. Á causa del viento reinante del NE, la erupción se precipitó sobre la región S y SW, destruyendo completamente los tres pueblecitos más cercanos y en parte otros dos dentro de un radio de más de 15 kilómetros: quedaron asolados por completo todos los sembrados y plantas, con muerte de más de 1,200 personas, en 5 horas escasas que duró lo más fuerte de la erupción. La cantidad de deyecciones sólidas, piedras, arena y ceniza ó polvo, arrojada por el volcán fué tan exorbitante que en pueblos distantes 10 kilómetros quedó una capa de unos 0.40 metros. Las detonaciones de esta erupción se oyeron desde los puntos más distantes del Archipiélago y el polvo volcánico llevado por las corrientes atmosféricas llegó hasta Manila y otras provincias más distantes.

Tan horrible y desastrosa erupción fué precedida, según atestigua el mencionado Párroco de Guinobatan, de temblores de tierra frecuentes pero de poca intensidad durante unas 24 horas y de temblores muy frecuentes é intensos durante las 10 ó 12 horas inmediatas á la catástrofe. El autor no menciona ruidos subterráneos antes de la erupción; tampoco habla ya más de temblores de tierra desde el momento en que reventó el volcán.

1853. Volcán Mayon, 13 de Julio.—Dícese que esta erupción fué precedida de fuertes ruidos subterráneos, pero sin terremotos. Hacia 12h de la expresada fecha vióse una inmensa columna de humo y cenizas, rodando al mismo tiempo por las laderas del cono volcánico piedras incandescentes que destruyeron muchas casas en los cultivos ó sementeras y causaron la muerte de 33 personas é hirieron otras muchas. La erupción duró solamente unas pocas horas, toda la región más próxima que rodea el volcán quedó cubierta de una regular capa de ceniza. No se especifica si los ruidos subterráneos precedieron horas ó días, de tal manera que la gente tuviese tiempo de alejarse.

Cítanse otras pequeñas erupciones correspondientes á los años 1827, 1828, 1835, 1845, 1846, 1851, 1855, 1858 y 1868.

1871. Volcán de Camiguín, 30 de Abril.—Este volcán situado en la pequeña Isla de Camiguín, cerca de la costa N de Mindanao, había estado durmiente desde tiempo inmemorial. Tan solo corrían noticias vagas de que en la montaña más septentrional de la isla, evidentemente volcánica, existía una laguna circular cuyas aguas se habían visto emitir en diferentes épocas gran cantidad de vapores.

Llegó el año 1871 y desde mediados de Febrero hasta la fecha de la erupción se sintieron diariamente en toda la pequeña isla y principalmente en su extremidad N, temblores de tierra de variable intensidad, si bien 4 ó 5 de ellos fueron destructores y se sintieron en toda la extensa región de las Islas Visayas y Mindanao.

Por fortuna, debido á la diligencia del gobernadorcillo del pueblo de Catarman, distante una milla escasa del sitio donde reventó el volcán y en gran parte destruído por la erupción, poseemos el catálogo casi completo de la serie de temblores que precedieron á la erupción. Á continuación damos un resumen de dicho catálogo; en él se verá que desde el 16 de Febrero hasta el 20 de Abril no se pasó un solo día sin sentirse varios temblores de tierra, generalmente acompañados de ruidos subterráneos procedentes del interior de la montaña próxima. Esta última circunstancia y los grandes derrumbes y grietas producidos en sus laderas fué lo que bien pronto sugirió á los habitantes de los pueblos vecinos la idea de una futura erupción volcánica.

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Fecha.	Temblores de tierra.	Notas.
Febrero 16	Dos temblores ligeros	
Febrero 17	Frecuentes todo el día y noche	1 de intensidad VIII.
Febrero 18	id	1 de intensidad VII.
Febrero 19	id	
Febrero 20	id	1 de intensidad IX.
Febrero 21	id	1 de intensidad VIII.
Febrero 22	id	
Febrero 23 á 28	id	
Marzo 1 á 3	id	1 de intensidad VI.
Marzo 4	id	
Marzo 5 á 7	Menos frecuentes, no más de 10 diarios	2 de intensidad VI.
Marzo 8	id	
Marzo 9	id	Id.
Marzo 10	id	
Marzo 11 á 13	id	
Marzo 14 á 17	Menos frecuentes, 4 ó 5 diarios	
Marzo 18 á 19	Más frecuentes y fuertes que los días precedentes	
Marzo 20 á 31	Menos frecuentes, no pasan de 6 diarios	
Abril 1 á 29	Frecuentes todo el mes sin bajar de 6 ni pasar de 10 diarios	
Abril 30	A 7h con una espantosa detonación y una nube de vapores, piedras y ceniza explotó un volcán en el extremo NNE de la isla y á pocos metros de la playa del mar. Continuó luego surgiendo pacíficamente lava en estado semifluido durante unos 3 años, formándose un cono de unos 400 metros de altura. Las cenizas de la primera explosión se extendieron á 200 kilómetros al rededor del volcán. La devastación fué completa en un radio de 2 á 3 kilómetros al rededor del nuevo cono volcánico. Los terremotos cesaron casi por completo desde los primeros días después de la erupción. No hubo desgracias personales por haberse retirado mucho antes los habitantes de Catarman, que es el pueblo más próximo, y el único que fué destruído: muchas personas se habían ya embarcado para otras islas desde fines de Febrero.	

1871. Volcán Mayon, 8 de Diciembre.—Amaneció este día percibiéndose algunos ruidos subterráneos y habiéndose oído tres muy fuertes entre 7 y 8 de la mañana se vió en la cúspide del volcán una gruesa columna de humo, luego se notó la salida de cenizas, arena y lavas arrojadas con poca violencia: sin embargo la nube de humo y cenizas impulsada por el viento del NE envolvió toda la parte S y SW del volcán, causando verdadera oscuridad hasta una distancia de 20 kilómetros. Á las 10h se despejó, pero á la una de la tarde explotó la grande erupción con fuertes detonaciones y relámpagos: cayó gran cantidad de ceniza hasta 30 kilómetros del volcán y las corrientes de lava llegaron por el S y SE á los barrios más próximos. No se sabe que pereciesen más que dos personas, una de asfixia y otra quemada: estas víctimas perecieron á unos 10 kilómetros al SE del volcán. Los demás habitantes de esta región más azotada, sin duda se habían alejado á los primeros síntomas de la erupción, que comenzaron á notarse unas 8 ó 10 horas antes. No se hace mención ninguna de temblores de tierra.

1872. Volcán Mayon, Septiembre.—Pequeños derrames de lava acompañados de ruidos subterráneos y débiles explosiones.

1873. Volcán Mayon, 15 de Junio á 22 de Julio.—Pequeños derrames de lava acompañados de ruidos subterráneos y débiles explosiones: las principales ocurrieron la noche del 20 al 21 de Junio.

1874. Volcán Taal, 19 de Julio.—Explosión de gases y ceniza que cubrió toda la isla, matando la vegetación y no poco ganado que en ella se criaba.

1878. Volcán Taal, 1 á 15 de Noviembre.—Durante muchos días se oyeron frecuentes ruidos en el volcán, al fin desde el 12 al 15 de Noviembre hubo pequeñas explosiones; quedando toda la isla cubierta de ceniza.

1881 y 1882. Volcán Mayon, 6 de Julio, 1881.—Enero, 1882.—Este largo período de erup-

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ción se distinguió por la tranquila deyección de lava á través de varias bocas ó grietas que forman las hendiduras y rajas superiores del cono, en su parte S y SSE: las lavas salían en estado casi sólido, fragmenticio é incoherente, aunque siempre incandescentes; hubo incrementos y decrecimientos irregulares de actividad; durante algunas noches se oían ruidos subterráneos muy profundos, generalmente precursores de mayor abundancia en la deyección de lava.[1] No causó daño ninguno. Las principales explosiones tuvieron lugar el 21 de Noviembre y el 14 de Diciembre.

1885. Volcán Mayon, 23 y 24 de Noviembre, 2 de Diciembre.—Erupciones de lava, con ruidos subterráneos, que comenzaron ya el día 21. Los arroyos de lava no llegaron á los sitios cultivados y habitados.

1887. Volcán Mayon, 22 de Febrero á 10 de Marzo.—Lo más fuerte de esa erupción, que duró, con intervalos más ó menos largos de calma, unos 20 días, se venía ya anunciando desde un período eruptivo de menor importancia durante el año precedente. En realidad desde el 8 de Julio de 1886 el volcán no había cesado de arrojar frecuentemente lava y cenizas en muy pequeña cantidad. Las cuatro principales explosiones de la erupción de 1887 tuvieron lugar el 22 y 27 de Febrero, y el 1 y 9 de Marzo: arrojó el volcán grandes cantidades de lava, á la par que inmensas nubes de ceniza; éstas se extendieron á más de 20 kilómetros al rededor del cono volcánico. Parece que solamente durante las explosiones del 1 de Marzo se oyeron intensos ruidos subterráneos, mas no se hace mención de temblores de tierra. Desde el 22 de Febrero los habitantes de los barrios del S, hacia donde parecían dirigirse las corrientes de lava, habían buscado refugio en sitios más seguros.

1888. Volcán Mayon, 15 de Diciembre; 1890, 30 de Septiembre y 1 de Octubre; 1891, 3 á 18 de Octubre.—Tres erupciones de poca importancia acompañadas todas de ruidos subterráneos pero no de temblores. La más importante fué la del año 1890, en que las corrientes de lava llegaron hasta los campos cultivados de los barrios orientales más próximos, pero sin causar daños apreciables. Esta erupción se anunció ya el día 10 de Septiembre y no llegó á su mayor intensidad hasta el 30 del mismo mes.

1892. Volcán Mayon, 21 á 29 de Febrero.—El día 3 comenzó á observarse resplandor ó incandescencia en el volcán y el 9 se vió que había ya algún derrame de lava. El 21 principió la verdadera erupción con explosiones que arrojaban bombas volcánicas á gran distancia, mucha ceniza y regular cantidad de lava fluyente: así continuó con intervalos variables de calma, hasta el 29. Los materiales arrojados por el volcán cayeron á poca distancia del cráter y así no hubo que lamentar desgracias personales ni pérdidas materiales: sin embargo los habitantes de los barrios más próximos, situados en las vertientes orientales del inmenso cono, habían ya tomado la precaución de alejarse del peligro. Lo singular de esta erupción fué que no hubo ruidos subterráneos hasta el 24, cuando llegaba ya á su mayor intensidad: no se mencionan temblores de tierra.

1893. Volcán Mayon, 2 á 22 de Octubre.—Anunciόse la erupción los días 2 y 3 de Octubre con ruidos subterráneos que solo se oían de los pueblos más cercanos al cono. El día 4 al anochecer comenzó á distinguirse vivo resplandor que salía del cráter; el día siguiente se oyeron explosiones y comenzó á salir una inmensa columna de humo y ceniza y á derramarse lava, pero sin llegar aún á gran distancia del cráter.

El 6 por la tarde entró el volcán en plena erupción, con intensos ruidos y una columna inmensa de humo y ceniza, bombas volcánicas y torrentes de lava por el lado oriental y occidental: el 8 comenzó á disminuir algo la fuerza de la erupción, aunque se prolongó hasta el 22; la ceniza llegó á distancias de 30 y 40 kilómetros. Aunque las corrientes de lava destruyeron muchos sembrados en la parte oriental del volcán, pereciendo también en ellos buen número de animales, no hubo sin embargo que lamentar desgracia alguna

[1] Véase "El Mayon ó volcán de Albay," por D. Enrique Abella y Casariego. Madrid, 1885.

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personal por haberse alejado las gentes de los barrios más próximos durante los 4 días que precedieron á la grande erupción. Sintiéronse dos temblores de tierra; uno el 11 y otro el 18 en que duraba aún la actividad volcánica extraordinaria.

1895 y 1896. Volcán Mayon, Julio y Septiembre.—Fueron más bien principios de erupción ó tal vez erupciones abortadas, acompañadas de ruidos subterráneos pero no de temblores de tierra. El volcán arrojó alguna lava y piedras candentes, á poca distancia del cráter. La primera ocurrió el 20 de Julio de 1895 y duró sólo una hora; la segunda duró desde el 31 de Agosto hasta el 26 de Septiembre de 1896.

1897. Volcán Mayon, 25 y 26 de Junio.—Esta erupción de lava fluente, piedras y cenizas causó unas 350 víctimas en cinco pequeños barrios situados sobre la vertiente oriental del volcán y á unos 6 kilómetros del cráter. Asegúrase que ya el día 22 se notó algo extraordinario en la actividad del volcán. Al anochecer del 23, pudo ya observarse distintamente que arrojaba piedras candentes y había algún derrame de lava, acompañado de ruidos subterráneos. Al amanecer del 24 aumentaron los ruidos, siendo algunos tan intensos que hacían retemblar la tierra. No se sintió sin embargo terremoto alguno propiamente dicho. Á las 10 de la mañana la erupción comenzó á ser imponente, los nubarrones de vapores y cenizas cubrían todas las cercanías del volcán, especialmente hacia el E, á donde eran llevados por el viento reinante. La lava fluía también con más abundancia por el lado oriental, indicada por las fumarolas, que parecían precipitarse por las vertientes del volcán. Así continuó todo el día y la siguiente noche del 24 al 25. Á las 6 de la mañana de esta última fecha comenzó la grande erupción. La lava corrió á torrentes por el lado oriental hasta el mar, que dista unos 20 kilómetros, arrollando cuanto se encontró á su paso. Inmensas nubes de vapores y ceniza envolvieron toda la región como para ocultar la catástrofe con las tinieblas: todo esto acompañado de retumbos espantosos que se oían á más de 250 kilómetros de distancia. Este paroxismo duró hasta la mañana del 26, aproximadamente unas 24 horas. Las cenizas llegaron á distancias de 160 kilómetros hacia el W y NW y á mucho mayores hacia el E.

Á esta erupción no precedieron ni acompañaron verdaderos terremotos: precedióronla sin embargo síntomas algo dudosos de nueva erupción durante 50 horas, y un aumento extraordinario de actividad, con crecientes ruidos subterráneos durante 27 horas. Dió por consiguiente tiempo á los habitantes de los barrios más próximos al cráter para ponerse en salvo y no ser víctimas del cataclismo. No todos sin embargo lo lograron.

1903.[1] Volcán Taal, Abril.—Pequeña erupción explosiva que probablemente duró hasta 1904. Abrióse un pequeño cráter dentro del principal y estuvo arrojando á intervalos, lodo y piedras á poca distancia. Las principales explosiones no hay duda que tuvieron lugar durante la primera quincena de Abril de 1903; en algunas publicaciones, sin embargo se las asigna á 1904.[2]

1911. Volcán Taal, 30 de Enero.—Los terremotos precursores comenzaron la noche del 27, continuaron con creciente intensidad y frecuencia todo el 28 y el 29. Además el volcán entró al mismo tiempo en actividad extraordinaria, arrojando ya lodo y ceniza durante las 52 horas que transcurrieron entre los primeros terremotos y la grande explosión, que ocurrió poco después de 2^{h} a. m. del día 30. Tenemos pues que á esta mortífera explosión precedieron 52 horas de temblores de tierra y de ruidos subterráneos y actividad volcánica muy alarmantes. Semejante estado de cosas fuera más que suficiente para alejarse á todo trance del volcán: así muchas de las 1,300 víctimas se hubieran salvado. Los temblores de tierra continuaron por muchos días después de la grande erup-

[1] Véase el "Monthly Bulletin Phil. Weather Bureau, April, 1903."

[2] "Geological Reconnaissance of Southwestern Luzon." By George I. Adams. The Philippine Journal of Science, Vol. V, No. 2, March, 1910.—"The Eruption of Taal Volcano, January 30, 1911." By Rev. M. Saderra Masó, S. J., Manila, 1911.

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ción á pesar de que el estado eruptivo del volcán había disminuido de tal manera que el día 1 de Febrero parecía haber vuelto ya á su estado normal.[1]

En la plancha VIII que acompaña el texto inglés se verá el diagrama de la frecuencia de temblores desde el 27 de Enero al 5 de Febrero, así como el estado de la presión atmosférica durante esta terrible erupción del Volcán Taal. Dicho diagrama se ha trazado con los registros de los aparatos siguientes: Seismógrafo Vicentini, Péndulos Horizontales (sistema Omori), y Seismógrafo Wiechert, todos montados en el Observatorio de Manila que dista del volcán Taal 63 kilómetros. Comprende por consiguiente tanto los temblores de tierra perceptibles, que á esta distancia llegaron á la intensidad IV, como los puramente instrumentales, ó del grado I de la escala.

III. DISCUSIÓN.

En las precedentes páginas hemos reseñado 21 erupciones principales; 13 del volcán Mayon, 7 del Taal y una de Camiguin. Solamente dos causaron un número considerable de víctimas: la del Mayon de 1814, de la que resultaron 1,200 muertos, con inmenso número de heridos, y la última del Taal, 1911, en que perecieron unas 1,300 personas. Á primera vista ya presentan caracteres distintos las erupciones del Taal y las del Mayon: las primeras han sido siempre de carácter explosivo sin fluir nunca lava; las segundas pueden llamarse mixtas, consistiendo generalmente en explosiones que parecen abrir el camino á la lava que continúa después fluyendo sin grandes esfuerzos. Las erupciones del Taal casi siempre van acompañadas no solo de grandes detonaciones y ruidos subterráneos sino también de fuertes terremotos los cuales continúan aún después de la erupción: en las del Mayon no se notan tales conmociones terrestres.

Lo que hace más á nuestro propósito es que ni en un volcán ni en otro los paroxismos, ó la máxima intensidad de sus erupciones se presentaron nunca tan repentinamente que no precedieran algunas horas por lo menos de indicios sospechosos, ó de erupción de poca intensidad. Esta afirmación es aplicable también á la erupción del Taal en 1749; pues aunque vino muy de improviso, según testimonio del Cura de Sala, dió tiempo sin embargo para alejarse, y hasta presentó el volcán resplandores ó indicios unas 4 horas antes. Solamente alguna erupción del Mayon ha sido anunciada por temblores de tierra precursores; tomando esta palabra en el sentido de haber los temblores realmente precedido á las primeras manifestaciones extraordinarias de actividad volcánica. Más frecuentemente precedieron á las erupciones de este volcán ruidos subterráneos, unas veces simultáneos con una mayor emisión de vapores, y otras sin aumento aparente de actividad.

La erupción de 1814, precedida de temblores de tierra, fué de carácter principalmente explosivo y sobrevino después de muchos años, durante los cuales el volcán permaneció tan durmiente que había llegado á desaparecer el penacho de vapores que suele coronar siempre su cúspide. No parece sino que los antiguos respiraderos se habían obturado y así la nueva erupción se abrió camino con tal violencia que cuarteó é hizo volar la parte superior del cono, según indica el autor de la relación arriba citada. "La cúspide," dice, "ó cráter del volcán bajó á mi parecer más de 20 varas y por la parte del Sur quedó descubierta una espaciosa y horrenda boca que causaba espanto mirarla; se abrieron también otras tres nuevas á bastante distancia de la principal, que continuaron por mucho tiempo arrojando humo y ceniza." Es pues probable que la inmensa cantidad de piedras, arena y polvo que cubrieron las cercanías del volcán, procedieron en gran parte del mismo cono, arrancadas por las explosiones; no se menciona salida alguna de lava en esta ocasión, en ninguna de las relaciones que varios autores escribieron.

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[1] Para más detalles acerca de las erupciones del volcán Mayon y del volcán Taal véanse los escritos siguientes: "La Erupción del volcán Mayon, 1897." Por el P. José Coronas, S. J., Manila, 1898. "The Eruption of Taal Volcano, January 30, 1911." By Rev. Miguel Saderra Masó, S. J., Manila, 1911.

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La erupción del volcán de Camiguin revistió caracteres especiales y propios de las que tienen lugar en volcanes aparentemente extintos, en los cuales las antiguas chimeneas deben estar obturadas con lavas solidificadas hasta una gran profundidad. De aquí el prolongado é inmenso esfuerzo que la lava y los vapores necesitaron para abrirse de nuevo camino al exterior: esfuerzo manifestado por dos meses y medio de continuos terremotos. Al fin la rotura se verificó no precisamente por el antiguo cráter sino por la base del cono volcánico, por ofrecer sin duda esta parte menor resistencia. Caso análogo á lo sucedido en el Usu-San en 1910. Los débiles temblores de tierra que se sintieron todavía en Camiguin durante los primeros días de la erupción, eran probablemente debidos en su mayor parte á las vibraciones producidas por el mismo violento escape de lava y vapores.

De todo lo dicho parece poder deducirse:

(1) Que en Filipinas solamente las erupciones de volcanes aparentemente extintos ó por largos años durmientes han sido precedidas de temblores de tierra, y que estos mismos han acompañado las grandes erupciones explosivas; pero no las erupciones de lava fluente.

(2) La intensidad de las erupciones ha sido generalmente inversamente proporcional á su duración, excepto durante el largo período eruptivo del Taal en 1754.

(3) Los temblores de tierra que acompañaron casi siempre y siguieron á las grandes erupciones del Taal, no pueden atribuirse á las vibraciones producidas por el escape violento de las deyecciones, sino á movimientos geológicos á lo largo de la falla en que se halla el volcán. Esta conclusión parece deducirse tanto de su persistencia, después que el volcán vuelve ya á su estado normal, como de la diferente área de máxima intensidad y efectos que suelen tener; prolongada unas veces al NNE (1749), y otras al SSW del volcán (1911). En cambio los temblores de poca intensidad que algunas veces se han sentido durante las erupciones del Mayon, pueden bien atribuirse á vibraciones superficiales del mismo cono volcánico.

(4) Que tanto las erupciones explosivas del Taal como las de lava del Mayon han aumentado progresivamente, desde un principio, indicado, ya con temblores, ya con ruidos subterráneos ó con ambos fenómenos á la vez, hasta un máximo que ha sobrevenido algunos días, y en pocos casos, unas horas después: el intervalo mínimo puede decirse que fué de cuatro horas. No es por consiguiente aventurado el afirmar que todas han dado tiempo á los habitantes de los sitios más próximos y peligrosos para alejarse á otros más seguros.

IV. LLUVIA.

Las erupciones del Mayon cuya fecha es conocida pueden reducirse á 22. y se reparten de la siguiente manera entre los meses del año: Enero 1, Febrero 3, Marzo 1, Abril y Mayo 0, Junio 2, Julio 4, Agosto 0, Septiembre 3, Octubre 3, Noviembre 2, Diciembre 3. Las 8 del Taal, cuyo mes se conoce, ocurrieron todas en diferentes meses, quedando sin ninguna los de Febrero, Junio, Octubre y Diciembre: esto si hacemos caso omiso de las explosiones de menor importancia que durante el largo período eruptivo (Mayo á Diciembre) de 1854, ocurrieron en tres de estos cuatro meses. Por manera que si atendemos tanto al número como á su intensidad no hallaremos apenas diferencia entre el número de las erupciones del Taal que tuvieron lugar durante el período seco, Enero–Mayo, y el de las acaecidas en el lluvioso, Junio–Diciembre. La erupción del volcán de Camiguin principió el último día de Abril. Por consiguiente tan solo las 22 del Mayon se prestan para una comparación con la distribución de las lluvias.

En la región de este volcán no existe propiamente estación seca y estación de lluvias, como en otras partes del Archipiélago: el promedio mensual de la lluvia deducido de 14 años de observaciones pluviométricas hechas parte en Albay y parte en Legaspi, distantes

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entre sí 2 kilómetros escasos, demuestra que existen cinco meses, Marzo, Abril, Mayo, Junio y Agosto con una cantidad media de lluvia que oscila entre 147 y 220 milímetros, y los siete restantes en que los promedios oscilan entre 250 y 484 milímetros. Si sumamos el número de erupciones que tuvieron lugar en las dos series de meses veremos que corresponden 3 erupciones á los primeros y 19 á los segundos: resultado que apenas se modifica si á las del Mayon se agregan las del Taal y la única de Camiguin, siempre resulta triple número para la temporada de mayores lluvias.

V. PRESIÓN ATMOSFÉRICA.

La presión media de cada período eruptivo se compara con su correspondiente promedio mensual y con la normal. Por falta de observaciones barométricas más antiguas este estudio solo comprende las erupciones ocurridas después del año 1890, que son 7 del volcán Mayon y una del Taal. Omitimos la de este volcán que tuvo lugar en 1903, por la incertidumbre que existe acerca de su duración: se sabe cierto que comenzó en Abril de 1903, pero se duda si tuvo un segundo período en el mismo mes de 1904. Debemos sin embargo advertir que la primera quincena de Abril de 1903 fué de presión barométrica 0.91 milímetros superior á la normal, mientras que durante la misma quincena de Abril de 1904 fué por el contrario 0.91 milímetros inferior.

Los datos van distribuidos en el siguiente cuadro: La primera columna lleva el volcán, el mes, año y período principal eruptivo; en la segunda, señalada con la letra (a), damos la presión normal correspondiente al mes de cada erupción, deducida de 12 años de observaciones al tratarse del Mayon, y de 26 años al tratarse del Taal. Para el primer caso nos hemos servido de las observaciones de Albay, y para el segundo de las de Manila. La tercera columna (b) presenta la presión media del mes en que ocurrió la erupción; y la cuarta (c) el promedio de los días que duró cada período eruptivo. Al fin van las diferencias entre los precedentes valores.

Erupciones y período eruptivo.	Presión atmosférica media.			Diferencias.		
	Normal. a	Mensual. b	Período eruptivo. c	a-b	b-c	a-c
Mayon, Septiembre, 1890 (10 Sept. á 4 Oct.)	757.5	755.0	754.8	—2.5	—0.2	—2.7
Mayon, Octubre, 1891 (1 á 20)	758.4	758.4	758.7	0.0	+0.3	+0.3
Mayon, Febrero, 1892 (21 á 29)	761.7	760.2	759.0	—1.5	—1.2	—2.7
Mayon, Octubre, 1893 (2 á 11)	758.4	758.0	756.4	—0.4	—1.6	—2.0
Mayon, Julio, 1895 (20)	757.9	757.8	754.7	—0.1	—3.1	—3.2
Mayon, Septiembre, 1896 (30 Ag. á 8 Sept.)	757.5	758.0	757.3	+0.5	—0.7	+0.2
Mayon, Junio, 1897 (21 á 30)	757.7	757.2	756.6	—0.5	—0.6	—1.1
Taal, Enero, 1911 (26 Enero á 5 Febr.)	761.0	759.8	758.3	—1.2	—1.5	—2.7

Los valores de este cuadro son ciertamente curiosos aunque no concluyentes, por tratarse de tan corto número de casos. No solamente la presión media del período eruptivo, pero aun la mensual, resulta siempre menor que la normal, excepto en dos casos. Además si se dan á las diferentes erupciones valores que representen su intensidad relativa, se ve que entre éstos y el déficit de la presión atmosférica hay verdadera proporción directa.

El más notable es el último caso de 1911. En 31 años, ó sea durante el período 1880 á 1911, solo una vez, 1890, la presión media del mes de Enero había resultado tan baja como en 1911. Por otra parte el período de 6 días, del 26 al 31 de Enero, 1911, en que el valor diario medio de la presión atmosférica se mantuvo constantemente entre 757.2 y 758.2 milímetros, es único en los registros de este Observatorio desde 1880. Este año hubo 3 días de baja presión que fueron el 6, 7 y 8, con un promedio diario de 757.4 á 757.8 milímetros.

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VI. INUNDACIONES RELACIONADAS CON LOS VOLCANES MAYON Y BANAHAO.

Antes de concluir estas notas debemos añadir unas líneas sobre un fenómeno meteorológico asociado á los volcanes y que tanto en Filipinas como en otras partes se atribuyó antiguamente á verdaderas erupciones. Nos referimos á los torrentes de fango, piedras y arena, que en épocas de lluvias excepcionales suelen producirse en las vertientes de los conos volcánicos, los cuales á manera de avalancha se precipitan sobre las campiñas circundantes, llevando á ellas la destrucción y la muerte.

El primer caso que recuerda la historia del volcán Mayon ocurrió el 23 de Octubre de 1766, por efecto de las lluvias torrenciales de un ciclón que pasó á poca distancia por el N de la Provincia de Albay. No se cita el número de víctimas, pero debió ser grande á juzgar por la devastación causada en los pueblos y sembrados de la parte meridional del volcán. El 31 de Octubre de 1875 otro ciclón causó en las cercanías del mismo volcán una hecatombe de igual carácter en que perecieron 1,500 personas.

Dos hechos semejantes se citan también del volcán extinto de Tayabas, llamado Banahao (121° 27′ Long. E; 14° 2′ Lat. N). Uno ocurrió en 1743;[1] la más probable versión es que el borde meridional del antiguo cráter cedió á la presión del agua que lo llenaba, y precipitándose ésta sobre el pueblo de Saryaya y sus campiñas en forma de avalancha de piedras y lodo lo destruyó todo, no sin muerte de buen número de personas. Últimamente en Enero de 1909 se repitió el hecho aunque con menores proporciones: esta vez la causa párece haber sido que durante la época de lluvias de 1908 se produjeron grandes desprendimientos de terreno en los bordes de una de las principales barrancas, que en la parte S se abren desde la cumbre del volcán hasta el mar, cegándola completamente y formándose en la parte superior una laguna. Filtróse por fin el agua, el improvisado dique cedió, y una regular avalancha de lodo y piedras destruyó muchos sembrados pertenecientes al pueblo de Saryaya. Ambas ocurrencias, la de 1743 y la de 1909 se anunciaron equivocadamente como verdaderas erupciones del volcán Banahao. Lo mismo debe decirse de los dos casos citados ocurridos en el Mayon, los cuales en algunas historias figuran entre las erupciones de dicho volcán.

[1] Algunos autores colocan este hecho en el año 1730. En el "Estado Geográfico etc. de la Apostólica Provincia de San Gregorio Magno," por el P. Fr. Felix de Huerta, Binondo (Manila) 1865, pág. 231, se dice que: "en 1743 (se trasladó el pueblo de Saryaya) por haber reventado la gran laguna en que se convirtió el referido volcán (Banahao), cuando hizo su última erupción en el año 1730." Lo mismo se repite en la pág. 232: hablando de la Iglesia de Saryaya "que se arruinó completamente en los temblores de 1743," prosigue el autor: "En el mismo año reventó la gran laguna del Banahao y sus corrientes arrasaron casi todo el pueblo, etc." Lo que se llama última erupción del año 1730 fué por ventura otro acontecimiento semejante al de 1743 y no verdadera erupción? Lo cierto es que no la encontramos citada en ninguna relación anterior á la publicación del "Estado Geográfico."

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RECORDS OF THE MICROSEISMOGRAPHS.

(Time of the one hundred and twentieth meridian east of Greenwich. Midnight=0.ʰ)

No.	Date.	Character.	Instrument and component.	Beginning. First preliminary tremors.	Beginning. Second preliminary tremors.	Beginning. Principal portion.	Maximum range of motion. Hour.	Maximum range of motion. Amplitude (2a).	Maximum range of motion. Period.	End.	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
142	1	I_d	W. N	2 37 20	.....	2 37 49	2 38 35	0.01	4.8	2 41	Vertical Component 0.68 mm.
143	3	I_v	V.	0 09 57	.....	0 10 20	0 10 32	.05	2.4	0 13	V. C. 0.02 mm. Earthquake. III at Nueva Caceres (SE of Luzon).
144	4	I	H. NNW	5 49 18	.....	5 51 50	5 53 48	.15	7.5	6 18	
			H. WSW	5 49 18	.....	5 51 [illegible]	5 56 [illegible]	.[illegible]	8.4	6 [illegible]	
			W. N	[illegible]	.....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
145	4	I_d	V.	17 42 10	.....	17 42 36	17 42 43	.10	2.4	17 46	V. C. 0.03 mm.
146	4	II_a	V.	21 42 01	21 49 00	21 53 40	21 56 24	.02	6.8	22 37	V. C. 0.02 mm. Asia, Tashkent.
			H. NNW	21 42 02	21 49 01	21 54 07	21 57 09	.11	8.1	22 32	
			H. WSW	21 42 02	21 49 02	21 53 35	21 57 13	.09	8.4	22 31	
			W. N	21 42 01	21 49 10	21 53 45	21 57 03	.06	10	22 40	
			W. E	21 42 11	21 49 11	21 54 16	21 57 24	.05	10	22 28	
147	5	I_r	V.	.....	.....	10 38 58	10 43 17	.04	[illegible]	11 00	V. C. 0.02 mm.
			H. NNW	.....	.....	10 38 59	10 43 25	.10	7.5	11 02	
			H. WSW	.....	.....	10 38 59	10 43 22	.08	8.4	11 10	
			W. N	.....	.....	10 39 03	10 43 32	.11	8	11 06	
			W. E	.....	.....	10 39 03	10 43 28	.09	7.2	11 06	
148	6	II_d	V.	2 44 45	.....	2 45 14	2 46 11	1.12	2.4	3 04	V. C. 0.70 mm.
149	8	I_d	V.	2 07 15	.....	2 07 43	2 07 45	.02	2.4	2 09	
150	8	I	H. WSW	9 45 45	.....	.....	.....	.....	.....	10 10	
151	9	I_d	V.	7 25 51	.....	7 28 30	7 28 47	.12	2.4	7 28	
152	11	I_d	V.	1 10 00	.....	1 10 20	1 10 34	.02	2.4	1 12	
153	12	I_r	V.	5 31 29	.....	5 38 44	5 39 19	.02	6	5 57	
			H. WSW	5 31 30	.....	5 38 45	5 39 15	.14	7.8	6 10	
			W. N	5 31 33	.....	5 38 48	5 39 18	.01	8.8	6 05	
154	12	I	H. WSW	.....	.....	9 49 41	9 55 32	.06	8.4	10 12	
155	12	III_v	V.	12 09 44	.....	12 10 54	12 12 01	1.80	2.4	14 30	V. C. 0.40 mm. Eqke., VIII-IX, Agusan River Valley, eastern Mindanao.
			H. WSW	12 09 44	.....	12 10 51	.....	.....	.....	15 12	
156	12	II_r	V.	16 03 20	16 07 06	16 10 20	16 12 25	.03	10.4	17 24	
			H. NNW	16 04 26	16 08 46	16 10 46	16 13 36	.83	8.1	17 43	
			W. E	16 03 26	16 08 42	16 10 00	16 14 18	.18	9.2	17 31	
157	13	I_r	H. WSW	.....	16 42 42	16 45 37	16 49 34	.10	12.6	17 17	NE sea of Formosa.
158	14	I_v	H. WSW	9 47 22	.....	9 49 24	9 52 43	.39	9.3	10 45	Eqke., III, Agusan River Valley, aftershock.
159	16	I_d	V.	13 00 43	.....	13 09 37	13 01 11	.36	2.4	13 06	V. C. 0.24 mm.
160	19	I	H. WSW	18 12 10	.....	.....	.....	.....	.....	19 15	V. C. 0.02 mm.
161	20	II_v	V.	4 22 55	.....	4 25 14	4 29 01	.08	12	.....	V. C. 0.01 mm. Eqke., III, Agusan River Valley, aftershock.
			W. E	4 22 58	.....	4 25 01	4 28 38	.30	8	.....	
162	20	I_r	V.	.....	5 23 00	5 25 09	5 26 28	.02	11.6	6 28	V. C. 0.01 mm.
			H. NNW	.....	5 23 00	5 25 09	5 26 37	.20	10.5	6 55	
163	21	I_v	V.	18 59 39	.....	19 01 27	19 04 52	.02	4.8	19 32	Eqke., IV, Agusan River Valley, aftershock.
			H. NNW	18 59 39	.....	19 01 31	19 04 01	.11	7.5	19 24	
164	22	I_d	V.	8 14 47	.....	8 14 22	8 14 56	.05	2.4	8 18	V. C. 0.03 mm.
165	22	I	H. NNW	.....	11 13 56	.....	.....	.....	.....	11 45	
166	22	I_v	V.	13 18 53	.....	13 20 51	13 22 10	.08	2.4	14 12	V. C. 0.02 mm. Eqke., IV, Agusan River Valley, aftershock.
			W. N	13 19 00	.....	13 20 45	13 23 08	.05	12.4	14 11	
167	22	I_d	V.	17 49 07	.....	17 49 19	17 49 31	.03	2.4	17 52	V. C. 0.01 mm.
168	28	I_d	V.	10 19 35	.....	10 19 45	10 19 53	.01	2.4	10 22	V. C. 0.02 mm.
169	28	I_d	V.	10 46 38	.....	10 46 49	10 46 51	.05	2.4	10 50	V. C. 0.02 mm.
170	30	I_r	H. NNW	19 54 42	.....	19 57 18	19 58 05	.05	9.6	20 36	
171	30	I	H. WSW	.....	.....	21 52 29	.....	.....	.....	22 11	
172	31	I_r	H. NNW	8 11 55	.....	8 14 37	8 14 44	.16	7.8	8 28	

Instrumental constants.—Vicentini microseismograph (V.): Length of the pendulum, 1.50 meters; weight of the bob, 100 kilograms; period of simple oscillation, 1.2 seconds. Magnification of the record, 50 times.

Horizontal pendulums (H.): Vertical distance between the point of suspension and the point of support, 1.05 meters; horizontal distance between the point of support and the center of the heavy bob, 0.77 meter; weight, 20 kilograms; period of oscillation: NNW–SSE pendulum, T=8.1 seconds; WSW–ENE pendulum, T=8.7 seconds. Magnification of the record: NNW–SSE, 15 times; WSW–ENE, 15 times.

These seismographs have no damping arrangement.

Foundation and location.—The instruments are mounted against a solid cut-stone pier measuring 5 by 5 meters at its base and 3.30 by 3.30 at the top, with a foundation about 4 meters deep, and insulated from the surrounding walls of the building by a space, 2 meters wide, filled with sand. The Vicentini microseismograph stands at a height of 9.5 meters above the ground and 10.5 above sea level, while the horizontal pendulums stand at 1.50 meters above the ground and 2.50 above sea level.

Geological structure.—The geological formation of the ground is alluvium and beach sand to a depth of some 14 meters which extends many kilometers toward north and south and only 4 to the east, where volcanic tuff outcrops. To the west there lies the Manila Bay at a distance of some 300 meters. The alluvial plain of Manila is crossed by creeks in many directions and by the Pasig River, which flows in an E–W direction, at a distance of 1.5 kilometers to the north of the Observatory.

Wiechert seismograph (W.); 1,000 kilograms; N=N–S component; E=E–W component; period 7 seconds; magnification 98; damping 4:1; 2.40 meters above sea level.

TEMBLORES DE TIERRA SENTIDOS EN FILIPINAS.[1]

3, 0h 09m 57s.* **Nueva Cáceres** (SE de Luzón). Temblor oscilatorio, dirección NNE–SSW, intensidad III, duración 5 segundos.

7, 18h 47m. **Laoag** (NW de Luzón). Temblor de tierra de intensidad II.

16, 4h 38m. **Tacloban** (NE de Leyte). Temblor oscilatorio, dirección ENE–WSW, intensidad III, duración 6 segundos.

19, 11h 30m. **Sarangani** (S de Mindanao). Temblor de tierra de intensidad II.

22, 4h 36m. **Zamboanga y Basilan.** Temblor oscilatorio, dirección SW–NE, intensidad IV, duración 8 segundos.

24, 11h 36m. **Sarangani** (S de Mindanao). Temblor de tierra de intensidad III.

25, 12h 15m. **San Fernando, Unión** (NW de Luzón). Temblor oscilatorio, dirección WSW–ENE, intensidad III, duración 3 segundos.

28, 6h 30m. **Sarangani** (S de Mindanao). Temblor de tierra de intensidad II.

30, 18h 02m. **Baguio** (W de Luzón). Temblor oscilatorio, dirección NNE–SSW, intensidad III, duración 5 segundos.

NOTA.—La relación del terremoto de Mindanao del día 12, y de las repeticiones ó aftershocks que le siguieron en Julio y Agosto se encontrarán al fin del Boletín.

REGISTROS DE LOS MICROSEISMÓGRAFOS.

Véase en el texto inglés la tabla correspondiente que contiene una lista completa de estos registros.

[1] **La intensidad de los terremotos se indica conforme á la conocida escala de De Rossi-Forel. Cuanto á la hora de su ocurrencia, adoptamos la indicada por los seismógrafos de este Observatorio siempre que los hayan registrado, distinguiéndola por medio de un asterisco (*). En caso contrario copiamos la apuntada por los observadores que nos envían las notas. Todas las indicaciones del tiempo se refieren al tiempo oficial del Archipiélago que es el del meridiano 120° E de Greenwich.**

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THE EARTHQUAKE OF THE AGUSAN VALLEY AND THE EASTERN COAST OF MINDANAO, JULY 12, 1911.

The Agusan River Valley and the region to the east of it as far as the coast of the Pacific Ocean, constitute that part of the Philippine Archipelago which at present shows the greatest seismic activity, both as to number and intensity of disturbances. In June, 1893, and again in the same month of 1894, the Agusan district experienced the severest seismic upheavals recorded in the annals of the valley. During the seventeen years which have passed since then, no fewer than 16 earthquakes have occurred in the same territory whose intensities lay between degrees VI and IX of the scale. On the eastern coast of Mindanao the most recent earthquake of force VIII took place in March, 1909. The greater number of these earthquakes of the Agusan make themselves felt chiefly, and possibly even have their origin, near the central part of the valley, which is characterized by a broad expanse of level, marshy ground, partly occupied by three principal lakes of permanent character which, however, in times of extraordinarily heavy rainfall coalesce into one having a length of about 50 kilometers and a maximum width of some 20 kilometers. This entire region subsided considerably on the occasion of the earthquakes of 1893 and 1894, whereby large tracts of wooded and partly cultivated land were converted into swamps, though formerly the water reached them only during the highest floods. This region is undoubtedly the most unstable portion of the line of fracture which runs along the Agusan Valley and extends beyond it in the direction of the Davao Gulf in the south, and Leyte Island in the north. In this same region of the lakes a second, less important fault-line seems to meet the one mentioned, or to cross it. This secondary line of fracture runs from the valley across the eastern range of elevations and, following a W–E direction, extends toward the Great Trough of the Pacific of more than 8,000 meters' depth, which lies about 90 kilometers off the coast. The existence of such secondary fault seems to be established by the earthquake of March, 1909,[1] and many others which could be traced to the same origin. But as we have only recently described these two fault-lines in a paper under the title "The Seismic Centers of Samar, Leyte, and Eastern Mindanao,"[2] we refer the reader to the latter, and proceed to describe the most recent earthquake which took place in that region.

Time.—At Manila the earthquake of July 12 was registered at $12^h\ 9^m\ 44^s$ Insular time (one hundred and twentieth meridian east of Greenwich); hence, on the Agusan, or along the epicentral line whose middle portion is at a distance of some 900 kilometers from Manila, it must have occurred at $12^h\ 8^m\ 6^s$, or thereabout. It is impossible to ascertain the instant of its occurrence even approximately from the reports received at the Observatory, since this part of Mindanao has no telegraphic connection with the rest of the Archipelago, nor any other adequate means for keeping correct time.

Intensity.—A fair idea of the intensity of the earthquake may be gained from the reports sent to the Central Observatory from a number of places; some of them situated within the valley itself, like Talacogon, La Paz, Bunauan, Veruela, and Butuan; others at some distance from it, as Hinatuan, Boston, Baganga, Caraga, and Davao to the east and south, Cagayan to the northwest, Nasipit and Cabarbaran to the north-northwest and north.

Talacogon.—The Rev. Salvator Giralt, S. J., writes: "While we were dining (after 12 o'clock noon), there took place a very violent earthquake which wrought great havoc in the convento and church. The creaking of the beams was something awe-inspiring; doors and windows were wrenched from their hinges. Both, in the church and in the house, not only light objects, but also quite heavy pieces of furniture were rolling ab

[1] Weather Bureau, "Bulletin for March, 1909." [2] Weather Bureau, "Bulletin for August, 1910."

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on the floor, statues of the altars, candlesticks, cumbersome chests, pictures, jugs and jars, etc., everything going to pieces! The houses in the town remained tilted to one side. Never since I came to the Philippines in 1894, had I experienced an earthquake of equal violence and duration."

The supervising teacher of Talacogon, Mr. Macario Torralba, in a note received later adds the following particulars. The earthquake threw down many big trees; in the hemp plantations placed on sloping ground numerous and extensive land slidings were produced, some of them carrying down five hundred and more plants (these plants are set in ranges some 3 meters apart, thus each hectare contains from 800 to 1,000 plants); similar and even greater slidings are seen from Talacogon on the nearest hills of the east. The damage caused by the earthquake both to houses and ground was found to be equally serious in all the barrios visited by said supervisor; most of the houses being overthrown in the E–W direction. He further states that the most violent movements were preceded by weak vibrations during a very noticeable interval, the earth remaining about three minutes in continuous motion. Some people told him that in one of the lakes the high waves produced by the earthquake invaded the shore and penetrated far into the land.

La Paz.—The Rev. Christopher Sastre, S. J., who happened to be traveling in a boat on the river at the time of the earthquake, writes: "Suddenly there arose some waves of such dimensions and confused directions that the oarsmen needed all their skill and strength to prevent the capsizing of the boat. Soon we reached the village of La Paz where I found church and house unroofed and the walls fallen to the ground, which forced me to seek shelter in a private hut. Many dwellings remained permanently tilted and were in bad shape, while three had been destroyed completely. The ground showed many and large cracks. The people of the place say that already on the 11th they had felt some weak shocks." It must be borne in mind that the church and houses mentioned in the preceding lines were constructed of wood, bamboo, and nipa.

Bunauan.—Regarding this village and the region of the lakes and marshes, it is known that the banks of the river and other water courses caved-in in many places, carrying with them trees and other obstructive material and blocking the navigable channels to such an extent that the governor of the Province of Agusan requested authority to expend the sum of ₱500, this being the estimated cost of clearing the channels which connect Bunauan with Clavijo and Veruela.

Veruela.—Some inhabitants of this place furnished to our observer at Butuan the following details: "When it was time to eat (noon), there occurred an earthquake of frightful force; the ground moved so violently that the swaying houses remained at the end permanently inclined, none, however, collapsed. (They are, without exception, constructed of bamboo and wood, held together by rattan.) The ground showed waves like those of water, and the commotion of the waters of the river was something imposing. Everybody was convinced that the village would be utterly destroyed as had happened in 1893. The terror was increased by a thunderstorm which raged at the same time. The ground was fissured everywhere and in many places of the river formed quite extensive banks of mud and sand, leaving not enough depth even for small boats. During three days the river water was so muddy that it could not be used for any household purposes, which caused great hardships. After the great quake the earth continued to tremble frequently during several days, which circumstance kept alive the fear that after all the place might be doomed to destruction. Soon rumors were current that the earthquake had been much more disastrous at Hinatuan, where nearly all the houses had been destroyed.

Butuan.—The observer at Butuan, Mr. Generoso Copin, sent us the following report. "Violent earthquake of oscillatory and trepidatory character; observed directions: S–N, SW–NE, and ESE–WNW; duration about two minutes. At first nobody took much notice

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of the phenomenon, as for many seconds the movements were of little intensity, objects swaying but slightly. But thereafter the earth shook so violently that everybody rushed into the streets in terror, the violent movements lasting about 50 seconds. Within the houses everything moveable went skidding about the floor. Nearly all the houses were damaged and even in the church and convento portions of partition walls came down which were of masonry with wooden trusses, the greatest damage being on the west side. Two houses of the town fell toward north and the upright posts of one were lifted about one foot out of the ground in which they were imbedded. The latter fact proves that there were also vertical movements. Of a variety of objects, such as pictures, chairs, lamps, etc., some were thrown toward east, others toward west. Some large trees whose trunks were partly rotten, came down. Several fissures opened in the direction NE–SW. Some people who were washing in the river, say that at first the water rushed from the western to the eastern bank and then back again, the agitation being so violent that a huge log which was floating in the water secured by a thick rattan, broke its mooring and was carried away by the waves."

Hinatuan, Boston, Baganga, Caraga.—Concerning these places, all of which lie on the Pacific coast, we have only the following brief notes couched in general terms, sent us by the Rev. Bernard Llobera, Jesuit missionary at Caraga, which, however, enable us to estimate the intensity developed by the earthquake in that region. He says: "On the 12th we had an earthquake such as I do not remember having ever before experienced. The shocks appear to have come from several directions, as the bells and lamps of the church had a circular motion. The earthquake was even more severe to the north of Caraga. At Baganga it opened two fissures close to the wharf; at Boston it brought to the ground a massive stone wall which formed the façade of the church and had a thickness exceeding 2 "varas" (1.68 meters). It is said that the earthquake showed still greater violence at Hinatuan, but I have no details."

Davao.—Regarding the town of Davao, situated on the northwestern shore of the gulf of the same name, the observer in charge of the station reports that the earthquake was very strong: it stopped clocks, caused church bells to ring, and produced general alarm, principally on account of its long duration of one minute and five seconds. It had, however, no evil consequences. From the record traced there by a pendulum seismograph we learn that the movements were mainly in the directions NNW–SSE, NNE–SSW, and ENE–WSW. In the daily papers it has been stated that the earthquake was much more violent on the northeastern side of the gulf, where it damaged buildings and opened fissures in the ground. Hence, it must have had greater intensity in that region than at Caraga.

Cagayan (Misamis).—A note from the Jesuit missionaries stationed there says: "An earthquake of long duration, though not very strong, as it did not throw down any objects. The sway of the heads of the coconut palms seemed to be from SSE or S to NNW or N. The duration was such that there was plenty of time to leave the room, descend the stairs and go into the yard while the earth still continued to tremble."

Nasipit and Cabarbaran.—The observer at Butuan, whom we mentioned before, adds in a second note that several persons from Nasipit and neighboring places, situated in the northwestern part of the Agusan Province, told him that the earthquake was very strong and of long duration, but did not damage buildings, though it made a great noise in them and still more so in the woods which cover the nearby mountains lying to the west of those places. From Cabarbaran, which is east of Butuan Bay, comes practically the same information—the earthquake was strong and prolonged without doing any damage; the trees swayed violently, and the abacá plants rocked until the leaves appeared to touch the ground.

We found it impossible to obtain any information concerning the villages on the northeastern coasts of Mindanao, between Hinatuan and Surigao, our requests for

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same having remained unanswered. The fact, however, that our observer at Surigao, the provincial capital, has heard nothing of any extraordinary occurrences in this region is sufficient reason for assuming that the earthquake was there much less intense than in the villages of the Agusan Valley situated on the same parallels.

All the places mentioned lie within 150 kilometers from the central region of the Agusan Valley; beyond this zone the earthquake was much less violent, but of extraordinary duration. In the following table we give the direction, force, and duration of the seismic movements as observed in various localities beyond the 150-kilometer limit. After each place we add its approximate distance and bearing from the middle region of the Agusan Valley.

Place.	Distance and bearing from the center.	Observed direction of movements.	Intensity.	Duration.
	Kms.			*m.* *s.*
Surigao	175 N	ESE-WNW, SSW-NNE	V	1 30?
Parang (Cotabato, D.)	200 WSW		IV	
Jagna (Bohol)	230 WNW	SW-NE	IV	0 37
Maasin (Leyte)	240 NNW	SE-NW	IV	0 30
Tagbilaran (Bohol)	260 NW		IV	
Sarangani	310 SSW		IV	
Dumaguete	312 WNW		III	0 20
Cebu	320 NW	S-N	III	0 40
Guiuan (Samar)	320 N	E-W	III	0 15
Ormoc (Leyte)	330 NNW	S-N, SSE-NNW	III	0 15
Tacloban (Leyte)	330 NNW	ENE-WSW	II	0 10
Borongan (Samar)	380 N		II	0 20
Calbayog	440 NNW	ENE-WSW	II	0 7
Legaspi	570 NNW		II	0 8

Isoseismic curves.—From the preceding data we may conclude that the isoseismal VIII–IX inclosed the entire middle reaches of the Agusan Valley, the eastern coasts of the island between Baganga and Lianga (north of Hinatuan), and, if the press notices are true, also the region northeast of Davao Gulf, Plate VII. As regards the eastern coast, we cannot vouch for the fact that the disturbance was really of such violence there, since we do not know the condition of the thick wall which tumbled down at Boston, nor the nature of the ground in which fissures opened at Baganga. It is, however, very probable that it had the same intensity there as it had in the Agusan Valley itself where, to judge from the effects which we have mentioned, it was comprised at least between degrees VIII and IX. This gives to the meizoseismic area a very irregular shape, as it includes a zone along the Agusan River running in the direction NNW–SSE from Butuan to the northeastern coast of Davao Gulf, and a second, much shorter zone, comprising the coast and eastern mountain range lying between the parallels of Baganga and Lianga. To explain this irregular form, it is necessary to assume that dislocations took place in the two fault-lines mentioned in the beginning of this paper; the one running along the Agusan Valley, and the other, of secondary character and almost perpendicular to the former, from the Agusan toward the Great Trough of the Pacific.

The principal reason which moves us to believe that some movements occurred also in this secondary line, lies in the fact that the earthquake of July 12th was felt on Palau Island, Western Carolines (134.6° longitude E; 7.5° latitude N), which lies about 900 kilometers from the eastern coasts of Mindanao. According to a communication from the Reverend Capuchin missionaries on the island, there were felt on that day, at about 13ʰ (that is 12 o'clock noon, or a little later, time of the one hundred and twentieth meridian) seismic oscillations in the direction WNW–ESE, which were of intensity III and lasted about 10 seconds. We can hardly doubt that the Palau earthquake was identical with the one of Mindanao and the Visayas and, hence, that the two fracture

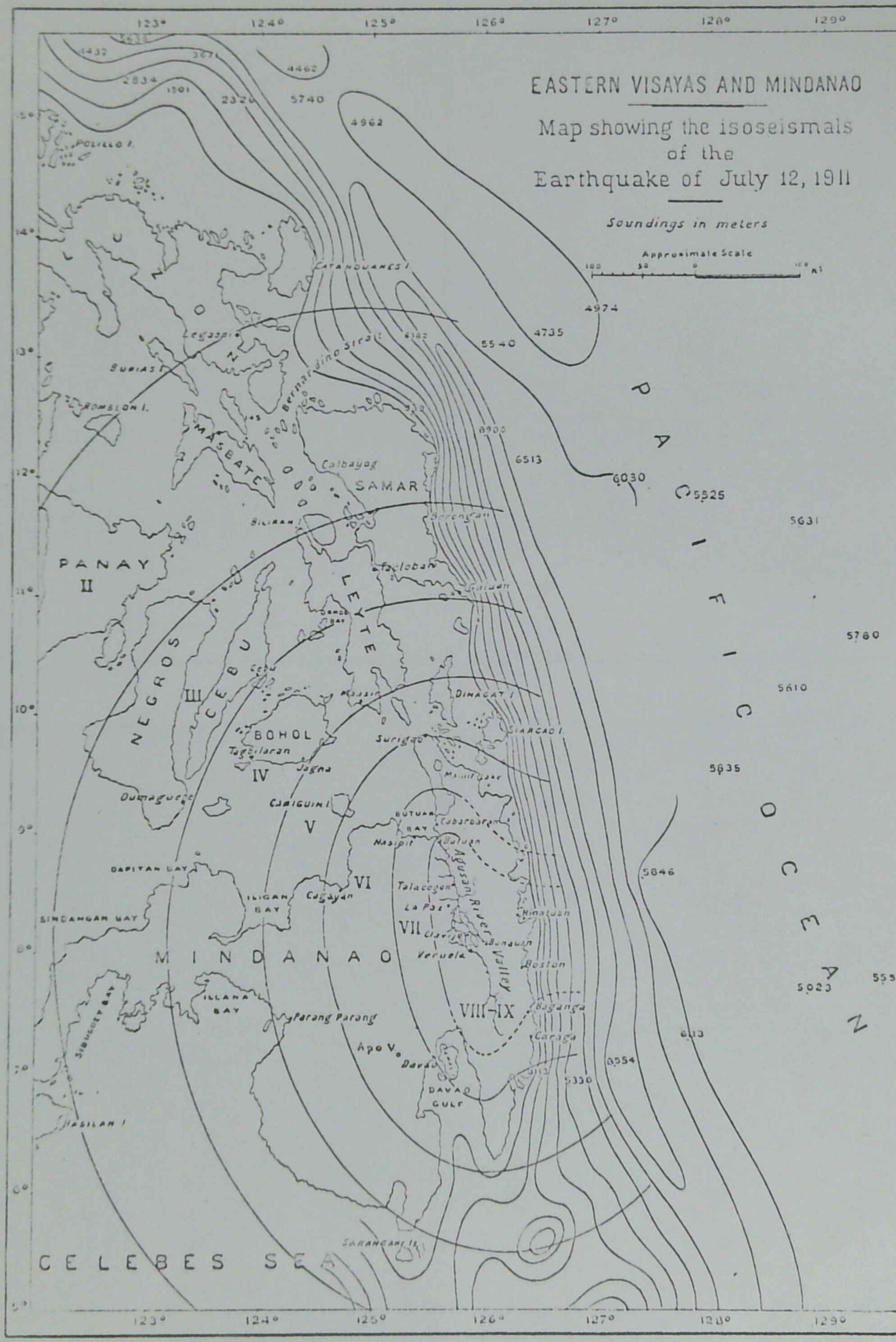
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Plate VII

EASTERN VISAYAS AND MINDANAO

Map showing the isoseismals of the Earthquake of July 12, 1911

Soundings in meters



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lines in question entered into action. There only remains to investigate in which of the two the movement started. The observer at Butuan, situated at the northern extremity of the meizoseismic area, reports that the earthquake began with weak movements which lasted many seconds, giving the people time to become conscious of them and to disregard them in the belief that they were the ordinary tremblings so frequent in that region. These preliminary movements were followed by violent shocks having the extraordinary duration of 50 seconds. Similar indications are made by the reporter of Talacogon. This would seem to indicate that the origin of the preliminary tremors was at a considerable distance from Butuan and even from Talacogon; hence, it may well be that the disturbance started along the Pacific fault-line and was communicated to that of the Agusan. This would likewise explain the long duration of the earthquake. Unfortunately we have no confirmation of these deductions, as neither the times assigned to the phenomenon by the observers stationed in Mindanao, nor the seismograms traced by the Manila instruments serve for the purpose, especially as the latter make the point of origin of the disturbance appear to have been much nearer than it was in reality, a circumstance which is due to the fact that the earthquake was well perceptible up to a distance of 340 kilometers from Manila. Nor can the directions of the seismic waves serve as guides: as is usually the case during violent earthquakes, they were everywhere of very complex character. Thus at Butuan, the water of the river rushed toward the eastern bank at the beginning of the violent shocks, the principal fissures ran in the direction NE–SW, and the pendulum seismograph registered violent motions in the directions NE–SW, ESE–WNW, and S–N. From Caraga we are informed that suspended objects swung in circular paths. The curves of the pendulum seismograph at Davao show the greatest oscillations to have been in the directions NNW–SSE, NNE–SSW, and ENE–WSW, those in the last-named direction having been the most persistent. If there really were movements along both faults, as it seems to have been the case, the movement in the Pacific line must either have started far from the east coast of Mindanao, or have propagated itself a great distance toward east, otherwise it would not have been possible to be felt in the Pelew group of islands.

The isoseismals VII and VI enclose a zone of about 100 kilometers in width all around the meizoseismic area, thus comprising a great part of the north, center, south, and southeast of Mindanao.

The outermost isoseismal, corresponding to degree II, extends toward north and northwest as far as the southeastern end of Luzon, encloses the islands of Samar, Cebu, and Negros, and crosses Mindanao near the meridian 122° east. Hence, if we assume the central portion of the Agusan Valley as the center of the disturbance, the earthquake was perceptible toward north up to distances exceeding 500 kilometers, but only of about 400 kilometers toward west. Toward south, the farthest station from which we have information is Sarangani which is only about 310 kilometers from the supposed origin and was comprised within the isoseismal IV. This earthquake has been registered by the seismographs throughout the world.

Repetitions or aftershocks.—These were very numerous during the whole afternoon and night of the 12th and likewise during the following two days, July 13 and 14. Then their frequency decreased considerably, especially toward the end of the month, though they were still quite numerous during August and in the beginning of September, and have not yet ceased entirely at the date of writing (September 20). Unfortunately there is at present, with the exception of Butuan, no meteorological station in the Agusan Valley, nor on the eastern coasts of Mindanao, which, as stated, were the regions most affected by the earthquake. Hence, we cannot present a complete list even of the stronger repetitions. Butuan is situated at the northern extremity of the valley, some 50 kilometers from the place where the two faults probably meet, and it is clear that many of the less severe aftershocks originating at the juncture were not

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perceptible at so great a distance. Consequently, the list furnished by the observer at Butuan must be considered as containing only some of the more intense disturbances whose waves were perceptible at a distance of more than 50 kilometers. Thus, for instance, during the afternoon of the 12th as many as 20 aftershocks have been counted at Talacogon and they were innumerable at La Paz; yet at Butuan only 8 have been recorded. According to a report from La Paz, the aftershocks were there very frequent on the 13th and similarly at Talacogon, but at Butuan only two were perceived, etc. From Bunauan we are informed under date of July 17th that earthquakes have been very frequent in that place during those days.

Some idea of the frequency wherewith the repetitions took place in the region of Talacogon during July and August may be gained from two remarks which a missionary of the place added at the end of lists of the more important aftershocks. In the first, dated July 27th, he inquires whether the frequent, nay well-nigh continuous tremors were perhaps the heralds of a fresh destructive earthquake; in the second, written about the end of August, he states that earthquakes were still being felt almost continually. In the following table we present the list of aftershocks recorded at Butuan, to which we add under "Remarks" some of the principal disturbances observed at Talacogon. Of some of the latter the hour and intensity are known, while others have been reported only in general terms:

AFTERSHOCKS FELT AT BUTUAN, JULY 12 to AUGUST 30.

Day.	Hour.		Duration.	Intensity.	Direction.	Remarks.
	h.	m.	s.			
July 12	13	12	----	III	----	Long duration.
July 12	13	35	----	III	----	Short duration.
July 12	15	00	----	III	----	Do.
July 12	16	00	----	III	----	Do.
July 12	16	10	----	IV	----	Long duration.
July 12	18	00	----	II	----	Short duration.
July 12	20	35	30	III	----	At Talacogon 20 aftershocks were recorded during the same afternoon and evening.
July 13	4	30	----	III	SW–NE, ESE–WNW	
July 13	8	20	----	II	----	Talacogon and La Paz report very frequent aftershocks during this and the following day and many on the 15th.
July 14	3	26	27	IV	SE–NW, E–W	
July 14	9	47	25	IV	S–N, SE NW	Registered at Manila.
July 16	10	11	10	II	----	Three or four reported from Talacogon.
July 18	1	57	8	III	SSW–NNE	Four at Talacogon.
July 20	4	22	50	VI	ENE–WSW	Two aftershocks shortly after. Registered at Manila. Felt at Davao. Talacogon reports many other slight quakes.
July 21	18	59	20	IV	----	
July 22	13	18	35	IV	----	Registered at Manila. Talacogon reports four shocks this day and three the following two days.
July 24	22	20	4	II	ESE–WNW	
July 26	14	24	17	III	SE–NW	Talacogon reports quakes at $12^h\ 55^m$ III, $14^h\ 24^m$ V, $15^h\ 00^m$ III, with some slighter ones.
July 31	4	00	----	III	SE–NW	Short duration.
July 31	15	38	----	II	----	Do.
Aug. 3	17	01	24	IV	ESE–WNW	
Aug. 10	10	45	----	III	SSW–NNE	
Aug. 15	4	54	37	IV	SSW–NNE, S–N	Registered at Manila. Felt at Davao and Surigao.
Aug. 17	10	33	3	II	----	
Aug. 18	10	56	1	VI	ESE–WNW, S–W	Registered at Manila.
Aug. 23	5	46	5	III	ESE–WNW	
Aug. 25	11	33	30	III	SSW–NNE	
Aug. 25	12	16	10	II	S–N	
Aug. 27	22	00	----	II	----	
Aug. 29	21	07	----	II	SSW–NNE	
Aug. 29	21	45	20	III	S–N	
Aug. 30	3	54	----	II	----	

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EL TERREMOTO DEL VALLE DEL RÍO AGUSAN Y DE LA COSTA ORIENTAL DE MINDANAO, 12 DE JULIO DE 1911.

La región que comprende el valle del río Agusan y la costa oriental de Mindanao es actualmente la parte del Archipiélago donde los temblores de tierra se repiten con mayor frecuencia é intensidad. En Junio de 1893 y 1894 ocurrieron en el Agusan los más intensos terremotos que registran los anales del valle. Durante los 17 años transcurridos desde aquella fecha se han sentido en él no menos de 16 terremotos comprendidos entre las intensidades VI y IX de la escala. En la costa oriental el último de intensidad VIII tuvo lugar en Marzo de 1909. La mayor parte de los terremotos del Agusan se hacen sentir principalmente, y aún es posible tengan su origen, hacia el centro del valle, caracterizado por una extensión de terreno llano y pantanoso, donde existen tres principales lagos permanentes, los cuales en tiempo de lluvias extraordinarias se juntan y extienden hasta formar uno solo de cerca de 50 kilómetros de longitud por unos 20 de anchura máxima. Toda esta parte sufrió marcado descenso á causa de los terremotos de 1893 y 1894, convirtiéndose en pantano grandes extensiones de bosque y de tierras en parte cultivadas, á donde antes sólo llegaban las aguas en las más grandes avenidas. Esta es sin duda la parte más instable de la línea de fractura que corre á lo largo del valle y aún se extiende por el S hacia el Golfo de Davao y por el N hacia la Isla de Leyte. Á esta misma zona de los lagos, en las proximidades del paralelo 8.2° N y del meridiano 125.8° E, parece concurrir ó cruzar otra falla ó línea secundaria de fractura que, partiendo del valle atraviesa los macizos montañosos orientales y sigue en dirección W–E hacia la gran Fosa del Pacífico de más de 8,000 metros de profundidad, la cual se halla á unos 90 kilómetros de la costa. La existencia de esta falla secundaria parece comprobarla el terremoto de Marzo de 1909 [1] y otros muchos que podrían referirse al mismo origen. Como recientemente describimos estas dos líneas seismotectónicas en un artículo titulado "Centros Séismicos de Sámar, Leyte y de la Parte Oriental de Mindanao" [2] á él remitimos al lector y pasamos á la descripción del último terremoto.

Hora.—En Manila se registró este terremoto á $12^h\ 9^m\ 44^s$ y en el Agusan ó sea en la línea epicentral, cuyo punto medio dista 900 kilómetros próximamente, debió tener lugar en las proximidades de $12^h\ 8^m\ 6^s$. No es posible deducirla ni aún aproximadamente de las notas recibidas por el Observatorio, á causa de estar esa parte de Mindanao sin comunicación telegráfica con el resto del Archipiélago y no tener medio preciso de arreglar los relojes.

Intensidad.—Esta se podrá deducir de las diferentes notas recibidas tanto de las poblaciones situadas en el mismo valle, Talacogon, La Paz, Bunauan, Veruela, y Butúan, como de otras más lejanas, Hinatúan, Boston, Baganga, Caraga, y Davao, situadas al E y S; Cagayán al NW; Nasípit y Cabarbarán al NNW y N.

Talacogon.—El R. P. S. Giralt, Misionero S. J., escribe: "Estando comiendo (después de las 12^h mediodía) ocurrió un terremoto muy violento que causó muchos destrozos en el Convento y la Iglesia. El crujir de las maderas era espantoso, las puertas y ventanas

[1] Weather Bureau, "Bulletin for March, 1909. [2] Weather Bureau, "Bulletin for August, 1910."

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eran sacadas y arrancadas de sus goznes. Tanto en la Iglesia como en el Convento rodaron por el suelo toda clase de objetos pesados y ligeros: estatuas de los altares, candeleros, armarios grandes, cuadros, damajuanas y jarras, etc., destrozándose todo. En el pueblo las casas se quedaron inclinadas. Desde que llegué á Filipinas en 1894 no había experimentado un terremoto tan violento y largo."

El Maestro Inspector de Talacogon, D. Macario Torralba, añade en una nota recibida más tarde que el terremoto derribó varios árboles grandes; y que en los terrenos inclinados plantados de abacá se produjeron muchos resbalones de extensiones ocupadas por más de quinientas matas (estas plantas suelen colocarse en hileras separadas unos 3 metros entre sí, entrando de 800 á 1,000 plantas en una hectárea): iguales y aun mayores derrumbes se ven desde Talacogon en las vecinas colinas del E. En todos los barrios visitados por dicho Inspector encontró destrozos semejantes tanto en el terreno como en las casas, éstas generalmente se cayeron en la dirección E–W. Además hace notar que á los movimientos violentos del suelo precedieron suaves vibraciones durante un rato muy apreciable y que la tierra estuvo en movimiento unos 3 minutos. También añade que, según referencias, en uno de los lagos se formaron tan inmensas olas que se precipitaron sobre las riberas y llegaron á gran distancia tierra adentro.

La Paz.—Escribe el R. P. C. Sastre, Misionero S. J., quien se hallaba navegando por el río cuando ocurrió el terremoto: "Se levantaron unas olas tan grandes y encontradas que los remeros necesitaron de toda su habilidad y esfuerzo para que no se hundiera el bote. Al poco rato llegué al pueblecito de La Paz y encontré la Iglesia y casa destechadas y con las paredes caídas, de manera que hube de albergarme en una casita particular. Muchas casitas quedaron inclinadas y malparadas y tres completamente derrumbadas. El suelo está lleno de muchas y grandes grietas. Los vecinos de este pueblo aseguran que ya el 11 se sintieron algunos temblores de tierra de poca intensidad."—Nótese que se trata de casas é Iglesia de madera, caña y nipa.

Bunauan.—De este pueblecito y de la región de los lagos y pantanos se sabe que los bancos del río y de otros canales se derrumbaron en muchas partes arrastrando en su caída árboles y otras malezas, obstruyéndose los cursos navegables de tal manera que el gobernador de la Provincia de Agusan pide autorización para un gasto de ₱500, que calcula costará el trabajo de quitar las obstrucciones de los canales navegables que desde Bunauan conducen á Clavijo y Veruela.

Veruela.—Algunas personas de este pueblo dieron al observador de Butúan los siguientes pormenores: "Estando para comer á las 12 m. d. ocurrió el terremoto con una fuerza espantosa; movíase la tierra de tal manera que las casas en sus vaivenes se quedaban completamente inclinadas, ninguna sin embargo se tumbó, siendo todas de bambú y maderos atados entre sí con bejuco. La tierra formaba ondulaciones como las olas en el agua: la perturbación de las aguas del río era imponente. Toda la gente estaba creída que el pueblo se hundiría y destruiría como sucedió en 1893. Aumentaba el espanto la tormenta de truenos y rayos que en el mismo momento se desarrollaba. El suelo quedó agrietado en todas partes; en el fondo del río se formaron en muchos sitios extensos bancos de lodo y arena, donde no hay ahora fondo suficiente ni para los pequeños botes. Durante tres días estuvo el agua del río tan cenagosa que era imposible servirse de ella para los usos domésticos, causando esto grande incomodidad. Después de este grande terremoto continuó por varios días temblando la tierra con mucha frecuencia, de tal manera que no cesaba el temor de que por fin se hundiese el pueblo. Corrieron luego rumores de que el terremoto había sido mucho más desastroso en Linatuan, donde quedaron destruídas casi todas las casas."

Butúan.—El observador de esta población, D. G. Copin, nos envía la siguiente nota: "Temblor violento oscilatorio y susultorio; notáronse las direcciones S–N, SW–NE y ESE–WNW; duró unos dos minutos. Al principio durante muchos segundos nadie hacía

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caso por ser los movimientos poco intensos y moverse poco los objetos; pero luego se sacudió de tal manera el terreno que todo el mundo se lanzó á la calle aterrorizado, durando los movimientos violentos unos 50 segundos. En las casas no quedó trasto alguno sin rodar por el suelo, casi todas quedaron con desperfectos. Aún en la Iglesia y en el Convento se cayeron algunos trozos de los tabiques de mampostería con crucetas de madera; los mayores desperfectos fueron en el lado W. Dos casas del pueblo se tumbaron hacia el N, y en una los postes ó harigues se salieron del suelo donde estaban empotrados más de un pié: esto prueba que hubo movimientos verticales. Varios objetos como cuadros, sillas, lámparas, etc., unos fueron arrojados hacia el E y otros hacia el W. Cayéronse también algunos troncos grandes de árboles ya carcomidos. Abriéronse varias grietas en dirección NE–SW. Personas que estaban lavando en el río aseguran que el agua en el primer momento se precipitó de la orilla del W á la del E, retrocediendo luego y agitándose de tal manera que un tronco grande que estaba flotando, amarrado con un grueso bejuco, rompió la amarra y fué arrastrado por el agua."

Hinatúan, Boston, Baganga, Caraga.—De estos pueblos situados todos en la costa del Pacífico, no tenemos más que las siguientes breves noticias generales enviadas de Caraga por el R. P. B. Llobera, Misionero S. J., las cuales sin embargo bastan para juzgar de la intensidad que allí tuvo el terremoto. Dice pues así: "El 12 hemos tenido un terremoto que no recuerdo haber sentido otro tan fuerte nunca: parece haber sido de circunvalación, puesto que los movimientos de las campanas y de las lámparas de la Iglesia eran circulares. El terremoto fué más fuerte hacia el N de Caraga: en Baganga abrió dos grietas juntos al embarcadero. En Boston derribó la gruesa muralla de cal y canto que formaba la fachada de la Iglesia y tenía más de dos varas de espesor. Dicen que en Hinatúan fué aún más violento, pero no tengo detalles."

Dávao.—De la población de Dávao, que se halla en la parte NW del golfo de este nombre, el observador allí estacionado dice que el terremoto fué muy fuerte; paró relojes, hizo tocar las campanas de la Iglesia y produjo espanto general, aunque sin consecuencias, principalmente á causa de su larga duración de un minuto y cinco segundos. Además, del registro trazado por un seismógrafo de pendulo se deduce que los movimientos fueron principalmente en las direcciones NNW–SSE, NNE–SSW, y ENE–WSW. Por otra parte se ha dicho en la Prensa local que en la parte NE del golfo el terremoto fué mucho más violento, causando desperfectos en las casas y abriendo grietas en la tierra. Según esto el terremoto tuvo mayor intensidad en esta región que en Caraga.

Cagayán.—Una nota de los PP. Misioneros S. J. de esta población dice: "Temblor de larga duración, si bien no muy fuerte, pues no se cayeron los objetos. La dirección del vaivén de las palmas de coco parecía ser de SSE ó S á NNW ó N. La duración fué tal que hubo tiempo de salir de las habitaciones, bajar la escalera y salir al patio y aún seguía temblando la tierra."

Nasípit y Cabarbarán.—El citado observador de Butúan añade en una segunda nota que varias personas de Nasípit y otros pueblos cercanos, de la parte NW del Agusan, le aseguraron que el terremoto fué muy fuerte y largo, pero no causó desperfectos en las casas; aunque sí extraordinario ruido no sólo en éstas sino mucho más en los bosques de los montes vecinos del W. De Cabarbarán, que está al E de la Bahía de Butúan, dicen casi lo mismo, que fué muy fuerte y largo pero sin desperfectos; los árboles oscilaban mucho y las plantas de abacá se mecían tanto, que sus hojas parecían tocar al suelo.

No nos ha sido posible conseguir datos de los pueblos situados en la costa NE de Mindanao, desde Hinatúan hasta Surigao, no obstante de haberlos solicitado. Sin embargo el hecho de no haber oído el observador de Surigao, capital de la provincia, rumor alguno de que hubiese ocurrido en ellos algo extraordinario, siendo así que en muchos hay Misioneros Europeos, siempre más atentos á esta clase de fenómenos, nos hace con

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razón deducir que el temblor tuvo allí mucho menor intensidad que en los del valle del Agusan situados en idénticos paralelos.

Todos los pueblos mencionados se hallan dentro de 150 kilómetros de distancia de la parte central ó media del valle del Agusan: fuera de esta zona tuvo ya el terremoto mucho menor intensidad, pero fué aún extraordinariamente larga su duración. En la siguiente tabla presentamos la dirección, intensidad y duración de los movimientos observados en algunas principales localidades situadas á más de 150 kilómetros: después del nombre de cada localidad ponemos su distancia y posición aproximadas con respecto al centro del valle del Agusan.

Lugar.	Distancia y posición respecto del Agusan.	Dirección observada de los movimientos.	Intensidad.	Duración.
	Kms.			*m.* *s.*
Surigao	175 N	ESE-WNW, SSW-NNE	V	1 30?
Parang (Cotabato, D.)	200 WSW		IV	
Jagna (Bohol)	230 WNW	SW-NE	IV	0 37
Maasin (Leyte)	240 NNW	SE-NW	IV	0 30
Tagbilaran (Bohol)	260 NW		IV	
Sarangani	310 SSW		IV	
Dumaguete	312 WNW		III	0 20
Cebú	320 NW	S-N	III	0 40
Guiuan (Sámar)	320 N	E-W	III	0 15
Ormoc (Leyte)	330 NNW	S-N, SSE-NNW	III	0 15
Tacloban (Leyte)	330 NNW	ENE-WSW	II	0 10
Borongan (Sámar)	380 N		II	0 20
Calbayog	440 NNW	ENE-WSW	II	0 7
Legaspi	570 ------		II	0 8

Líneas isoséismicas.—De los datos procedentes puede deducirse que la isoséismica VIII–IX encierra toda la parte central del valle del Agusan, la costa oriental de la isla, desde Baganga hasta Lianga al N de Hinatúan y, si son ciertas las noticias de la Prensa antes mencionadas, también la parte NE del Golfo de Dávao, Plancha VII. Respecto de la costa oriental, como no se indica el estado del gran muro derribado en Boston, ni la clase de terreno en que se abrieron grietas en Baganga, no se puede asegurar si realmente el terremoto tuvo allí alguna mayor intensidad; es muy posible que tuviese la misma que en el valle Agusan, la cual por los efectos mencionados consideramos comprendida entre VIII y IX. Por consiguiente el área de mayor intensidad resulta muy irregular puesto que comprende una faja á lo largo del río Agusan, que se prolonga en dirección NNW–SSE desde Butúan hasta las costas NE del Golfo de Dávao; y en segundo término toda la costa y cordillera oriental comprendida entre los paralelos de Baganga y de Lianga, zona mucho más corta que la de dentro del valle. Para explicar esta irregularidad sería preciso admitir alguna dislocación en las dos diferentes fallas mencionadas al principio; en la que corre á lo largo del Agusan y en la otra secundaria y casi perpendicular que se dirige desde el Agusan hacia la gran Fosa del Pacífico.

La razón principal que nos obliga á creer que hubo algún movimiento en dicha línea secundaria es que, según parece, el terremoto del día 12 fué perceptible en las Islas Palaos, Carolinas Occidentales (134.6° Long. E; 7.5° Lat. N) las cuales distan de las costas de Mindanao unos 900 kilómetros. Conforme á una nota recibida de los RR. PP. Misioneros, O. M. Cap., percibiéronse allí hacia las 13^h (12^h m. d. ó momentos después, tiempo del meridiano 120° E de Greenwich) oscilaciones séismicas en dirección WNW–ESE y de intensidad III, durante unos 10 segundos. Como apenas dudamos de que el temblor de Palaos corresponde al de Mindanao y Visayas, es preciso decir que entraron en acción las dos líneas de fractura mencionadas. Resta ahora investigar en cual de

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las dos se inició el movimiento. El observador de Butúan, situado en el límite N del área meizoséismica, asegura que el terremoto comenzó con movimientos débiles durante muchos segundos, de modo que la gente tuvo tiempo suficiente de darse cuenta de ellos y no hacer caso por considerarlos como debidos á un temblor de los que allí son muy frecuentes: á estos movimientos preliminares siguieron los violentos que fueron de una duración extraordinaria de 50 segundos. Semejantes indicaciones hace el de Talacogon. Esto parece indicar que el origen de los movimientos preliminares se hallaba distante de Butúan y aún de Talacogon: pudo por consiguiente originarse el movimiento en la línea del Pacífico y comunicarse luego á la del Agusan. Así se comprendería también la larga duración del terremoto. Para confirmar esto sin embargo nada puede deducirse ni de las horas dadas por los observadores de Mindanao, ni de los seismogramas de Manila. Éstos, como el terremoto fué bien perceptible hasta 340 kilómetros de distancia, hacen aparecer el origen mucho más cercano de lo que en realidad estaba. Tampoco es fácil determinarse por las direcciones de las ondas séismicas, las cuales fueron complejas en todas partes, como de ordinario sucede en todos los terremotos violentos. Así en Butúan el agua del río al principiar los movimientos violentos se precipitó hacia la ribera oriental ó sea hacia el E; las grietas principales se encontraron en dirección NE–SW; hubo vaivenes violentos en las direcciones NE–SW, ESE–WNW, y S–N, registrados por un seismógrafo de péndulo. De Caraga hacen notar que los objetos suspendidos oscilaban formando un círculo. La curva del seismógrafo de péndulo de Dávao presenta oscilaciones máximas en las direcciones NNW–SSE, NNE–SSW, y ENE–WSW, siendo las de esta última dirección las más persistentes. Si realmente existieron movimientos en ambas líneas, como parece, entonces el movimiento de la falla del Pacífico debió originarse ó por menos extenderse á gran distancia de las costas de Mindanao para poder llegar á ser perceptible en Palaos.

Las isoseismales VII y VI comprenden una zona de unos 100 kilómetros de anchura al rededor de la región meizoséismica, encerrando gran parte del N, centro, S y SE de Mindanao.

La última ó sea la de intensidad II, se extiende por el N y NW hasta el extremo SE de Luzón y las Islas de Sámar, Cebú y Negros, y atraviesa á Mindanao por el meridiano 123° E; de manera que tomando como centro la parte media del Agusan, el temblor fué perceptible por el N hasta más de 500 kilómetros de distancia y por el W hasta unos 380 solamente. Por la parte S la última estación es Sarangani, que dista solamente 310 kilómetros y estuvo comprendida dentro de la isoseismal IV. Registraron este terremoto todos los seismógrafos del mundo.

Repeticiones ó aftershocks.—Estos fueron muy numerosos toda la tarde y noche del 12 y los días siguientes 13, 14 y 15; después disminuyó mucho su número principalmente hacia el fin de Julio; pero continuaron aún siendo frecuentes durante Agosto y principios de Septiembre sin haber terminado en la fecha en que escribimos (20 de Septiembre). Más el no existir actualmente en la región Agusana y costas orientales de Mindanao más afectadas otra estación meteorológica que la de Butúan, hace que no podamos presentar una lista completa, á lo menos de las más perceptibles repeticiones. Butúan se halla en el límite N del valle á unos 50 kilómetros del centro donde probablemente concurren las dos líneas de fractura y así muchas de las menores repeticiones allí originadas no debieron ser perceptibles á tanta distancia: por consiguiente la lista de Butúan sólo representa algunas de mayor intensidad, cuyas ondas fueron perceptibles á más de 50 kilómetros. Por ejemplo, la tarde del mismo día 12 se contaron 20 aftershocks en Talacogon é innumerables en La Paz, mientras que en Butúan se registraron 8: el día 13, según una nota de La Paz fueron allí muy frecuentes lo mismo que en Talacogon, al paso que en Butúan sólo se anotaron 2, y así sucesivamente. Una nota de Bunauan del 17 dice que por aquellos días eran muy frecuentes los temblores.

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Una idea de la frecuencia con que continuaron repetiéndose en la región de Talacogon durante los meses de Julio y Agosto, puede formarse con las dos notas que añade un Misionero de Talacogon á una lista de varios aftershocks. En la primera del 27 de Julio se pregunta si tan frecuentes y casi continuos temblores de poca intensidad serán prenuncio de otro terremoto destructor; en la segunda de fines de Agosto dice que allí todavía se sienten continuos temblores. En el texto inglés damos la lista de Butúan á la cual añadimos por vía de explicación algunos principales de Talacogon, cuya hora é intensidad conocemos, así como otros vagamente anunciados.

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VOLCANIC ERUPTIONS IN THE PHILIPPINES IN RELATION TO EARTHQUAKES AND SUBTERRANEAN NOISES, TO RAINFALL AND ATMOSPHERIC PRESSURE.

I. INTRODUCTION.

The exorbitant toll of human lives levied by the recent eruption of Taal Volcano is a lesson which must not be forgotten, so much the less in view of the fact that, under similar circumstances, on a likewise recent occasion (July, 1910) not a single life was lost in Japan. We refer to the eruption of Usu-San Volcano, situated in the southwestern part of Yezo Island (140° 50′ long. E; 42° 33′ lat. N.) near Volcano Bay.

This volcano had been dormant since the year 1853. On July 21, 1910, earthquakes began to be felt in its neighborhood, which by July 23 had acquired an alarming frequency and intensity. These caused the inhabitants of the nearest five towns and villages, located around the volcano at distances ranging only between 3.3 and 8.4 kilometers, to begin on the latter date to desert the immediate vicinity of the mountain, even before the police intervened. The latter soon afterward obliged everybody to keep at a minimum distance of 12 kilometers from the volcano, despite the fact that the same showed not the least sign of extraordinary activity.

At 10 p. m. of July 25 began the explosions which, however, did not take place from the principal crater, but along the northern flank of the volcanic cone. There, at a distance of some 500 meters and about 150 meters below the summit, formed a belt of 45 new craterlets, whose activity lasted until the month of October of the same year. This belt lay only approximately 500 meters from the southern shore of Lake Toya, thickly populated in its whole extent. Some of the earthquakes which preceded and accompanied the formation of the new craters were sufficiently severe to destroy a few weak buildings constructed of wood and brick; an impetuous stream of mud, ejected from one of the new vents, flowed as far as the said lake; rocks and ashes fell likewise in abundance. The topography of the southern shore of the lake was changed completely, a new mountain was elevated, and the bottom of the lake underwent profound alterations. Still, this imposing upheaval did not cost a single life, thanks to the precautions which had been taken when the earthquake began to become frequent.[1]

These occurrences in Japan and those which we have recently witnessed in connection with the eruption of Taal Volcano, January 30, 1911, prove conclusively that some eruptions can be foreseen; a conclusion likewise stated by the eminent seismologist, Prof. F. Omori, at the end of his memoir on the Japanese eruption.[2] Hence, we believe that it will be both interesting and instructive if we let pass in rapid review the eruptions of the most noted Philippine volcanos—to wit, Taal (120° 59′ E; 14° 2′ N), Mayon (123° 39′ E; 13° 16′ N), and Camiguin (124° 42′ E; 9° 12′ N)—giving particular attention to those concerning which we possess sufficient data for studying their character and for investigating in how far they could have been foretold by means of the indica-

[1] See "Bulletin of the Imperial Earthquake Investigation Committee," Vol. V, No. 1.—Tokyo, June, 1911.

[2] Ibid., page 38.

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tions given by earthquakes, subterranean noises, and other symptoms which usually precede great volcanic paroxysms and may serve as timely warnings to escape the fury of the eruption. We will also add a few data bearing on the relation of the eruptions to rainfall and atmospheric pressure. The eruptions are mentioned in chronological order, from the most ancient known down to our own days.

II. ERUPTIONS.

1707, 1716, 1731. Taal Volcano.—Relative to these ancient eruptions of Taal there are hardly any data extant as to the manner of their beginning and still less any details concerning earthquakes and premonitory rumblings, if such preceded. The eruption of 1707 took place chiefly from the cone called Binintiang Malaqui, while those of 1716 and 1731 arose from the lake itself, to the east of the principal cone, where a series of explosions resulted in the ejection of a sufficient mass of rocks and sand to form a new islet. The first of these was coincident with violent earthquakes and "conmotions of the earth."

1749. Taal Volcano, August 11.—According to the narrative of Fr. Buencuchillo, an eyewitness of the eruption, a rather extensive glare was seen over the summit of the volcano at about 11 p. m. of that day, and the eruption began toward 3 a. m. of the following morning with loud detonations. While the eruption was at its height, there occurred strong earthquakes which opened numerous and great fissures; light earthquakes continued also to be felt during several months after the outburst: nevertheless, it would seem that none preceded the eruption. The latter lasted about three weeks, with greater or less intervals.

1754. Taal Volcano, May 15 to December 1.—Whether or not this prolonged and formidable eruption, or rather series of eruptions, was preceded by earthquakes, subterranean noises, or other signs, cannot be ascertained, though it is certain that intense shocks and strong rumblings occurred during the frequent explosions. The aforementioned Fr. Buencuchillo who witnessed also this phenomenon and left us a very detailed description of it, says that between 9 and 10 p. m. the volcano began quite unexpectedly to roar, shoot forth formidable flames, etc. But, as the ejecta of this first outburst fell back exclusively upon the island and into the lake surrounding it, the inhabitants of the near-by villages had time to flee, with the result that only 12 victims are mentioned.

1766. Mayon Volcano, July 20.—The whole summit of the cone suddenly appeared incandescent, and during six consecutive days a mighty stream of lava was seen descending the eastern slope. The report says nothing of the damage done, nor whether the outburst had been preceded by earthquakes or subterranean rumblings.

1800. Mayon Volcano, October.—Of this eruption nothing is known except that the volcano belched forth, *"as it always had been accustomed to do,"* vast quantities of rocks, sand, and ashes, which caused great damages and loss of life in the villages of Budiao and Cagsana, situated on the southern slope of the volcano.

1808. Taal Volcano, March.—Nothing is on record concerning this eruption, if we except some general statements as to its occurrence and the damage which it caused on the island and in the neighboring villages, without any particulars being given.

1814. Mayon Volcano, February 1.—This, the greatest eruption of the Albay volcano mentioned in Philippine annals, was not preceded by any premonitory signs, save some earthquakes during the preceding day. "During the 31st of January," wrote the Franciscan, Fr. Aragoneses, parish priest of Guinobatan, "We felt some slight earthquakes, but paid little attention to them as they had been very frequent in this region ever since the terrible earthquake of October, 1811. During the night the quakes increased, and at 2 in the morning (February 1) we felt one of greater force than any previously ex-

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perienced. It was repeated at 4 a. m., and from this time on the shocks were practically continuous until the eruption began."

"Tuesday dawned, and rarely ever had I seen in the Camarines a more lovely and peaceful morning or clearer sky. I noticed, however, that the hills nearest to the volcano were covered by a haze which I believed to be the smoke of some house burned during the night. Eight o'clock of that fatal morning sounded, and at that moment the volcano began suddenly to belch forth a mighty column of rocks, sand, and ashes which in an instant reached the highest heights (?) of the atmosphere. The sight was overwhelming and filled our hearts with extreme terror, especially when we became aware that the side of the mountain was being rapidly covered. Never had we seen an eruption like this! At once we became convinced that a vast torrent of fire was coming upon us to consume us; hence we took to precipitous flight." Cagsaua, where the author of the last preceding lines was staying at the time, is situated some 10 kilometers south-southeast of the volcano. Owing to the northeast wind prevailing at the time, the ejecta fell chiefly on the southern and southwestern slopes, destroying the nearest three hamlets completely and two others partly, the zone of destruction extending to a distance of more than 15 kilometers from the crater. All vegetation was ruined and over 1,200 persons were killed within the short space of barely five hours during which the fury of the mountain was at its height. The mass of solid ejecta, rocks, sand, and ashes or dust, was so enormous that even in places at a distance of 10 kilometers the layer was still about 0.40 meter deep. The detonations accompanying this outburst were heard in the remotest points of the Archipelago, and the volcanic dust was carried by the atmospheric currents as far as Manila and even more distant provinces.

According to the testimony of the aforementioned parish priest of Guinobatan, this terrific and disastrous eruption was preceded by frequent but feeble shocks which commenced 24 hours before the catastrophe, and by very frequent and violent earthquakes during the last 10 or 12 hours before it. The author says nothing of subterranean noises before the eruption, nor does he mention any earthquake after its beginning.

1853. Mayon Volcano, July 13.—It is said that this eruption was preceded by loud subterranean noises, but not by earthquakes. At about noon of the 13th an immense column of smoke and ashes was seen to rise from the volcano, while at the same time incandescent boulders came rolling down the slopes of the cone, destroying many dwellings in the adjoining fields and causing the death of 33 persons, while many more were injured. The eruption lasted only a few hours; nevertheless the immediate vicinity of the mountain was covered by a layer of ashes of considerable depth. It cannot be ascertained whether the subterranean rumblings were heard days, or only hours in advance of the outbreak and, consequently, how much time people had to flee.

Eruptions on a small scale are mentioned as having occurred in the years 1827, 1828, 1835, 1845, 1846, 1851, 1855, 1858, and 1868.

1871. Camiguin Volcano, April 30.—This volcano, situated on the small island of the same name, which lies close to the northern coast of Mindanao, had been dormant since time immemorial. There were, however, some vague rumors that on the top of the evidently volcanic northernmost mountain of the island there existed a circular lake from whose waters great masses of vapors had been seen rising on various occasions.

The year 1871 brought a change. From the middle of February until the day of the eruption the small island, but above all its northern extremity, was daily shaken by earthquakes of varying intensity. Of these four or five were of destructive violence and were felt throughout the extensive region of Mindanao and the Visayas.

Thanks to the industry to the then "gobernadorcillo" (president) of Catarman, a town situated barely a mile from the spot where the volcano burst, and to a great extent

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destroyed by the eruption, we are in possession of an almost complete catalogue of the series of shocks which preceded the outburst. We present herewith a résumé of his list, which shows that from February 16 until April 29 not a single day passed without there being felt some earthquakes, which were usually accompanied by subterranean rumblings proceeding from the interior of the near-by mountain. This latter circumstance, coupled with the extensive landslides and fissures caused on the slopes of the mountain, soon suggested to the people the idea that a volcanic eruption was imminent.

Date.	Earthquakes.	Remarks.
February 16	Two slight earthquakes	
February 17	Frequent shocks during day and night	
February 18	----do	One of intensity VIII.
February 19	----do	One of intensity VII.
February 20	----do	
February 21	----do	One of intensity IX.
February 22	----do	One of intensity VIII.
February 23 to 28	----do	
March 1 to 3	----do	
March 4	----do	One of intensity VI.
March 5 to 7	Less frequent, not more than 10 per day	
March 8	----do	Two of intensity VI.
March 9	----do	
March 10	----do	Do.
March 11 to 13	----do	
March 14 to 17	Less frequent, 4 or 5 per day	
March 18 to 19	More frequent and violent than during preceding days	
March 20 to 31	Less frequent, not exceeding 6 per day	
April 1 to 29	Frequent during the entire month; number never less than 6–10 per day.	
April 30	At 7 a. m., with a terrific detonation and a cloud of vapor, rocks, and ashes, a volcano burst on the north-northeastern end of the island, only a few meters from the shore. After this explosion, semifluid lava continued to rise peacefully during about three years, building-up a cone approximately 400 meters high. The ashes of the first explosion were carried to distances of 200 miles. Within a radius of 2 to 3 kilometers from the new crater destruction was complete. The earthquakes ceased almost completely a few days after the eruption. There was no loss of life as the people of Catarman, the town nearest to the volcano, and the only one destroyed by it, had deserted their homes long before, some having left for other islands as early as the end of February.	

1871. Mayon Volcano, December 8.—At daybreak some subterranean noises were heard and after three very strong rumblings between 7 and 8 a. m., a mighty column of smoke was seen rising from the top of the mountain. .Soon ashes, sand, and lava were noticed to issue from the crater, but the force ejecting them was not powerful. Nevertheless, the clouds of smoke and ashes, impelled by the northeast wind, covered the entire southern and southwestern slopes of the volcano, causing considerable darkness up to a distance of 20 kilometers. By 10 a. m. the sky became clear again, but at 1 p. m. occurred the principal explosion accompanied by strong detonations and vivid lightnings. A great quantity of ashes fell as far as 30 kilometers from the crater and the lava streams reached the nearest villages situated on the south and southeast sides of the mountain. Only two persons are known to have perished, the one asphyxiated, the other burned, both at a distance of about 10 kilometers southeast of the volcano. All the other inhabitants of this so-often-chastised region had evidently fled when the first symptoms of the impending eruption became manifest, which was about 8 to 10 hours before the outburst. No mention is made of earthquakes.

1872. Mayon Volcano, September.—Small flows of lava, accompanied by subterranean noises and weak explosions.

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1873. Mayon Volcano, June 15 to July 22.—Small flows of lava, accompanied by subterranean noises and weak explosions, the principal ones occurring during the night of June 20 to 21.

1874. Taal Volcano, July 19.—Explosion of gases and ashes which covered the whole island, destroying the vegetation and killing a considerable number of the cattle which was being raised on it.

1878. Taal Volcano, November 1 to 15.—During many days noises were frequently heard within the volcano; finally, from November 12 to 15 there occurred small explosions which left the whole island covered by ashes.

1881 and 1882. Mayon Volcano, July 6, 1881 to January, 1882.—This long eruptive period was characterized by a quiet flow of lava from the various openings and fissures on the southern and south-southeastern sides which form the gulches and ravines of the upper reaches of the cone. The lava issued from them in an almost solid state, in broken and loose masses, but always incandescent; there were irregular increases and decreases of activity; and during some nights very deep subterranean rumblings were heard which usually were the forerunners of a more abundant flow of lava.[1] No damage was done on the occasion of this eruption, the principal explosions of which took place on November 21st and December 14th.

1885. Mayon Volcano, November 23, 24, and December 2.—Lava flows accompanied by subterranean noises, which latter began already on the 21st. The streams of lava did not reach any of the inhabited or cultivated parts of the mountain.

1887. Mayon Volcano, February 22 to March 10.—The climax of this eruption which, with longer or shorter intervals of calm, lasted some 20 days, had been heralded ever since the eruptive period of less importance of the preceding year. In fact, since July 8, 1886, the volcano had frequently ejected small amounts of lava and ashes. The four principal explosions of the eruption of 1887 occurred on February 22 and 27 and on March 1 and 9. The volcano ejected vast quantities of lava and immense clouds which latter extended themselves to a distance of more than 20 kilometers around the volcanic cone. It would seem that only during the paroxysm of March 1 subterranean noises were heard, while no mention whatever is made of earthquakes. Already on February 22 the inhabitants of the villages on the southern flank of the mountain, whither the streams of lava threatened to take their course, had sought refuge in more secure places.

1888. Mayon Volcano, December 15; 1890, September 30, and October 1; 1891, October 3 to 18.—Three unimportant eruptions, each of which was accompanied by subterranean noises, but not by earthquakes. The most serious of them was that of 1890, when the lava streams reached the fields of the nearest villages on the east side without, however, doing very great harm. Indications of this eruption were noticeable as early as September 10, but it did not acquire its greatest intensity until the 30th of the month.

1892. Mayon Volcano, February 21 to 29.—On the 3d of February a glow or incandescence began to be noticed on the volcano and on the 9th it was discovered that a flow of lava had taken place. But the real eruption began only on the 21st, when the mountain hurled volcanic bombs to great distances and emitted a great quantity of ashes together with quite an amount of fluid lava. Thus it continued, with various intervals of calm, until the 29th. The ejecta fell mainly in the neighborhood of the crater, hence neither loss of life nor material damage resulted. The people living in the nearest villages on the eastern slopes of the immense volcanic cone had, however, taken the precaution of deserting the dangerous neighborhood. A strange circumstance of this eruption was that no subterranean noises were heard until the 24th, when the outburst reached its greatest intensity. Nothing is said of earthquakes.

1893. Mayon Volcano, October 2 to 22.—The impending eruption announced itself on

[1] See "El Mayon ó volcán de Albay," by D. Enrique Abella y Casariego, Madrid, 1885.

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October 2 and 3 by subterranean rumblings which, however, could be heard only in the villages closest to the volcano. At nightfall of the 4th a vivid glare coming from the crater was first noticed. The following day explosions were heard, an immense column of smoke and ashes began to issue and lava commenced to flow without, however, reaching as yet a great distance from the crater.

At 6 p. m. the volcano entered into full activity with intense rumblings, tremendous column of smoke and ashes, volcanic bombs, and torrents of lava streaming down the eastern and western sides. On the 8th the fury of the outburst began to relax somewhat, though the eruption lasted until the 22d. The ashes were carried to distances of 30 and 40 kilometers. The lava streams ruined many fields on the eastern side of the volcano and killed quite a number of animals found there, but no loss of human lives was to be lamented, as the people had evacuated the nearest villages during the four days which preceded the violent eruption. Two earthquakes were felt: one on the 11th, the other on the 18th while the extraordinary activity of the volcano was still continuing.

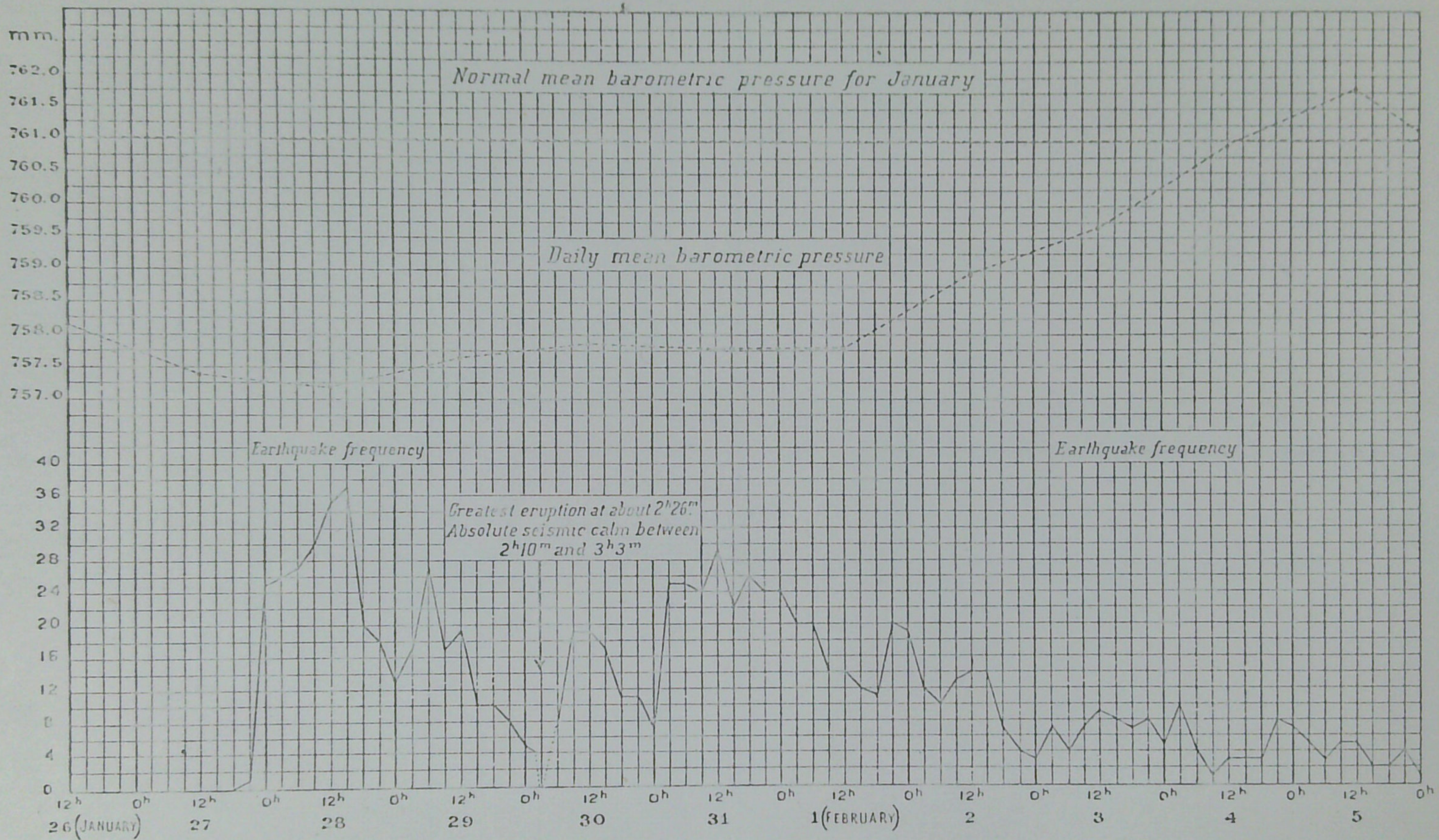
1895 and 1896. Mayon Volcano, July and September, respectively.—These were rather preliminaries of eruptions or perhaps abortive eruptions, accompanied by subterranean noises, but not by earthquakes. The volcano ejected some lava and glowing rocks, neither of which reached any great distance from the crater. The first eruption occurred on July 20, 1895, and lasted only one hour, the second lasted from August 31 to September 26, 1896.

1897. Mayon Volcano, June 25 and 26.—This eruption of flowing lava, rocks, and ashes claimed some 350 victims in five hamlets situated about 6 kilometers from the crater on the eastern slopes of the mountain. It is asserted that as early as the 22d there was observed something unusual about the activity of the volcano. At nightfall of the 23d it could be seen distinctly that glowing rocks were being ejected and that a flow of lava had taken place, accompanied by subterranean noises. At daybreak of the 24th the rumblings increased some being so intense as to cause the ground to tremble; but no real earthquake was felt. By 10 a. m. the phenomenon began to be imposing; vast clouds of vapors and ashes covered the entire neighborhood of the volcano, especially toward east, whither they were driven by the prevailing wind. The flow of lava was likewise more abundant on the eastern side, as was indicated by the fumaroles which seemed to precipitate themselves down the sides of the mountain. Thus matters went on during that whole day and the following night, June 24 to 25. At 6 a. m. of the 25th began the great eruption. Lava flowed in mighty streams down the eastern side as far as the sea, some 20 kilometers distant, sweeping before it everything which it encountered; immense clouds of vapor and ashes shrouded the entire region as if to hide the catastrophe in darkness; while all the while terrific roars reverberated which could be heard at places more than 250 kilometers from the volcano. This paroxysm lasted until the morning of the 26th, some 24 hours! The ashes were carried to a distance of 160 kilometers toward west and northwest, and much farther toward east.

The eruption was neither preceded nor accompanied by true earthquakes. There were, however during the space of 50 hours some doubtful warnings of an impending outburst, and an extraordinary increase of activity with increasing subterranean rumblings during the last 27 hours preceding the disaster. Hence, the mountain gave ample time to the people of the villages closest to the crater to avoid falling victims to the final catastrophe, but not all heeded the warnings.

1903. Taal Volcano, April.[1]—An unimportant eruption of explosive character, which probably continued until 1904. A small outlet opened within the principal crater which

[1] See "Monthly Bulletin," Philippine Weather Bureau, April, 1903.



Variation of Barometric Pressure and Earthquake Frequency during Eruption of Taal Volcano, January 30, 1911.

(Three-hour intervals)

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at intervals ejected mud and rocks to short distances. There is no doubt that the principal explosions took place during the first half of April, 1903, the fact notwithstanding that some publications assign them to April, 1904.[1]

1911. Taal Volcano, January 30.—The premonitory earthquakes began during the night of the 27th and continued, with increasing frequency and intensity, during the 28th and 29th; at the same time the volcano began to show extraordinary activity, ejecting mud and ashes during the 52 hours which elapsed between the first earthquakes and the great explosion, which latter occurred shortly after 2 a. m. of the 30th. Hence we find that this death-dealing outburst was for no less than 52 hours preceded by earthquakes, subterranean rumblings, and an increased volcanic activity; all of which was alarming enough. One should imagine that such state of affairs would have sufficed to induce every rational being to leave the neighborhood of the volcano at all cost; had it been so, possibly everyone of the 1,300 victims would have been saved! The earthquakes continued during many days after the great eruption, although already on February 1 the eruptive activity had subsided to such degree that the volcano appeared to have returned to its normal state.[2]

The Plate VIII accompanying this paper shows the frequency curve of earthquakes from January 27 to February 5, together with the atmospheric pressure during this terrible outburst of Taal Volcano. The former has been traced from the records of the following instruments: Vicentini universal seismograph, horizontal pendulums (system Omori), and Wiechert seismograph, which are mounted at Manila Observatory, 63 kilometers from the volcano. Hence, the curve comprises not only the earthquakes which were perceptible at this distance and reached degree IV, but likewise the so-called purely instrumental disturbances; that is, such as, *in Manila,* did not exceed intensity I of the scale.

III. DISCUSSION.

In the preceding paragraphs we have reviewed 21 more important eruptions, 13 of Mayon, 7 of Taal, and 1 of Camiguin. Of these only two caused the loss of a considerable number of lives—the one of Mayon in 1814, with 1,200 killed and an immense number of injured; and the most recent of Taal, in 1911, in which 1,300 perished.

At first sight the eruptions of Taal and Mayon present different characteristics: The former have without exception been of an explosive nature, without flow of lava; while the latter may be called *mixed,* as they usually consisted of initial explosions which appeared to open a path for the lava, which then issued without further violence. The eruptions of Taal have nearly always been accompanied not only by loud detonations and subterranean rumblings, but also by strong earthquakes which continued even after the eruption; those of Mayon, on the contrary, are not characterized by such commotions. Both agree, however, in one particular which is very much to our purpose: In neither volcano have the paroxysms or the maximum violence of their eruptions ever come on so suddenly that they were not, at least for some hours, preceded by ominous signs or mild eruptions. This remark applies even to the outburst of Taal in 1749. Fore, although, according to the parish priest of Sala, the disaster came as a surprise, there was nevertheless sufficient time to flee, especially as the volcano exhibited a certain

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[1] "Geological Reconnaissance of Southwestern Luzon." By George J. Adams; the Philippine Journal of Science, Vol. V, No. 2, March, 1910. "The Eruption of Taal Volcano, January 30, 1911." By Rev. Miguel Saderra Masó, S. J., Manila, 1911.

[2] For further details concerning the eruptions of Mayon and Taal volcanoes the reader is referred to the following publications: "La Erupción del Volcán Mayon, 1877." By Rev. José Coronas, S. J., Manila, 1898; and "The Eruption of Taal Volcano, January 30, 1911." By Rev. Miguel Saderra Masó, S. J., Manila, 1911.

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glow some 4 hours before the catastrophe. Only one eruption of Mayon has been heralded by earthquakes, if we take the words in their proper meaning, that is that they actually preceded the first unusual manifestations of volcanic activity. More frequently have they been announced by subterranean rumblings which on some occasions were simultaneous with an increased emission of vapors, while on others there was no indication of unwonted activity on the part of the volcano.

The one eruption of 1814 which was preceded by earthquakes, was chiefly of explosive character and took place after a period of many years during which the volcano had been dormant to such extent that even the wisp of vapors which at other times always crowns its summit, had disappeared. It would seem that the ancient vents had become obstructed with the result that the new eruption opened a passage with a violence which rent asunder the upper part of the cone and blew it to pieces. The author of the description mentioned in the earlier part of this paper says: "According to my estimate the walls of the crater of the volcano had been lowered some 20 *varas* (16.8 meters) and on the south side there was laid bare a wide and horrid chasm whose very sight was awe-inspiring. Three new vents had been opened at a considerable distance from the principal crater and continued for a long time to emit smoke and ashes." It seems plausible that the immense amount of rocks, sand, and dust which after this eruption covered the region of the volcano was largely due to the part of the cone blown to pieces by the explosions. None of the several descriptions extant mentions any flow of lava on this occasion.

The eruption of Camiguin Volcano showed special features proper to apparently extinct volcanos, in which the old outlets must have been blocked to great depths by solidified lava. Hence the prolonged and immense efforts which the lava and gases needed in order to open a new passage and which manifested themselves by two months and a half of continual earthquakes. Finally the rupture occurred, not precisely through the old crater, but at the base of the volcano, no doubt because this part offered less resistance. Something analogous happened on the Usu-San in 1910. The slight earthquakes which continued to be felt on Camiguin Island during the first days after the explosion, were probably for the most part due to the vibrations set-up by the violent escape of lava and gases.

The facts thus far adduced would seem to warrant the following conclusions:

(1) In the Philippine Islands only the eruptions of apparently extinct, or at least for a long time dormant volcanoes have been preceded by earthquakes; the great explosive eruptions have, however, been accompanied by them, but not the eruptions of lava.

(2) The intensity of the eruption has usually been in inverse proportion to its duration, if we except the long eruptive period of Taal in 1754.

(3) The earthquakes which have nearly always accompanied and followed the great eruptions of Taal cannot be ascribed to vibrations caused by the violent escape of the ejecta, but are due to geological movements in the fault-line on which the volcano is situated. This seems to follow from both, the persistence of the tremors even after the volcano has returned to its normal state, and the differences in the meizoseismic area which have been observed, the said area being some times elongated toward north-northeast, as in 1749, and at others toward south-southwest of the volcano, as in 1911. On the contrary, the weak earthquakes which occasionally have been felt during eruptions of Mayon Volcano, may well be attributed to superficial tremors of the volcanic cone itself.

(4) Both, the explosive eruptions of Taal and those of lava of Mayon, have invariably increased from a mild beginning indicated now by earthquakes, now by subterranean noises, or by both phenomena, to a maximum intensity which followed generally after a few days, and only on rare occasions already a few hours later, the shortest interval

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having been one of 4 hours. It is, therefore, not too bold to state that on all occasions the volcanoes gave sufficient time to the inhabitants of the immediate and, therefore, most endangered neighborhood, to withdraw to safer places.

IV. RAINFALL.

The eruptions of Mayon Volcano whose dates are known may be said to be 22, and they were divided among the months of the year as follows: January 1, February 3, March 1, April and May 0, June 2, July 4, August 0, September 3, October 3, November 2, December 3. Of the 8 eruptions of Taal, the month of whose occurrence is known, each took place during a different month, there remaining without one February, June, October, and December, at least if we do not take into account the many minor explosions which during the prolonged eruptive period, May to December, 1854, took place during three of these months. Hence, whether we consider the number or the intensity of the eruptions of Taal, we find hardly any difference between those which occurred in the dry season, January to May, and those of the rainy season, June to December. The eruption of Camiguin Volcano began on the last day of April. Consequently, there remain only the 22 eruptions of Mayon for a comparison with the distribution of rainfall. In the region of this volcano there are no dry and wet seasons like in other parts of the Archipelago. The monthly means of rainfall deduced from 14 years of observations which were made partly at Albay, partly at Legaspi (barely 2 kilometers from the former town) show that there are 5 months, March, April, May, June, and August, with an average amount of precipitation ranging between 147 and 220 millimeters, while the remaining 7 months have monthly means between 250 and 484 millimeters. If we ascertain the number of eruptions which correspond to each group of months, we find that 3 occurred during the former, but 19 during the latter; a result which would hardly be affected if we took into account the outbursts of Taal and the one of Camiguin Volcano: we would still have three times as many during the period of more abundant rainfall.

V. ATMOSPHERIC PRESSURE.

We have compared the mean atmospheric pressure of each eruptive period with the corresponding monthly mean and the normal mean for the month. As no earlier barometric observations exist, this investigation can cover only the eruptions which took place since 1890, which are 7 of Mayon and one of Taal, as we have to omit the eruption of the latter volcano in 1903, owing to the uncertainty of its duration. While there is no doubt that it began in April, 1903, it is not certain whether or not there was a recrudescence during the same month of 1904. We beg, however, to remark that during the first half of April, 1903, the atmospheric pressure was 0.91 millimeters in excess of the normal, while during the first half of the same month, 1904, it was exactly the same amount below.

The following table contains the various data bearing on this investigation. The first column contains the name of the volcano, the month, year, and eruptive period. The second gives the different mean values of atmospheric pressure in three subdivisions. Of these the first marked, "a," shows the normal mean pressure for the month during which the eruption occurred: in the case of Mayon Volcano, this value is derived from 12 years of observations, but from those of 26 years as regards Taal: for the former having been used the observations made at Albay, for the latter those made at Manila. The second subdivision, marked "b," gives the actual mean pressure of the month of eruption; while the third, marked "c," contains the mean pressure for the days during which each eruption was in progress. Finally, the third principal column exhibits the differences between the various values of column two.

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Eruptions and eruptive periods.	Mean atmospheric pressure.			Differences.		
	Normal. a	Monthly. b	Eruptive period. c	a-b	b-c	a-c
Mayon, September, 1890 (Sept. 10 to Oct. 4)	757.5	755.0	754.8	—2.5	—0.2	—2.7
Mayon, October, 1891 (1 to 20)	758.4	758.4	758.7	0.0	+0.3	+0.3
Mayon, February, 1892 (21 to 29)	761.7	760.2	759.0	—1.5	—1.2	—2.7
Mayon, October, 1893 (2 to 11)	758.4	758.0	756.4	—0.4	—1.6	—2.0
Mayon, July, 1895 (20)	757.9	757.8	754.7	—0.1	—3.1	—3.2
Mayon, September, 1896 (Aug. 30 to Sept. 8.)	757.5	758.0	757.3	+0.5	—0.7	+0.2
Mayon, June, 1897 (21 to 30)	757.7	757.2	756.6	—0.5	—0.6	—1.1
Taal, January, 1911 (Jan. 26 to February 5)	761.0	759.8	758.3	—1.2	—1.5	—2.7

The values shown in this table are certainly very interesting, though not conclusive, owing to the small number of cases. Not only the mean pressure for the actual period of eruption, but even the monthly mean is found to have been below the normal of the month in all except two instances. Moreover, if we assign to the various eruptions values expressing their relative intensities, it is at once evident that these and the deficiency of atmospheric pressure are in direct proportion.

The most notable eruption in this regard is the most recent, in 1911. During 31 years, that is during the period 1880 to 1911, the mean atmospheric pressure for January had been only once, in 1890, as low as in 1911; while the period of 6 days, from January 26 to 31, 1911, during which the mean pressure remained constantly between 757.2 and 758.2 millimeters, has no parallel in the records of the Observatory since 1880. Only in January of the latter year there were three days, the 6th, 7th, and 8th, whose daily average pressures were between 757.4 and 757.8 millimeters.

VI. INUNDATIONS CONNECTED WITH MAYON AND BANAHAO VOLCANOES.

Before concluding the present discussion we must say a few words on a meteorological phenomenon which is connected with some volcanoes and has formerly been attributed, in the Philippines as well as elsewhere, to real eruptions; to wit the torrents of mud, stones, and sand which during seasons of extraordinarily heavy rainfall are occasionally formed on the slopes of volcanic cones, and after the manner of avalanches overwhelm the vicinity, carrying with them death and destruction.

The earliest instance recorded in the history of Mayon Volcano occurred on October 23, 1766, having been caused by the excessively abundant rains accompanying a typhoon which passed close to the north of Albay Province. The number of victims is not stated, but must have been great, if we may judge from the havoc wrought in the villages and fields lying south of the volcano. On October 31, 1775, another typhoon brought a similar disaster to the neighborhood of the volcano, in which 1,500 persons perished.

Two occurrences of the same character are likewise recorded of the extinct volcano of Tayabas, called Banahao (121° 27′ long. E; 14° 2′ lat. N). The first of these happened in 1743.[1] The most probable explanation is, that the southern rim of the ancient

[1] Some authors place this event in the year 1730. In "Estado Geográfico, etc., de la Apostólica Provincia de S. Gregorio Magno" (Binondo [Manila], 1865) the author, Fr. Felix de Huerta, tells us on page 231, that the town of Saryaya was transferred to another site "in 1743, as the great lake had burst, into which the mentioned volcano (Banahao) had changed on the occasion of its last eruption in 1730." The same he repeats on page 232. Speaking of the church of Saryaya "which had been destroyed completely by the earthquakes of 1743," he continues: "During the same year the great lake of Banahao broke through and its waters swept away nearly the entire town," etc. May it not be, that the occurrence of 1730 which the author calls the last eruption of Banahao, was in reality a disaster similar to the one of 1743, and not a true eruption? At least we have been unable to find such eruption mentioned in any description prior to the publication of the "Estado Geográfico," etc.

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crater gave way under the pressure of the water which filled the crater and now precipitated itself in the form of an avalanche of mud and stones upon Saryaya and its surroundings, ruining everything and killing a large number of people.

Quite recently, in January, 1909, the phenomenon was repeated, though on a much smaller scale. On this occasion the cause seems to have been great slides which during the rainy months of 1908 had taken place on the borders of one of the principal ravines, which on the south side of the volcano run from the summit to the sea. As this material had completely blocked the gulch, a lake formed above it; but seepage gradually undermined the improvised dam which finally yielded with the result that an avalanche of mud and rocks swept down the mountainside and destroyed a part of the fields cultivated by the people of Saryaya.

Both occurrences, that of 1743 and that of 1909, have been announced as eruptions of Banahao; but this is an error. The same is to be said of the two similar happenings in connection with Mayon which we have mentioned and which likewise in some histories figure among the eruptions of the said volcano.

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July, 1911.

No.	Date	Character.	Instrument and Component	Beginning P h. m. s.	Beginning S h. m. s.	Beginning L h. m. s.	Maximum range of motion Hour h. m. s.	A mm.	T s.	F h. m.	Remarks.
142	1	I_d	IV. N	2 37 20		2 37 49	2 38 35	0.04	4.8	2 41	Vertical Component 0.03 m/m.
143	3	I_v	V.	0 09 57		0 10 20	0 10 32	.05	2.4	0 13	V. C. 0.02 m. m. Earthquake, III at
			H. NNW	5 49 18		5 51 50	5 53 48	.15	7.5	6 18	Nueva Caceres (SE of Luzon).
144	4	I	H. WSW	5 49 18		5 51 53	5 56 40	.46	8.4	6 26	
			W N	5 49 25		5 51 54	5 53 52	.08	7	6 22	
145	4	I_v	V.	17 42 10		17 42 36	17 42 43	.10	2.4	17 46	V. C. 0.03 m.m. Eqke., III at Baguio (NW
											of Luzon).
			V.	21 42 01	21 49 00	21 53 40	21 56 24	.02	6.8	22 37	V. C. 0.02 m.m.
			H. NNW	21 42 02	21 49 01	21 54 07	21 57 09	.11	8.1	22 32	
146	4	II_u	H. WSW	21 42 02	21 49 02	21 53 35	21 57 13	.60	8.4	22 51	
			W. N	21 42 11	21 49 10	21 53 45	21 57 06	.06	10	22 40	
			W. E	21 42 11	21 49 11	21 54 16	21 57 24	.05	10	22 38	
			V.	10 38 58		10 43 04	10 43 17	.04	7.2	11 00	V. C. 0.02 m.m.
			H. NNW	10 38 59		10 43 09	10 43 25	.40	7.5	11 02	
147	5	I_r	H. WSW	10 38 59		10 43 02	10 43 22	.48	8.4	11 10	
			W. N	10 39 03		10 43 18	10 43 32	.11	8	11 06	
			W. E	10 39 03		10 43 10	10 43 28	.09	7.2	11 06	
148	6	II_d	V.	2 44 45		2 45 14	2 46 11	1.12	2.4	3 04	V. C. 0.70 m.m.
	7	At $18^h 47^m$ Eqke., II at Lnoag (NW of Luzon).									
149	8	I_v	V.	2 07 15		2 07 43	2 07 45	.02	2.4	2 09	Eqke., III at Baguio (NW of Luzon).
150	8	I	H. WSW	9 45 45						10 10	
151	9	I_r	V.	7 25 51		7 26 30	7 26 47	.12	2.4	7 28	

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Seismological Bulletin No. 7, b.

July, 1911.

No.	Date	Character	Instrument and Component	Beginning. P	Beginning. S	Beginning. L	Maximum range of motion. Hour	Maximum range of motion. A	Maximum range of motion. T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
152	11	I_d	V.	1 10 00		1 10 20	1 16 34	.02	2.4	1 12	
			V.	5 31 29		5 38 44	5 39 19	.09	6	5 57	
153	12	I_r	H. NNW	5 31 29		5 38 44	5 39 25	.12	7.5	5 55	
			H. WSW	5 31 30		5 38 45	5 39 15	.14	7.8	6 10	
			W. N	5 31 35		5 38 48	5 39 18	.01	8.8	6 05	
			H. WSW			9 49 41	9 55 32	.06	8.4	10 12	
154	12	I	W. N.			9 49 40	9 54 24	.02	9.7	10 09	
			V.	12 09 44		12 10 54	12 12 01	1.80	2.4	14 30	V.C. 0.40 mm. Eqke., VIII-IX, Agusan
155	12	III_r	H. WSW	12 09 44		12 10 51				15 12	River Valley, eastern Mindanao.
			V.	16 03 26	16 07 06	16 10 20	16 12 25	.03	10.4	17 24	
156	12	II_r	H. NNW	16 03 26	16 06 46	16 10 46	16 13 36	.83	8.1	17 43	
			W. E	16 03 26	16 06 42	16 10 00	16 14 18	.18	9.2	17 31	
157	13	I	H. WSW			16 42 42	16 49 34	.10	12.6	17 17	
158	14	I_r	H. WSW	9 47 22		9 49 24	9 52 43	.39	9.3	10 45	Eqke., III, Agusan River Valley, aftershock.
159	16	I_d	V.	13 00 43		13 00 57	13 01 11	.36	2.4	13 06	V.C. 0.24 mm.
	18	At 1h 57m Eqke., III, Agusan River Valley, aftershock.									
			V.	18 12 11						18 42	V. C. 0.02 mm.
160	19	I	H. NNW	18 12 10						18 48	
			H. WSW	18 12 10						19 15	

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Seismological Bulletin No. 7, c. July, 1911.

No.	Date	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
161	20	II_v	V	4 22 55		4 25 13	4 29 01	.08	12		V.C. 0.01 mm. Egke., III, Agusan River Valley, aftershock.
			W. E	4 22 53		4 25 04	4 28 33	.70	8		
			V.	5 23 00		5 25 09	5 26 28	.02	11.6	6 28	V.C. 0.01 mm.
162	20	I_r	H. NNW	5 23 00		5 25 09	5 26 57	.20	10.5	6 55	
			W. N	5 23 00		5 25 00	5 27 00	.04	14	6 30	
163	21	I_v	V.	18 59 39		19 01 27	19 04 52	.02	4.8	19 32	Egke., IV, Agusan River Valley, aftershock.
			H. NNW	18 59 39		19 01 31	19 04 04	.11	7.5	19 24	
	22	At 4h 36m 11s Egke., III at Zamboanga (W of Mindanao).									
164	22	I_d	V.	8 13 47		8 14 22	8 14 56	.05	2.4	8 18	V.C. 0.03 mm.
165	22	I	H. NNW		11 13 56					11 45	
166	22	I_v	V.	13 18 55		13 20 52	13 22 10	.08	2.4	14 12	V.C. 0.02 mm. Egke., IV, Agusan River Valley, aftershock.
			W. N	13 19 00		13 20 45	13 23 08	.05	12.4	14 11	
167	22	I_d	V.	17 49 07		17 49 19	17 49 34	.03	2.4	17 52	V.C. 0.01 mm.
	25	At 12h 15m Egke., III at San Fernando Union (NW of Luzon).									
168	28	I_d	V.	10 19 35		10 19 45	10 19 53	.03	2.4	10 22	V.C. 0.02 mm.
169	28	I_d	V.	10 46 38		10 46 49	10 46 51	.05	2.4	10 50	V.C. 0.02 mm.
	30	At 18h 02m Egke., III at Baguio (NW of Luzon).									
170	30	I_r	H. NNW	19 54 42		19 57 18	19 58 05	.05	9.6	20 36	
171	30	I	H. WSW			21 52 29				22 11	
172	31	I_r	H. NNW	8 11 55		8 14 37	8 14 44	.16	7.8	8 28	

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No.	Date.	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	A	T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
			V.	8 44 19		8 50 08	8 51 01	0.01	10.8	9 21	
172	2	I_r	H. NNW	8 44 19		8 50 18	8 51 01	0.08	9.3	9 15	
			H. WSW	8 44 19		8 50 23	8 51 57	.09	9.3	9 23	
	3	Ilt 17h01m Earthquake, at Butuan (N of Mindanao).									
			V.	9 16 35		9 20 36	9 21 14	.03	6	10 06	
173	4	I	H. WSW	9 16 36		9 20 16	9 23 13	.15	9	10 33	
174	8	I	H. WSW	22 30 03						23 22	
			H. WSW	2 23 47		2 27 56	2 29 45	.21	8.1	3 04	
175	9	I_r	W. E	2 23 47		2 27 46	2 25 32	.05	6.8	2 56	
176	9	I_d	V	14 47 56		14 48 15	14 48 17	.62	2.4	14 52	Vertical Component 0.16 mm.
	10	Ilt 10h45m Eqke., II at Butuan (N of Mindanao).									
177	10	I	H. WSW		11 09 33					11 35	
178	10	I_d	V.	13 18 30		13 18 49	13 18 55	.14	2.4	13 22	V. C. 0.03 mm.
179	13	II_r	V.	13 57 30		13 57 46	13 58 21	1.30	2.4	14 24	V. C. 1.93 mm. Eqke., III at Calapan (NE of Mindoro).
180	14	I_d	V.	8 15 35		8 15 48	8 16 01	.80	1	8 20	V. C. 0.80 mm.
			V.	4 54 34		4 56 33	4 57 07	.12	2.4	5 10	Agusan Valley, eastern Mindanao.
181	15	I_r	H. NNW	4 54 39		4 56 38	4 58 43	.27	7.5	5 15	
	15	Ilt 12h03m Eqke., III in Romblon Island.									
			V.	6 45 22	6 50 07	6 53 37	6 57 15	.27	9.6	9 00	V. C. 0.21 mm. Felt in Yap, intensity V, western Carolines.
182	17	II_r	H. NNW	6 45 22	6 49 54	6 53 34	6 57 10	3.13	9	9 10	
			W. N	6 45 22	6 49 47	6 53 31	6 57 26	.18	8	9 05	

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No.	Date	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	A	T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
	17	At $10^h 33^m$ Egke., II at Butuan (N of Mindanao)									
	17	At $15^h 10^m$ Egke., III at Laoag (NW of Luzon).									
183	17	I_d	V.	15 53 40		15 54 36	15 55 28	.08	2.4	16 00	V. C. 0.03 mm.
184	18	II_v	V.	10 56 30		10 58 16	11 00 02	.29	2.4	11 57	V. C. 0.02 mm. Origin north of the
			H. WSW	10 56 30		10 58 05	10 59 30	1.47	7.8	12 17	Agusan River Valley.
	18	At $16^h 02^m$ Egke., III at Aparri (NE of Luzon).									
185	18	I_d	V.	17 29 38		17 30 33	17 30 49	.18	2.4	17 40	V. C. 0.01 mm.
186	19	II_v	V.	8 05 01		8 05 37	8 06 30	1.30	2.4	8 19	V. C. 0.20 mm. Egke. in Camarines (SE of Luzon).
187	19	I.	V.	8 25 09		8 25 43	8 25 45	.03	2.4	8 30	V. C. 0.02 mm.
188	19	I	V.	10 06 03		10 06 47	10 07 13	.15	2.4	10 11	V. C. 0.03 mm.
189	19	I	V.	12 20 52		12 21 34	12 21 36	.03	2.4	12 23	V. C. 0.01 mm.
190	20	I_v	V.	7 54 06		7 54 42	7 55 05	.06	2.4	7 58	V. C. 0.01 mm. Egke. in Camarines.
191	20	I_d	V.	13 57 20		13 57 44	13 57 47	.03	2.4	13 59	
192	20	I	V.	16 34 41		16 35 22	16 36 07	.04	2.4	16 38	V. C. 0.02 mm.
			V.	0 39 51		0 48 34	0 49 26	.42	2.4	1 26	
			H. NNW	0 39 55		0 48 37	0 50 35	.81	7.8	1 20	
193	22	II_v	H. WSW	0 39 55		0 48 38	0 49 32	2.01	7.8	1 42	
			W. N	0 39 52		0 48 36	0 49 27	.18	2.4	1 24	
			W. E	0 39 52		0 48 39	0 49 43	.39	5	1 30	
	22	At $8^h 20^m$ Egke. in Camarines.									
194	22	II	V.	9 20 58		9 21 49	9 22 34	.96	2.4	9 38	V. C. 0.18 mm.

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No.	Date	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion. Hour	A	T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
195	22	I_v	V.	12 09 18		12 10 18	12 10 25	.08	2.4	12 14	V. C. 0.01 mm. Egke., III at Virac (Catanduanes).
196	22	II_v	V.	13 32 52		13 33 28	13 34 29	1.12	2.4	13 54	V. C. 0.11 mm. Egke. in Camarines.
197	22	I	V.	14 12 28		14 13 07	14 13 18	.04	2.4	14 18	V. C. 0.01 mm.
198	22	III_v	V.	14 26 52		14 27 28	14 28 06	1.80	2.4		V. C. 1.00 mm. Egke. in Camarines (SE of Luzon).
	22	At 14h 28m Quake, II in Camarines.									
199	22	II_v	V.	14 36 10		14 37 00	14 37 32	1.60	2.4	15 28	V. C. 0.28 mm.
200	22	I_v	V.	18 35 33		18 36 16	18 36 37	.02	2.4	18 40	Egke., III at Aparri (NE of Luzon).
201	22	I	V.	19 56 30		19 57 25	19 57 49	.26	2.4	20 04	V. C. 0.05 mm.
202	23	I_v	V.	4 23 20		4 23 58	4 24 39	.06	2.4	4 27	V. C. 0.02 mm. Quake in Camarines.
	23	At 5h 46m 30s Egke., III at Butuan (N of Mindanao).									
203	23	I_d	V.	15 45 30		15 45 47	15 46 02	.04	2.4	15 49	V. C. 0.01 mm.
204	23	I_v	V.	17 12 17		17 12 52	17 13 43	.12	2.4	17 18	V. C. 0.02 mm. Quake in Camarines.
205	24	I_d	V.	3 17 60		3 18 05	3 18 07	.07	1.2	3 21	V. C. 0.05 mm.
	24	At 9h 05m Egke., II at Paracale (SE of Luzon).									
206	31	I_r	H. WSW			2 55 53				3 16	

M. Saderra M.

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SEISMOLOGICAL BULLETIN FOR SEPTEMBER, 1911.

By Rev. MIGUEL SADERRA MASÓ, S. J.,
Assistant Director of the Weather Bureau.

EARTHQUAKES FELT IN THE PHILIPPINES.[1]

1, 3h 21m. Guam (Mariana Islands). Earthquake of intensity III.

1, 8h 38m. Laoag (NW of Luzon). Oscillatory earthquake of intensity III.

2, 16h 34m 47s.* Agusan Valley (E of Mindanao). Earthquake of intensity IV and long duration, which was perceptible throughout a portion of the valley measuring over 100 kilometers in the direction N–S. At 17h 30m there was a repetition which developed force III in the central part of the valley.

3, 6h 37m. Agusan Valley (E of Mindanao). Earthquake of intensity IV. A repetition at 18h 58m showed intensity II–III in the central part of the valley.

5, 10h 8m 48s.* Western Leyte. Earthquake of force VII on the entire western coast of the island lying between parallels 11° and 10° 20′ north, and on the Camote Islands which lie west thereof at a distance of about 35 kilometers. The epicenter appears to have been between the latter islands and the western coast of Leyte.

6, 10h 14m 47s.* Agusan Valley (E of Mindanao). Earthquake of intensity V, lasting 45 seconds. It was felt throughout the entire valley.

6, 21h 20m. Sarangani (S of Mindanao). Earthquake of intensity III.

7, 20h 2m. Catbalogan (W of Samar). Earthquake of intensity III.

8, 4h 57m. Western Leyte. Oscillatory earthquake of intensity IV; duration 18 seconds. This disturbance originated beyond doubt in the same center as that of the 5th. There was a repetition having intensity III at 0h 13m of the 9th.

10, 6h 13m. Agusan Valley (E of Mindanao). Earthquake of force III which was felt only in the central region of the valley.

11, 17h 36m. Vigan (NW of Luzon). Oscillatory earthquake. Direction SE–NW, intensity II–III, duration 4 seconds.

12, 3h 5m. Western Leyte. Oscillatory earthquake of force III–IV, felt throughout a large part of the island and on the Camote Islands. Two repetitions of less intensity, one at 14h 38m and the other at 18h 57m, were perceptible only along the western coast of Leyte, between parallels 11° and 10° 20′ north.

13, 23h 35m. Romblon Island. Oscillatory earthquake. Direction SW–NE, intensity II–III, duration 2 seconds.

14, 12h 3m. Yap (Western Carolines). Earthquake of intensity III.

14, 23h 53m. Agusan Valley (E of Mindanao). Oscillatory earthquake of intensity III–IV, perceptible throughout the valley. A repetition of intensity III occurred at 0h

[1] The intensity of earthquakes is given in the notation known as the scale of De Rossi-Forel. The time is stated as indicated by the seismographs at the Central Observatory whenever the disturbance has been registered by them. This fact is denoted by an asterisk (*). Otherwise the time is that noted by the observers who sent the notice. All time indications are in the official time of the Archipelago, which is that of the one hundred and twentieth meridian east of Greenwich.

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10m of the 15th. These two shocks are doubtlessly identical with those registered by the Manila seismographs at 23h 50m 58s of the 14th and 0h 6m 19s of the 15th.

17, 16h 38m. Western Leyte. Oscillatory earthquake of force II–III, lasting 6 seconds. A repetition at 5h 30m of the 18th developed force III–IV.

18, 4h 32m. Agusan Valley (E of Mindanao). Earthquake of intensity IV and long duration, felt throughout the valley.

18, 21h 35m 40s.* Aparri (NE of Luzon). Oscillatory earthquake. Direction E–W, duration 14 seconds, intensity IV. The shocks were preceded by subterranean noises, degree II of the Davison scale. The origin of this disturbance was underneath the Pacific Ocean, to the northeast of Aparri. It was likewise registered at Taihoku at 21h 35m 48s.

20, 1h 10m. Sarangani (S of Mindanao). Earthquake of intensity III.

20, 6h 7m. Guam (Mariana Islands). Earthquake of intensity II–III and short duration.

21, 21h 57m 54s.* Samar, Leyte and northeastern Mindanao. Earthquake of intensity IV–V in central and southern Samar, northern and eastern Leyte, and of intensity III in northeastern Mindanao. Its origin lay probably near the southern coast of Samar, in the neighborhood of 125.5° longitude east and 11° latitude north. The stations of Tacloban and Guiuan which are the nearest to the epicenter, report an extraordinarily long duration; the undulations from east to west and of intensity mentioned were well marked. The disturbance has not been registered outside of the Archipelago. At 22h 43m occurred a repetition of intensity II–III.

23, 2h 19m. Southern Samar and northeastern Leyte. Earthquake of intensity II, proceeding evidently from the same center as that of the 21st.

23, 2h 57m 20s.* Agusan Valley (E of Mindanao). Earthquake of intensity V–VI, felt throughout eastern and northeastern Mindanao and on Leyte Island. To judge from the intensities experienced at Butuan, which town lies near the northern end of the valley, and at Talacogon, which is some 50 kilometers south of the former place, the epicenter lay somewhat more to the north than that of the earthquakes during July, probably between the two stations mentioned. This explains why the seismic waves were perceptible toward north as far as Leyte. No shocks have, however, been reported by the stations at Davao, Cotabato, and Cagayan (Misamis), situated toward the south, southwest, and west, respectively, though these were nearer to the origin than Tacloban on Leyte Island. Within the Agusan Valley the shocks lasted about 50 seconds; they awoke sleepers, stopped clocks, and brought down some walls which had been left in a tottering condition by the preceding earthquakes. Nevertheless, the disturbance seems to have been registered only by the seismographs of Manila, Taihoku, and, possibly, of Batavia. At 21h 49m occurred a second earthquake of force IV, having the same epicenter, but which was not perceptible outside of Mindanao.

27, 1h 50m. Jolo and Zamboanga. Earthquake of intensity III. At Jolo were observed oscillations in the direction ENE–WSW during approximately 10 seconds.

27, 21h 37m. Agusan Valley (E of Mindanao). Earthquake of intensity III, felt only in the central region of the valley.

28, 8h 0m. Sarangani (S of Mindanao). Earthquake of intensity II.

30, 1h 44m. Guam (Mariana Islands). Earthquake of intensity IV and very short duration.

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SEISMOLOGICAL BULLETIN.

RECORDS OF THE MICROSEISMOGRAPHS.

(Time of the one hundred and twentieth meridian east of Greenwich. Midnight=0.ʰ)

No.	Date.	Character.	Instrument and component.	Beginning. First preliminary tremors.	Beginning. Second preliminary tremors.	Beginning. Principal portion.	Maximum range of motion. Hour.	Maximum range of motion. Amplitude (2a).	Maximum range of motion. Period.	End.	Remarks.
				h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*mm.*	*s.*	*h. m.*	
208	1	I_d	V.	12 40 22	----------	12 40 39	12 40 43	0.09	2.4	12 43	Vertical component 0.07 mm.
209	1	I_d	V.	23 44 15	----------	23 44 32	23 45 08	.34	2.4	23 49	V. C. 0.11 mm.
210	2	I	H. WSW	----------	----------	8 01 48	----------	------	-----	8 30	
211	2	I_v	H. WSW	16 34 47	----------	16 36 37	16 38 18	.05	6	16 55	Earthquake, IV, Agusan River Valley.
212	5	I_v	V.	10 08 48	----------	10 10 08	10 13 00	.02	7.6	10 25	Eqke., VII in the western part of Leyte.
			H. WSW	10 08 48	----------	10 10 02	10 12 03	.12	9.6	10 31	
213	5	I	H. WSW	----------	17 25 03	----------	----------	------	-----	17 48	
214	6	I_v	V.	9 01 04	----------	9 06 15	9 07 02	.04	2.4	9 27	V. C. 0.01 mm.
			H. NNW	9 01 06	----------	9 06 21	9 06 27	.12	7.2	9 26	
			H. WSW	9 01 06	----------	9 06 22	9 08 21	.20	7.8	9 33	
			W. N	9 00 57	----------	9 06 07	9 07 06	.04	2.8	9 28	
			W. E	9 00 57	----------	9 06 08	9 06 17	.11	4.8	9 32	
215	6	I_v	H. WSW	10 14 47	----------	10 16 27	10 17 41	.07	8 1	10 36	Eqke., V, Agusan River Valley.
216	7	I_d	V.	6 47 09	----------	6 47 33	6 47 41	.05	2.4	6 50	V. C. 0 03 mm.
217	8	I_d	V.	18 40 55	----------	18 41 10	18 41 25	.03	2.4	18 43	V. C. 0.02 mm.
218	9	I_r	H. WSW	6 52 43	----------	----------	----------	------	-----	7 19	
219	9	I	V.	18 57 57	----------	19 02 58	19 03 04	.04	2.4	19 12	V. C. 0.04 mm.
			H. WSW	18 58 02	----------	19 02 58	19 03 13	.04	9	19 14	
220	9	I_d	V.	19 47 21	----------	19 47 40	19 47 46	.07	2.4	19 50	V. C. 0.01 mm.
221	10	I_d	V.	14 51 06	----------	14 51 24	14 51 34	.02	2	14 54	V. C. 0.01 mm.
222	11	I_d	W. E	4 24 58	----------	4 25 34	4 25 56	.01	3.6	4 27	
223	12	I_d	V.	2 35 33	----------	2 35 47	2 35 55	.02	2.4	2 38	
224	12	I_r	V.	21 03 32	21 06 41	21 10 52	21 12 26	.01	6	21 22	
			H. WSW	21 03 32	21 06 55	21 10 52	21 12 21	.05	6.9	21 30	
225	14-15	I_v	V.	23 50 58	----------	----------	----------	------	-----	0 01	Agusan Valley?
226	15	I_v	V.	0 06 19	----------	----------	----------	------	-----	0 27	Agusan Valley?
227	15	I_r	H. WSW	21 30 18	----------	----------	----------	------	-----	22 15?	
			W. E	21 30 18	----------	----------	----------	------	-----	22 12?	
228	17	I_r	V.	11 38 49	11 47 42	11 54 32	12 01 27	.01	12	12 35	
			H. NNW	11 38 45	11 47 27	11 54 40	11 59 06	.07	11.4	12 31	
229	17	I_r	H. WSW	12 43 37	----------	12 55 52	12 57 09	.14	8.7	13 33	
230	18	II_v	V.	21 35 40	----------	21 37 07	21 37 50	.84	2.4	22 07	V. C. 0.07 mm. Eqke., IV at Aparri (NE of Luzon).
			W. E	21 35 40	----------	21 36 50	21 39 25	.97	3.6	22 09	
231	20	I_d	V.	13 35 26	----------	13 35 44	13 36 04	.16	2.4	13 40	V. C. 0.07 mm.
232	21	I	V.	15 22 25	----------	----------	----------	------	-----	15 54	
			H. WSW	15 22 26	----------	----------	----------	------	-----	16 20	
233	21	I_v	V.	21 57 54	----------	21 59 12	21 59 56	.05	2.4	22 06	V. C. 0 01 mm. Samar, Leyte and NE of Mindanao.
			W. E	21 57 54	----------	21 59 00	21 59 24	.03	4	22 06	
234	22	I	W. E	13 13 30	----------	----------	----------	------	-----	13 38	
235	24	II_d	V.	6 45 18	----------	6 45 37	6 46 23	1.18	2.4	6 51	V. C. 0.99 mm.
236	24	I_d	V.	11 57 13	----------	11 57 55	11 58 09	.06	2.4	12 26	V. C. 0.01 mm.
237	25	I_v	W. E	2 57 20	----------	2 58 30	2 59 37	.05	4	3 22	Eqke., V-IV, Agusan River Valley.

Instrumental constants.—Vicentini microseismograph (V.): Length of the pendulum, 1.50 meters; weight of the bob, 100 kilograms; period of simple oscillation, 1.2 seconds. Magnification of the record, 50 times.

Horizontal pendulums (H.): Vertical distance between the point of suspension and the point of support, 1.05 meters; horizontal distance between the point of support and the center of the heavy bob, 0.77 meter; weight, 20 kilograms; period of oscillation: NNW–SSE pendulum, T=8.1 seconds; WSW–ENE pendulum, T=8.7 seconds. Magnification of the record: NNW–SSE, 15 times; WSW–ENE, 15 times.

These seismographs have no damping arrangement.

Foundation and location.—The instruments are mounted against a solid cut-stone pier measuring 5 by 5 meters at its base and 3.30 by 3.30 at the top, with a foundation about 4 meters deep, and insulated from the surrounding walls of the building by a space, 2 meters wide, filled with sand. The Vicentini microseismograph stands at a height of 9.5 meters above the ground and 10.5 above sea level, while the horizontal pendulums stand at 1.50 meters above the ground and 2.50 above sea level.

Geological structure.—The geological formation of the ground is alluvium and beach sand to a depth of some 14 meters which extends many kilometers toward north and south and only 4 to the east, where volcanic tuff outcrops. To the west there lies the Manila Bay at a distance of some 800 meters. The alluvial plain of Manila is crossed by creeks in many directions and by the Pasig River, which flows in an E–W direction, at a distance of 1.5 kilometers to the north of the Observatory.

Wiechert seismograph (W.); 1,000 kilograms; N=N–S component; E=E–W component; period 7 seconds; magnification 98; damping 4:1; 2.40 meters above sea level.

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TEMBLORES DE TIERRA SENTIDOS EN FILIPINAS.[1]

1, 3h 21m. Guam (Islas Marianas). Temblor de tierra de intensidad III.

1, 8h 38m. Laoag (NW de Luzón). Temblor oscilatorio, intensidad III.

2, 16h 34m 47s.* Valle del Agusan (E de Mindanao). Temblor de tierra de intensidad IV, larga duración. Perceptible en gran parte del Valle, en una extensión de más de 100 kilómetros en la dirección N–S. Repitió á 17h 30m con intensidad III en el centro del Valle.

3, 6h 37m. Valle del Agusan (E de Mindanao). Temblor de tierra de intensidad IV. Á 18h 58m repetición de intensidad II–III en el centro del Valle.

5, 10h 08m 48s.* W De Leyte. Temblor de tierra de intensidad VII, en toda la costa occidental, desde el paralelo 11° N al 10° 20′ N, y en las Islas Camotes que se hallan al W á unos 35 kilómetros de distancia: el epicentro parece estar entre estas islas y la costa W de Leyte.

6, 10h 14m 47s.* Valle del Agusan (E de Mindanao). Temblor de tierra de intensidad V, sentido en todo el Valle, duración 45 segundos.

6, 21h 20m. Sarangani (S de Mindanao). Temblor de tierra de intensidad III.

7, 20h 02m. Catbalogan (W de Sámar). Temblor de tierra de intensidad III.

8, 4h 57m. W De Leyte. Temblor oscilatorio de intensidad IV, duración 18 segundos. Originado sin duda en el mismo lugar que el del día 5. Repitió con intensidad III á 0h 13m del día 9.

10, 6h 13m. Valle del Agusan (E de Mindanao). Temblor de tierra de intensidad III, sentido solamente en el centro del Valle.

11, 17h 36m. Vigan (NW de Luzón). Temblor oscilatorio, dirección SE–NW, intensidad II–III, duración 4 segundos.

12, 3h 05m. W De Leyte. Temblor oscilatorio de intensidad III–IV, sentido en gran parte de la isla y en las Camotes. Repitió con menos intensidad á 14h 38m y 18h 57m: estas repeticiones fueron solamente perceptibles á lo largo de la costa occidental entre los 11° y 10° 20′ latitud N.

13, 23h 35m. Isla de Romblón. Temblor oscilatorio, dirección SW–NE, intensidad II–III, duración 2 segundos.

14, 12h 03m. Yap (Carolinas Occidentales). Temblor de tierra de intensidad III.

14, 23h 53m. Valle del Agusan (E de Mindanao). Temblor oscilatorio de intensidad III–IV sentido en todo el Valle. Repitió con intensidad III á 0h 10m del 15. Estos dos temblores son sin duda los registrados por los seismógrafos de Manila á 23h 50m 58s del 14 y á 0h 06m 19s del 15.

17, 16h 38m. W De Leyte. Temblor oscilatorio de intensidad II–III, duración 6 segundos. Repitió á 5h 30m del 18 con intensidad III–IV.

18, 4h 32m. Valle del Agusan (E de Mindanao). Temblor de tierra de intensidad IV, sentido en todo el Valle; larga duración.

18, 21h 35m 40s.* Aparri (NE de Luzón). Temblor oscilatorio, dirección E–W, intensidad IV, duración 14 segundos. Precedido de ruido subterráneo; grado II de Davison. El origen de este temblor se hallaba sin duda en el Pacífico al NE de Aparri; registróse en Taihoku á 21h 35m 48s.

20, 1h 10m. Sarangani (S de Mindanao). Temblor de tierra de intensidad III.

20, 6h 07m. Guam (Islas Marianas). Temblor de tierra de intensidad II–III, corta duración.

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[1] La intensidad de los terremotos se indica conforme á la conocida escala de Rossi-Forel. Cuanto á la hora de su ocurrencia, adoptamos la indicada por los seismógrafos de este Observatorio siempre que los hayan registrado, distinguiéndola por medio de un asterisco (*). En caso contrario copiamos la apuntada por los observadores que nos envían las notas. Todas las indicaciones del tiempo se refieren al tiempo oficial del Archipiélago que es el del meridiano 120° E de Greenwich.

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21, 21h 57m 54s.* Sámar, Leyte y NE de Mindanao. Temblor de tierra de intensidad IV–V en la parte Central y S de Sámar, N y E de Leyte; de intensidad [illegible] en el NE de Mindanao. Su origen estaba probablemente cerca de la costa S de Sámar hacia los 125.5° E y 11° N. En las estaciones de Tacloban y Guiuan que son las más próximas al epicentro, fué el terremoto de una duración extraordinariamente larga; observáronse bien ondulaciones en la dirección E–W de la intensidad antes indicada. No se registró fuera del Archipiélago. Á 22h 43m hubo una repetición de intensidad II–III.

23, 2h 19m. S de Sámar y NE de Leyte. Temblor de tierra de intensidad II, procedente sin duda del epicentro del día 21.

25, 2h 57m 20s.* Valle del Agusan (E de Mindanao). Temblor de tierra de intensidad V–VI sentido en toda la parte E y NE de Mindanao y en la isla de Leyte. Á juzgar por la intensidad que tuvo en Butúan, que está cerca del extremo N del Valle y en Talacogon, que se halla unos 50 kilómetros más al S, su epicentro se hallaba algo más al N que en los terremotos de Julio, probablemente entre las dos citadas estaciones. De aquí que sus ondas se extendiesen por el N hasta Leyte, Empero ningún report se ha recibido de Dávao, Cotabato y Cagayán, estaciones situadas al S, SW y W, á menor distancia que Tacloban, en la isla de Leyte. Dentro del Valle del Agusan duró unos 50 segundos, despertó á los dormidos, paró relojes y derrumbó algunas paredes quebrantadas por los anteriores temblores. No parece sin embargo que lo hayan registrado más que los seismógrafos de Manila, Taihoku y tal vez los de Batavia. Á 21h 49m tuvo lugar en el mismo epicentro un segundo temblor de intensidad IV; el cual no fué perceptible fuera de la isla de Mindanao.

27, 1h 50m. Joló y Zamboanga. Temblor de tierra de intensidad III. En Joló se notaron oscilaciones en dirección ENE–WSW durante unos 10 segundos.

27, 21h 37m. Valle del Agusan (E de Mindanao). Temblor de tierra de intensidad III, sentido solamente en el centro del Valle.

28, 8h 00m. Sarangani (S de Mindanao). Temblor de tierra de intensidad II.

30, 1h 44m. Guam (Islas Marianas). Temblor de tierra de intensidad IV, duración muy corta.

REGISTROS DE LOS MICROSEISMÓGRAFOS.

Véase en el texto inglés la tabla correspondiente que contiene una lista completa de estos registros.

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SEISMOLOGICAL BULLETIN FOR OCTOBER, 1911.

By Rev. MIGUEL SADERRA MASÓ, S. J.,
Assistant Director of the Weather Bureau.

EARTHQUAKES FELT IN THE PHILIPPINES.[1]

2, 1h 20m. Guam (Mariana Islands). Earthquake of intensity III.

5, 4h 21m. Tacloban (NE of Leyte). Oscillatory earthquake of intensity II and 5 seconds' duration.

6, 18h 35m 54s.* Agusan Valley (E of Mindanao). Earthquake of intensity IV, felt throughout the valley. Seismic record No. 240 (see list), corresponding to this disturbance, appears to contain likewise waves due to a much more distant center.

7, 11h 30m. Southwestern Mindanao. Earthquake of force III–IV, whose origin was in the northeastern part of the Celebes Sea, between Sarangani and Basilan. It was felt on these two islands and in a large part of Cotabato District.

8, 7h 45m. Sarangani (S of Mindanao). Earthquake of intensity III, which was repeated with the same characteristics at 12h 10m. Its origin lay in the southwestern part of Cotabato District.

9, 21h 30m. Sarangani (S of Mindanao). Earthquake of intensity IV, proceeding undoubtedly from the same center as the preceding.

12, 13h 56m. Laoag (NW of Luzon). Quake of force II–III and very short duration.

13, 5h 37m. Agusan Valley (E of Mindanao). Earthquake of intensity III–IV, felt throughout the valley. At Butuan were observed oscillations in the directions S–N and E–W, which lasted a few seconds.

13, 5h 37m 59s.* Aparri (NE of Luzon). Oscillatory earthquake. Direction E–W, intensity III, duration 10 seconds.

14, 11h 2m 30s.* Aparri (NE of Luzon). Oscillatory earthquake. Direction NE–SW, intensity IV, duration 12 seconds.

15, 23h 0m. Sarangani (S of Mindanao). Earthquake of force IV.

18, 0h 17m. Tacloban (NE of Leyte). Oscillatory earthquake. Direction NE–SW, intensity II, duration 3 seconds.

20, 22h 7m 42s.* Baler (E of Luzon). Oscillatory earthquake. Direction N–S, intensity III, duration 4 seconds. Its center appears to have been in the south of Nueva Vizcaya.

22, 12h 4m. Basilan Island (SW of Mindanao). Earthquake of intensity II.

22, 20h 45m. Guam (Mariana Islands). Earthquake of intensity III.

25, 21h 47m. Sarangani (S of Mindanao). Earthquake of intensity IV.

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[1] The intensity of earthquakes is given in the notation known as the scale of De Rossi-Forel. The time is stated as indicated by the seismographs at the Central Observatory whenever the disturbance has been registered by them. This fact is denoted by an asterisk (*). Otherwise the time is that noted by the observers who sent the notice. All time indications are in the official time of the Archipelago, which is that of the one hundred and twentieth meridian east of Greenwich.

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26, 19h 54m 11s.* Agusan Valley (E of Mindanao). Earthquake of force IV, felt throughout eastern Mindanao. Its origin appears to have been identical with that of the disturbances in July.

27, 5h 31m 51s.* Agusan Valley (E of Mindanao). This second earthquake developed greater intensity than the preceding and was felt within the same territory. Both had their epicenters in the central and southern part of the Agusan Valley, and were well perceptible along the eastern coast of the island, the Sarangani group in the south, and Cotabato District in the west. As regards the north, we have notices only from Butuan and Surigao. In the former place the disturbance was of intensity IV–V and long duration; in the latter, it had intensity II–III. At 11h 30m there was an aftershock of intensity III. In the central portion of the valley repetitions were very frequent during the night of the 26th and forenoon of the 27th. None of these earthquakes appears to have been registered outside of the Archipelago.

28, 17h 37m 56s.* Baguio (W of Luzon). Oscillatory earthquake. Direction E–W, intensity III, duration 8 seconds.

RECORDS OF THE MICROSEISMOGRAPHS.

(Time of the one hundred and twentieth meridian east of Greenwich. Midnight=0.h)

No.	Date.	Character.	Instrument and component.		Beginning. First preliminary tremors.	Beginning. Second preliminary tremors.	Beginning. Principal portion.	Maximum range of motion. Hour.	Maximum range of motion. Amplitude (2a).	Maximum range of motion. Period.	End.	Remarks.
					h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
238	5	I	V.		10 28 35	----------	----------	----------	------	------	10 38	
239	5	I	V.		14 30 45	----------	----------	----------	------	------	14 47	
240	6	I_r	V.		18 35 54	----------	----------	----------	------	------	18 54	Agusan River Valley and Antilles.
			W.	E	18 35 54	----------	----------	----------	------	------	18 55	
241	6	I_r	V.		22 31 20	----------	22 35 45	22 38 12	0.01	10	23 04	
			W.	E	22 31 21	----------	22 35 32	22 37 07	.01	8.8	23 08	
242	7	I_r	V.		12 48 45	----------	12 52 24	12 54 26	.02	9	13 26	
			H.	NNW	12 48 45	----------	12 52 04	12 55 22	.07	8.4	13 20	
			W.	E	12 48 45	----------	12 51 26	12 53 44	.01	11.2	13 23	
243	13	I_r	V.		5 37 56	----------	5 38 51	5 40 40	.07	2.4	5 52	Vertical component 0.01 mm. Earthquake, III at Aparri (NE of Luzon).
			H.	NNW	5 37 58	----------	5 39 04	5 41 21	.07	6	5 56	
			W.	E	5 38 00	----------	5 38 56	5 40 33	.05	2.8	5 50	
244	13	I_r	V.		10 41 45	10 48 12	10 54 26	----------	------	------	11 29	
			H.	NNW	10 41 45	10 47 58	10 51 03	----------	------	------	11 32	
			W.	E	10 41 45	10 48 00	10 53 34	11 02 52	.01	16.2	11 30	
245	14	I	H.	NNW	0 41 00	----------	----------	----------	------	------	0 50	
246	14	I_d	V.		7 41 08	----------	7 41 14	7 41 16	.52	2	7 44	V. C. 0.38 mm.
247	14	I_r	V.		11 02 30	----------	11 03 17	11 04 28	.06	2.4	11 15	V. C. 0.01 mm. Eqke., IV at Aparri (NE of Luzon).
248	14	I_r	V.		20 34 55	20 41 02	20 46 54	20 52 30	.01	12	21 41	
			H.	NNW	20 34 55	20 41 00	20 46 29	20 49 21	.04	8.4	21 33	
249	15	I_r	V.		7 31 41	7 37 48	7 42 09	7 43 22	.01	7.2	8 16	
			H.	NNW	7 31 41	7 38 03	7 42 13	7 43 24	.13	7.2	8 28	
250	15	I_r	V.		15 35 47	----------	15 38 23	15 40 02	.02	11.2	16 03	
			H.	NNW	15 35 47	----------	15 38 44	15 40 38	.07	7.5	16 08	
251	16	II_d	V.		13 27 27	----------	13 28 01	13 28 13	1.20	2.4	13 51	V. C. 0.42 mm.
			W.	E	13 27 24	----------	13 28 03	13 28 28	.36	4.8	13 54	
252	17	I	H.	NNW	17 26 52	----------	----------	----------	------	------	17 57	
253	17	I	W.	E	20 01 00	----------	----------	----------	------	------	20 20	
254	19	I_d	V.		4 08 39	----------	4 09 01	4 09 05	.03	2.4	4 11	V. C. 0.02 mm.
255	20	I	V.		22 07 42	----------	22 08 10	22 08 15	.18	2.4	22 13	V. C. 0.09 mm. Eqke., III at Baler (E of Luzon).
256	21	I_r	V.		1 53 02	----------	2 00 22	2 01 40	.02	9.6	2 38	V. C. 0.05 mm.
			H.	NNW	1 53 08	----------	2 00 22	2 01 08	.39	10.2	2 31	
			W.	E	1 53 00	----------	2 00 22	2 00 52	.19	6.4	2 40	
257	23	I_d	V.		0 52 00	----------	0 52 24	0 52 28	.02	2	0 54	V. C. 0.01 mm.
258	23	I_d	V.		4 01 46	----------	4 03 24	4 03 38	.24	2.4	4 10	V. C. 0.15 mm.
259	24	I_d	V.		2 09 18	----------	2 09 36	2 09 54	.26	2.4	2 13	V. C. 0.24 mm.
260	24	I_r	V.		8 17 23	----------	8 22 51	8 25 59	.01	7.6	8 51	V. C. 0.01 mm.
			H.	NNW	8 17 24	----------	8 23 01	8 24 33	.24	7.2	8 56	
261	26	I_r	H.	NNW	19 54 11	----------	19 56 12	19 58 22	.06	7.5	20 18	Eqke., IV, east Mindanao.
262	27	I_r	H.	NNW	5 31 51	----------	5 33 50	5 36 06	.05	6.6	5 52	Eqke., IV, east Mindanao.
263	28	I_r	V.		17 37 56	----------	17 38 19	17 38 37	.58	2.4	17 46	V. C. 0.28 mm. Eqke., III at Baguio (W of Luzon).
264	30	I_r	H.	NNW	21 11 02	----------	----------	----------	------	------	21 35	
265	31	I_d	V.		----------	----------	19 11 41	19 11 43	.07	2.4	19 15	V. C. 0.03 mm.

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Instrumental constants.—Vicentini microseismograph (V.): Length of the pendulum, 1.50 meters; weight of the bob, 100 kilograms; period of simple oscillation, 1.2 seconds. Magnification of the record, 50 times

Horizontal pendulums (H.): Vertical distance between the point of suspension and the point of support, 1.05 meters; horizontal distance between the point of support and the center of the heavy bob, 0.77 meter; weight, 20 kilograms; period of oscillation: NNW–SSE pendulum, T=8.4 seconds; WSW–ENE pendulum, T=8.2 seconds. Magnification of the record: NNW–SSE, 15 times; WSW–ENE, 15 times.

These seismographs have no damping arrangement.

Foundation and location.—The instruments are mounted against a solid cut-stone pier measuring 5 by 5 meters at its base and 3.30 by 3.30 at the top, with a foundation about 4 meters deep, and insulated from the surrounding walls of the building by a space, 2 meters wide, filled with sand. The Vicentini microseismograph stands at a height of 9.5 meters above the ground and 10.5 above sea level, while the horizontal pendulums stand at 1.50 meters above the ground and 2.50 above sea level.

Geological structure.—The geological formation of the ground is alluvium and beach sand to a depth of some 14 meters which extends many kilometers toward north and south and only 4 to the east, where volcanic tuff outcrops. To the west there lies the Manila Bay at a distance of some 300 meters. The alluvial plain of Manila is crossed by creeks in many directions and by the Pasig River, which flows in an E–W direction, at a distance of 1.5 kilometers to the north of the Observatory.

Wiechert seismograph (W.); 1,000 kilograms; N=N–S component; E=E–W component; period 7 seconds; magnification 98; damping 4:1; 2.40 meters above sea level.

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TEMBLORES DE TIERRA SENTIDOS EN FILIPINAS.[1]

2, 1h 20m. Guam (Islas Marianas). Temblor de tierra de intensidad III.

5, 4h 21m. Tacloban (NE de Leyte). Temblor oscilatorio, intensidad II, duración 5 segundos.

6, 18h 35m 54s.* Valle del Agusan (E de Mindanao). Temblor de tierra de intensidad IV, sentido en todo el valle. El registro seismográfico No. 240 correspondiente á este temblor parece contener ondas procedentes de un origen mucho más lejano.

7, 11h 30m. SW de Mindanao. Temblor de tierra de intensidad III–IV, cuyo origen se hallaba al NE del mar de Célebes, entre Sarangani y Basilan. Fué perceptible en estas dos islas y en gran parte del Distrito de Cotabato.

8, 7h 45m. Sarangani (S de Mindanao). Temblor de tierra de intensidad III. Repitió con los mismos caracteres á 12h 10m. El origen se hallaba en la parte SW del Distrito de Cotabato.

9, 21h 30m. Sarangani (S de Mindanao). Temblor de tierra de intensidad IV: procedente sin duda del mismo origen que los anteriores.

12, 13h 56m. Laoag (NW de Luzón). Temblor de intensidad II–III, y de muy corta duración.

13, 5h 37m. Valle del Agusan (E de Mindanao). Temblor de tierra de intensidad III–IV, sentido en todo el valle. En Butúan se notaron oscilaciones en la dirección S–N y E–W por espacio de pocos segundos.

13, 5h 37m 59s.* Aparri (NE de Luzón). Temblor oscilatorio, dirección E–W, intensidad III, duración 10 segundos.

14, 11h 02m 30s.* Aparri (NE de Luzón). Temblor oscilatorio, dirección NE–SW, intensidad IV, duración 12 segundos.

15, 23h 00m. Sarangani (S de Mindanao). Temblor de tierra de intensidad IV.

18, 0h 17m. Tacloban (NE de Leyte). Temblor oscilatorio, dirección NE–SW, intensidad II, duración 3 segundos.

20, 22h 07m 42s.* Baler (E de Luzón). Temblor oscilatorio, dirección N–S, intensidad III, duración 4 segundos. El origen de este temblor parece se hallaba hacia el S de Nueva Vizcaya.

22, 12h 04m. Basilan (SW de Mindanao). Temblor de tierra de intensidad II.

22, 20h 45m. Guam (Islas Marianas). Temblor de tierra de intensidad III.

25, 21h 47m. Sarangani (S de Mindanao). Temblor de tierra de intensidad IV.

26, 19h 54m 11s.* Valle del Agusan (E de Mindanao). Temblor de tierra de intensidad IV, sentido en toda la parte oriental de Mindanao; su epicentro parece fué el mismo de los terremotos de Julio.

27, 5h 31m 51s.* Valle del Agusan (E de Mindanao). Este segundo terremoto tuvo mayor intensidad que el del día precedente y se sintió en la misma región que aquél. Ambos tuvieron su epicentro en la parte central y Sur del valle agusano, y fueron bien perceptibles en toda la costa oriental de la isla, en el grupo de Sarangani que está al Sur, y en el Distrito de Cotabato que demora al W. De la parte N solo poseemos datos de Butúan y Surigao: en Butúan tuvo intensidad IV–V y larga duración, en Surigao intensidad II–III. A 11h 30m hubo un aftershock ó repetición de intensidad III. En el

[1] La intensidad de los terremotos se indica conforme á la conocida escala de De Rossi-Forel. Cuanto á la hora de su ocurrencia, adoptamos la indicada por los seismógrafos de este Observatorio siempre que los hayan registrado, distinguiéndola por medio de un asterisco (*). En caso contrario copiamos la apuntada por los observadores que nos envían las notas. Todas las indicaciones del tiempo se refieren al tiempo oficial del Archipiélago que es el del meridiano 120° E de Greenwich.

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centro del valle las repeticiones fueron muy frecuentes desde la noche del 26 hasta las 12 m. d. del 27. Ninguno de estos terremotos parece haberse registrado fuera del Archipiélago.

28, 17h 37m 56s.* Baguio (W de Luzón). Temblor oscilatorio, dirección E–W, intensidad III, duración 8 segundos.

REGISTROS DE LOS MICROSEISMÓGRAFOS.

Véase en el texto inglés la tabla correspondiente que contiene una lista completa de estos registros.

108693——3

International Seismological Centre

SEISMOLOGICAL BULLETIN FOR NOVEMBER, 1911.

By Rev. MIGUEL SADERRA MASÓ, S. J.,
Assistant Director of the Weather Bureau.

EARTHQUAKES FELT IN THE PHILIPPINES.[1]

2, 16h 7m. Iba (W of Luzon). Earthquake of intensity II.

5, 8h 40m. Butuan (N of Mindanao). Oscillatory and trepidatory earthquake of intensity II–III and long duration.

6, 23h 26m 56s.* Central Luzon. Earthquake of intensity V–VI, with epicenter in the northwestern part of the Province of Nueva Ecija, near 120° 50′ longitude east and 15° 45′ latitude north. A note received from Lieut. Chas. G. Dodel, Philippine Constabulary, stationed at Cuyapo, indicates that the center of disturbance can not have been very far from the said place, since there the latter was felt with greater intensity. Strong oscillations (V–VI) in the directions E–W and N–S were noticed; still, the buildings suffered no harm, but the ground showed some cracks running in the direction north to south. The epicenter appears to include some elevations which rise in the north of the extensive plain of Luzon, between the Agno and Chico Rivers. This is one of the regions in which seismic noises are heard very frequently; but there is no evidence that any severe and widely extended earthquake has ever originated within it.

The earthquake of November 6 was perceptible, with decreasing intensity, in all the adjacent provinces of central Luzon, up to distances of 150 kilometers. Nevertheless it has not been registered by any seismograph outside of the Philippines.

8, 9h 0m. Sarangani (S of Mindanao). Earthquake of intensity IV.

10, 19h 2m. Guiuan (SE of Samar). Oscillatory earthquake. Direction E–W, intensity III, duration 8 seconds.

11, 5h 45m 2s.* Tacloban (NE of Leyte). Oscillatory earthquake. Direction WNW–ESE, intensity III, duration 4 seconds.

11, 20h 49m 17s.* Aparri (NE of Luzon). Oscillatory earthquake. Direction N–S, intensity IV, duration 10 seconds.

13, 10h 0m. Sarangani (S of Mindanao). Earthquake of intensity IV.

19, 10h 12m 0s.* Sarangani (S of Mindanao). Earthquake of intensity III. Between 10h and 14h the pendulum seismograph of Butuan registered likewise a seismic disturbance of force I–II. At both stations was probably felt the same shock which was registered at Manila, and whose epicenter seems to have been in the Pacific Ocean, to the east-southeast of Mindanao.

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[1] The intensity of earthquakes is given in the notation known as the scale of De Rossi-Forel. The time is stated as indicated by the seismographs at the Central Observatory whenever the disturbance has been registered by them. This fact is denoted by an asterisk (*). Otherwise the time is that noted by the observers who sent the notice. All time indications are in the official time of the Archipelago, which is that of the one hundred and twentieth meridian east of Greenwich.

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19, 22h 50m. Guiuan (SE of Samar). Oscillatory earthquake. Direction NW–SE, intensity IV, duration 10 seconds. Its epicenter was near the southern coast of Samar, and the disturbance was likewise felt, with intensity III, at Tacloban, northeastern Leyte.

20, 2h 16m. Cuyo Island (W of Visayas). Oscillatory earthquake. Direction W–E, intensity III, duration 3 seconds.

20, 18h 1m 31s.*. Nueva Caceres (Camarines). Oscillatory earthquake. Direction NNW–SSE, intensity III, duration 7 seconds.

22, 3h 23m 35s.* Northern Luzon. Earthquake of force VI, felt in all the provinces of northernmost Luzon as far parallel 17° north, and registered by all the seismographs in the Far East. Its epicenter was at a distance of approximately 460 kilometers from Manila, probably not far from the volcanic island Camiguin, in the neighborhood of meridian 121° 40′ east and parallel 18° 50′ north. We have not yet received the observations made on the nearby Batanes Islands. From the stations closest to the epicenter in northern Luzon we have received the following notes:

Aparri (Cagayan).—A very strong earthquake (VI) of trepidatory and gyratory character and long duration. Several persons maintain that during the disturbance they saw a reddish glow in the north, in the direction in which lies Claro Babuyan.

Laoag (Ilocos Norte).—A strong earthquake (V) of gyratory character. Direction of the principal waves NNE–SSW, duration 10 seconds. The earthquake was preceded by subterranean noises (VII of the Davison scale) which seemed to come from the direction of the cordillera to the east and northeast. Both, the earthquake and the noises were perceived throughout the province, creating excitement among the people who call this kind of noise "donorodor."

Tuguegarao (Cagayan).—Trepidatory and oscillatory earthquake. Direction N–S, intensity IV, duration 12 seconds.

Vigan (Ilocos Sur).—Oscillatory earthquake. Direction NNE–SSW, intensity III–IV, duration 10 seconds.

Baguio (Benguet).—Oscillatory earthquake; direction N–S, intensity III.

25, 16h 19m. Sarangani (S of Mindanao). Earthquake of intensity III.

26, 2h 3m. Tacloban (NE of Leyte). Oscillatory earthquake. Direction WNW–ESE, intensity III, duration 5 seconds.

29, 20h 24m. Aparri (NE of Luzon). Oscillatory earthquake. Direction NNW–ESE, intensity III, duration 5 seconds.

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RECORDS OF THE MICROSEISMOGRAPHS.

(Time of the one hundred and twentieth meridian east of Greenwich. Midnight=0.ʰ)

No.	Date.	Character.	Instrument and component.	Beginning. First preliminary tremors.	Beginning. Second preliminary tremors.	Beginning. Principal portion.	Maximum range of motion. Hour.	Maximum range of motion. Amplitude (2a).	Maximum range of motion. Period.	End.	Remarks.
				h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*mm.*	*s.*	*h. m.*	
266	1	I	V.	5 25 42	----------	----------	----------	----------	----------	5 37	
267	1	I_d	V.	16 06 09	----------	16 06 27	16 07 45	0.61	2.4	16 13	Vertical component 0.42 mm.
268	2	I	V.	6 58 55	----------	----------	----------	----------	----------	7 15	
			H. NNW	6 58 59	----------	----------	----------	----------	----------	7 18	
			H. WSW	6 58 59	----------	----------	----------	----------	----------	7 16	
269	2	I_d	V.	13 35 26	----------	13 35 51	13 36 11	.14	2.4	13 40	V. C. 0.09 mm.
270	6	I	V.	3 10 49	----------	3 12 25	3 14 28	.02	6.4	3 27	
			W. N	3 10 54	----------	3 12 18	3 16 24	.04	8.2	3 25	
271	6	II_r	V.	23 26 56	----------	23 27 21	23 28 54	1.97	2	23 42	V. C. 1.25 mm. Earthquake, V-VI, central Luzon.
			W N	23 26 56	----------	23 27 20	23 28 54	.98	7.6	23 39	
272	9	I	V.	12 28 27	----------	----------	----------	----------	----------	12 56	
273	11	I_d	V.	1 51 54	----------	1 52 11	1 52 14	.20	2.4	1 55	V. C. 0.06 mm.
274	11	I_r	V.	5 45 02	----------	5 46 50	5 47 13	.04	2.4	5 56	Eqke., III at Tacloban (NE of Leyte).
275	11	I_r	V.	20 49 17	----------	20 50 14	20 51 12	.04	3.6	20 56	V. C. 0.02 mm. Eqke., IV at Aparri (NE of Luzon).
276	12	I_d	V.	----------	----------	1 30 01	1 30 04	.02	2.4	1 32	
277	14	I_s	V.	0 23 11	0 30 51	0 36 21	0 38 47	.01	15.2	1 40	
			H. NNW	0 23 11	0 30 48	0 35 35	0 40 55	.04	10.8	1 26	
			H. WSW	0 23 11	0 30 53	0 35 28	0 37 17	.04	9.3	1 24	
			W. E	0 22 52	0 30 42	0 36 30	0 37 04	.07	9.6	2 02	
278	17	I_d	V.	9 35 42	----------	9 35 54	9 36 16	.14	2.4	9 40	V. C. 0.15 mm.
279	17	I_d	V.	13 44 50	----------	13 45 01	13 45 17	.10	2.4	13 49	V. C. 0.06 mm.
280	17	I_d	V.	20 07 20	----------	20 07 32	20 07 39	.07	2.4	20 11	V. C. 0.08 mm.
281	18	I_d	V.	13 10 32	----------	13 10 43	13 11 01	.05	2.2	13 14	V. C. 0.05 mm.
282	19	I_r	V.	10 12 00	----------	----------	----------	----------	----------	10 40	V. C. 0.01 mm.
			H. WSW	10 12 00	----------	----------	----------	----------	----------	10 38	
			W. E	10 12 00	----------	----------	----------	----------	----------	10 50	
283	20	I_d	V.	----------	----------	18 00 51	18 00 53	.02	2.4	----------	V. C. 0.01 mm.
284	20	I_r	V.	18 01 31	----------	18 02 02	18 02 12	.05	2.4	18 06	V. C. 0.03 mm. Eqke., III at Nueva Caceres (SE of Luzon).
285	21	I_r	H. WSW	15 40 02	----------	15 46 30	15 47 00	.03	5.7	16 01	
286	22	II_r	V.	3 23 34	----------	3 24 24	3 24 54	1.95	2.4	4 29	V. C. 1.02 mm. Eqke., VI, northern Luzon.
			H. NNW	3 23 36	----------	3 24 27	3 25 20	2.07	7.8	3 55	
287	22	I_d	V.	22 02 04	----------	22 02 30	22 02 37	.04	2.4	22 05	V. C. 0.02 mm.
288	23	I_r	V.	7 14 38	7 18 37	7 22 04	7 22 16	.06	2.4	7 48	
			H. NNW	7 14 43	7 17 58	7 22 05	7 22 22	.33	7.5	7 47	
			H. WSW	7 14 43	7 18 14	7 22 09	7 24 06	.27	7.8	7 55	
			W. N	7 14 42	7 18 12	7 22 00	7 24 24	.08	6.4	7 57	
			W. E	7 14 42	7 18 12	7 22 04	7 22 38	.35	5.6	7 54	
289	24	I_d	V.	12 41 52	----------	12 42 03	12 43 25	.03	2.2	12 45	V. C. 0.01 mm.
290	26	I_d	V.	10 31 10	----------	10 31 24	10 31 25	.08	2.4	10 34	V. C. 0.02 mm.
291	27	I_d	V.	21 32 13	----------	21 32 19	21 32 20	.12	2.4	21 34	V. C. 0.06 mm.
292	28-29	I	V.	23 52 04	----------	----------	----------	----------	----------	0 40	
			W. E	23 51 27	----------	----------	----------	----------	----------	0 32	
293	30	I_d	V.	13 54 28	----------	13 55 00	13 55 08	.07	2.4	13 57	V. C. 0.06 mm.

Instrumental constants.—Vicentini microseismograph (V.): Length of the pendulum, 1.50 meters; weight of the bob, 100 kilograms; period of simple oscillation, 1.2 seconds. Magnification of the record, 50 times.

Horizontal pendulums (H.): Vertical distance between the point of suspension and the point of support, 1.05 meters; horizontal distance between the point of support and the center of the heavy bob, 0.77 meter; weight, 20 kilograms; period of oscillation: NNW–SSE pendulum, T=8.4 seconds; WSW–ENE pendulum, T=8.2 seconds. Magnification of the record: NNW–SSE, 15 times; WSW–ENE, 15 times.

These seismographs have no damping arrangement.

Foundation and location.—The instruments are mounted against a solid cut-stone pier measuring 5 by 5 meters at its base and 3.30 by 3.30 at the top, with a foundation about 4 meters deep, and insulated from the surrounding walls of the building by a space, 2 meters wide, filled with sand. The Vicentini microseismograph stands at a height of 9.5 meters above the ground and 10.5 above sea level, while the horizontal pendulums stand at 1.50 meters above the ground and 2.50 above sea level.

Geological structure.—The geological formation of the ground is alluvium and beach sand to a depth of some 14 meters which extends many kilometers toward north and south and only 4 to the east, where volcanic tuff outcrops. To the west there lies the Manila Bay at a distance of some 300 meters. The alluvial plain of Manila is crossed by creeks in many directions and by the Pasig River, which flows in an E–W direction, at a distance of 1.5 kilometers to the north of the Observatory.

Wiechert seismograph (W.); 1,000 kilograms; N=N–S component; E=E–W component; period 7 seconds; magnification 98; damping 4:1; 2.40 meters above sea level.

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TEMBLORES DE TIERRA SENTIDOS EN FILIPINAS.[1]

2, 16h 7m. Iba (W de Luzón). Temblor de tierra de intensidad II.

5, 8h 40m. Butuan (N de Mindanao). Temblor de tierra oscilatorio y susultorio; intensidad II–III, larga duración.

6, 23h 26m 56s.* Centro de Luzón. Temblor de tierra de intensidad V–VI. Su epicentro se hallaba en la parte NW de la Provincia de Nueva Écija, hacia los 120° 50′ long. E y 15° 45′ lat. N. Una nota del Teniente de Constabularios, Mr. Chas. G. Dodel, estacionado en Cuyapó, indica que el origen no debía estar muy lejos de dicha población, por ser donde se sintió con mayor intensidad. Observáronse oscilaciones fuertes (V–VI) en la dirección E–W y N–S. No sufrieron daño los edificios, pero se vieron en el terreno algunas grietas en la dirección N–S. El epicentro parece comprender unas lomas que se levantan al N de la extensa llanura de Luzón entre el río Agno y el Chico. Es una región donde se oyen con mucha frecuencia ruídos séismicos, pero no consta se haya originado en ella ningún terremoto de grande intensidad y extensión.

El temblor del 6 fué perceptible con decreciente intensidad en todas las provincias circunvecinas del centro de Luzón hasta unos 150 kilómetros de distancia. No lo registraron sin embargo los seismógrafos de fuera de Filipinas.

8, 9h 0m. Sarangani (S de Mindanao). Temblor de tierra de intensidad IV.

10, 19h 2m. Guiuan (SE de Samar). Temblor oscilatorio. Dirección E–W, intensidad III, duración 8 segundos.

11, 5h 45m 2s.* Tacloban (NE de Leyte). Temblor oscilatorio. Dirección WNW–ESE, intensidad III, duración 4 segundos.

11, 20h 49m 17s.* Aparri (NE de Luzón). Temblor oscilatorio. Dirección N–S, intensidad IV, duración 10 segundos.

13, 10h 0m. Sarangani (S de Mindanao). Temblor de tierra de intensidad IV.

19, 10h 12m 0s.* Sarangani (S de Mindanao). Temblor de tierra de intensidad III. Entre 10h y 14h registró también el seismógrafo de péndulo de Butuan un temblor de tierra de intensidad I–II. Probablemente en ambas estaciones se sintió el mismo séismo registrado en Manila, y cuyo epicentro se hallaba al parecer en el Océano Pacífico al ESE de Mindanao.

19, 22h 50m. Guiuan (SE de Samar). Temblor oscilatorio. Dirección NW–SE, intensidad IV, duración 10 segundos. Su epicentro se hallaba cerca de la costa S de Samar y fué también sentido con intensidad III en Tacloban (NE de Leyte).

20, 2h 16m. Isla de Cuyo (W de Visayas). Temblor oscilatorio. Dirección W–E, intensidad III, duración 3 segundos.

20, 18h 1m 31s.* Nueva Cáceres (Camarines). Temblor oscilatorio. Dirección NNW–SSE, intensidad III, duración 7 segundos.

22, 3h 23m 35s.* N de Luzón. Temblor de tierra de intensidad VI, sentido en todas las provincias del extremo N de Luzón hasta el paralelo 17° lat. N, y registrado por todos los seismógrafos del Extremo Oriente. Su epicentro se hallaba á unos 460 kilómetros distante de Manila, probablemente no lejos de la isla volcánica de Camiguín, hacia el meridiano 121° 40′ E y el paralelo 18° 50′ N. No han llegado aún los datos de las vecinas islas Batanes. De las estaciones del N de Luzón más próximas al epicentro se recibieron las siguientes notas:

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[1] La intensidad de los terremotos se indica conforme á la conocida escala de De Rossi-Forel. Cuanto á la hora de su ocurrencia, adoptamos la indicada por los seismógrafos de este Observatorio siempre que los hayan registrado, distinguiéndola por medio de un asterisco (*). En caso contrario copiamos la apuntada por los observadores que nos envían las notas. Todas las indicaciones del tiempo se refieren al tiempo oficial del Archipiélago que es el del meridiano 120 E de Greenwich.

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Aparri (*Cagayán*).—Temblor susultorio y rotatorio muy fuerte (VI), duración larga. Varias personas aseguran haber visto durante el temblor un resplandor rojizo hacia el N, en la dirección de Claro Babuyan.

Laoag (*Ilocos Norte*).—Temblor fuerte (V), de caracter rotatorio; dirección de las ondas principales NNE–SSW, duración 10 segundos. Precedió al temblor ruido subterraneo (VII de escala Davison) que parecía proceder de la cordillera que está al E y NE. Tanto el temblor como el ruido fueron sentidos en toda la provincia, con extrañeza de la gente, que llama á semejante ruido con el nombre de "Donorodor."

Tuguegarao (*Cagayán*).—Temblor susultorio y oscilatorio. Dirrección N–S, intensidad IV, duración 12 segundos.

Vigan (*Ilocos Sur*).—Temblor oscilatorio. Dirección NNE–SSW, intensidad III–IV, duración 10 segundos.

Baguio (*Benguet*).—Temblor oscilatorio; dirección N–S, intensidad III.

25, 16^h 19^m. Sarangani (S de Mindanao). Temblor de tierra de intensidad III.

26, 2^h 3^m. Tacloban (NE de Leyte). Temblor oscilatorio. Dirección WNW–ESE, intensidad III, duración 5 segundos.

29, 20^h 24^m. Aparri (NE de Luzón). Temblor oscilatorio. Dirección NNW–SSE, intensidad IV, duración 6 segundos.

REGISTROS DE LOS MICROSEISMÓGRAFOS.

Véase en el texto inglés la tabla correspondiente que contiene una lista completa de estos registros.

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SEISMOTECTONIC LINES IN SOUTHERN LUZON.

In preceding papers an attempt has been made to determine the location of various seismic foci or epicenters in the Philippines, viz, those of the Batanes Islands and northern Luzon, of western Mindanao, of eastern Mindanao, the Visayas, and of the Camarines. At the same time was given a résumé of the most recent data concerning the physiography and geology of the respective regions. The present paper will treat of the epicenters (taking the word in the wider sense in which it is used at present) which chiefly affect Manila and the neighboring provinces. But instead of locating and describing each individual center independently of any connection which may exist between them, as was done hitherto, we will endeavor to determine the principal seismotectonic or fracture lines which seem to intersect in southern Luzon, and in which originate the more violent earthquakes which from time to time shake this region.

In order to determine these lines, we have gone over not only the documents on which is based the Earthquake Catalogue [1] published some time ago, but likewise the lists of less severe disturbances given in the "Monthly Bulletin of the Weather Bureau" and in "La Seismología en Filipinas" (Manila, 1895).

Three principal seismotectonic lines are found in southern Luzon. One of these runs from Balayan Bay in an approximately SSW–NNE direction through Taal Volcano, passes west of Talim Island (Lake Bay), and out into the Pacific Ocean at a point of the eastern coast of Luzon to the east-northeast of Manila. This line of fracture we shall designate as the *Taal-Volcano Line*. The second line appears to start from the extreme northwest of Mindoro and follows a SSE–NNW course underneath the China Sea, at a short distance from the coasts of Cavite and Zambales provinces. To it we give the name of the *Southwestern Line*. A third fracture line follows the eastern coast of Luzon in an approximate N–S direction from Baler Bay [2] southward, crossing the isthmus of Atimonan and, probably, passing west of Marinduque, Romblon and Panay Islands, extends as far as the Sulu Sea. This line we call the *Eastern Line*.

The location of these lines is shown on the accompanying map (Plate XV). In describing them we shall dwell chiefly on the Taal-Volcano Line, since it is a greater menace to Manila than the others. Aside from the seismotectonic lines mentioned there are several seismic centers of less importance within the volcanic region of southern Luzon, which occasionally give rise to earthquakes of volcanic character.

The Taal-Volcano Line.—During the great eruptions of Taal Volcano it has been noticed that the earthquakes accompanying them had their maximum intensity not merely on Volcano Island itself, but likewise within an adjacent zone which sometimes extended to the south-southwest, toward Balayan Bay, and at others toward north-northeast, as far as Lake Bay. Thus, for instance, during the eruption of 1749, the earthquakes displayed their energy in the entire zone to the north-northeast of the volcano—that is, in the region lying between lakes Bombon and Bay, throughout which they produced large fissures and extensive subsidences. On the contrary, in the recent outburst of

[1] Catalogue of Violent and Destructive Earthquakes in the Philippines, Manila, 1910.

[2] In default of a proper name, we designate by the name of Baler Bay the large indentation of the coast line between Point Inaguican and Cape San Ildefonso.

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1911, the region which suffered most from them, lay to the south-southwest of Taal, between Lake Bombon and Balayan Bay. These facts, together with the physiographic and geological aspects of the region in question, suggested to Messrs. Adams and Pratt, geologists of the division of mines, Bureau of Science, the idea, that the line of fracture on which rises Taal Volcano, starts from Balayan Bay and, running in an approximately SSW–NNE direction, passes through the depression in which flows the Pansipit River, the volcano, thence through the eastern slopes of Pico Gonzalez, and the western part of Lake Bay.[1] The prolongation of this line toward south-southwest would run almost parallel to the northwestern coast of Palawan Island, toward Balabac Strait and northeastern Borneo. Its prolongation toward north-northeast, after entering Lake Bay, passes through the narrows between Talim Island and the peninsula of Antipolo, then crosses the Eastern Cordillera of Luzon, the former district of Infanta (now part of Tayabas Province), and enters the Pacific Ocean through Baler Bay, continuing parallel to the southeastern coasts of Principe (likewise belonging to Tayabas) and Isabela Province. The existence of this fault line extending from the region to the south-southwest of Taal to the Pacific Ocean is suggested by the appearance of the territory and its physiographic conditions as well as by the meagre geological data concerning it which are available. It appears to be further confirmed by the situation of the principal seismic centers in southern Luzon, as will be seen anon.

The region south-southwest of Taal Volcano, between the latter and Balayan Bay, consists of the valley or depression in which flows the Pansipit River, the only outlet of Lake Bombon. The subsoil of this depression is formed by volcanic tuff and basaltic rocks, except the bed and mouth of the river, where alluvium has been deposited. Geologists do not agree whether or not this opening formerly was an arm of the sea, which communicated with Lake Bombon, but was gradually cut off and filled up by volcanic products. Mr. Adams prefers to ascribe its formation to the Pansipit River. The earthquakes incident to the most recent eruption (1911) opened a great number of fissures in this depression, all of which ran in the direction SSW–NNE. Their lengths varied between 1 and 7 kilometers. In two of them, one on either side of the valley, the edge of the fissure lying toward the latter was found to be over 1 meter lower than the up-hill edge. These fissures opened mainly in the bottom of the valley, only two occurring on its slopes, one on the eastern, the other on the western slope.[2]

Some geysers likewise stimulated to renewed activity, and mud cones formed near the coast, but within the fissured zone, in a locality where hot springs exist which appear and disappear at long and irregular intervals.

Wherefore, the existence of a line of fracture running through the Pansipit Valley from Taal Volcano to Balayan Bay seems to be established beyond doubt.

We now come to the prolongation of this line toward north-northeast of the said volcano. Its continuation through the relatively low zone which separates Lake Bombon from Lake Bay is demonstrated by the following facts: (1) Historians tell us that the fissures and subsidences produced on the occasion of the volcanic eruption in 1749 ran in a north-northeasterly direction from one lake to the other. (2) During the eruption of 1911, a fissure opened in the same region, which could be followed for a distance of 3 kilometers in the same direction. (3) In his recent geological reconnaissance of southwestern Luzon Mr. Adams came to the conclusion that the eastern side of Pico Gonzalez is in reality the western, elevated scarp of a geological fracture; the eastern edge lying buried underneath the tuff formation which covers the entire region. Hence, there can

[1] Geological Reconnaissance of Southwestern Luzon. By G. I. Adams. Philippine Journal of Science, Vol. V, No. 2. The Eruption of Taal Volcano, January 30, 1911. By W. E. Pratt. Ibid., Vol. VI, No. 2.

[2] W. E. Pratt, loc. cit.

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be no doubt that an important fault line running toward north-northeast exists in the region lying between Lakes Bombon and Bay. The configuration of this region seems likewise to confirm this conclusion: the territory appears in the main as a wide valley between Mount Gonzalez and the outermost western spurs of Mount Maquiling, in which are found several secondary cones pertaining to this volcanic group.

On leaving this zone, the fault crosses the western part of Lake Bay, passing between Talim Island and the southern extremity of the Antipolo peninsula or range. The south point of the latter and the north end of Talim are not exactly opposite each other; the former appears displaced toward west and advances toward south, while the latter lies east and protrudes northward. Hence, the narrow passage between them runs approximately from SSW to NNE, as if indicating that it owes its origin to a fault line having the same direction. This line then enters the valley of Morong which on the western, Antipolo sides, is bounded by very steep inclines, and finally crosses the Eastern Cordillera, reaching the Pacific coast north of Infanta.

The region of the Eastern Cordillera which is traversed by the supposed seismotectonic line, shows a very complicated and confused topography and hydrography, making it difficult to decide which of the many towering peaks, whose trend is frequently opposite, really constitute the cordillera. The principal water courses are especially remarkable on account of their irregular and abruptly changing directions. Thus the Agos River, which empties into the Pacific Ocean north of Infanta, traverses nearly the whole cordillera and reaches the coast flowing northeastward, while its own source as well as those of its principal tributaries, viz, the Lenatin and Limutan, lie to the northwest. The course of this river thus forms a V in whose opening lies one of the highest mountains of the range. Something similar happens to the Bosoboso River, which flows first northward, then turns sharply toward west, and finally toward south. It is very probable that a geological reconnaissance of this region will disclose proofs of great geological upheavals which at present we can only suspect on the strength of its evident topographical irregularities.

Once within the Pacific Ocean, the line runs diagonally across Baler Bay and then close to the coasts of Casiguran which, like the Eastern Cordillera or Sierra Madre, have the orientation SSW–NNE.

Of the seismic data which tend to confirm not only the existence of a fault line to the south-southwest and north-northeast of Taal Volcano, but likewise its assumed prolongation across the Eastern Cordillera and underneath the Pacific Ocean, we will mention only the most important. The following earthquakes which were accompanied by dislocations both, to the north-northeast and south-southwest of Taal Volcano, and, hence, along a large part of the fracture line, probably originated in the fault just described: 1645, 1658, 1716, 1728, 1749, 1754, 1771, and 1873. In our Earthquake Catalogue they bear the following ordinal numbers: 12, 17, 23, 24, 27, 28, 33, and 91. The earthquakes of 1675, 1852, 1869, 1877, 1889, and 1901 (Nos. 19, 51, 70, 104, 144, and 181 of the catalogue) had their origin evidently south-southwest of the volcano, between the latter and Mindoro Island—that is to say, in the south-southwestern end of the line of fracture. Within the portion lying to the north-northeast of Taal, viz, from Lake Bay to the Pacific Ocean, originated the following earthquakes: 1824 (two), 1862 (two), 1863, 1874 (two), 1880 (two), which bear the catalogue numbers 43, 44, 56, 58, 59, 98, 100, 116, and 117. All of this class of earthquakes had their meizoseismic areas in the Eastern Cordillera and its spurs, to the east and east-northeast of Manila, except No. 117 which was confined to the southwestern part of Lake Bay and its shores.

Hence, we may safely affirm that all the earthquakes which have caused notable damage to the city of Manila had their origin toward the east or east-northeast, where

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there passes the seismotectonic line under discussion. The most disastrous of these, the one in 1645, seems to have been due to simultaneous dislocations in the said line and in the Eastern Line, which latter, as we shall see presently, starting from the region of the Batanes and Babuyanes Islands, probably passes southward through Cagayan and Isabela Provinces, and intersects the Taal-Volcano Line underneath Baler Bay.

Of the earthquake of 1863 it is practically certain that its epicenter lay in the Eastern Cordillera, to the east-northeast of Manila, and as late as 1880 Señor Centeno found still very vivid recollections of it among the inhabitants of Infanta District.

As regards the earthquakes in July, 1880, which have been studied best by Señor D. A. Centeno, "Ingeniero de Minas," it is evident that two of them must have originated in the same fault line—the one to the east, the other to the east-northeast of Manila—at least, this is the conclusion to which leads the study of the isoseismal curves drawn by the said engineer. Of the three ellipses which represent the meizoseismic areas of the three earthquakes, two are indeed intersected by the fracture line in approximately the direction of their minor axes; but in both cases the anomaly can be explained by the fact that the ground toward west and northwest from the center consisted of alluvium, in which naturally enough the seismic waves developed greater violence than along the mountain range.

The preceding data establish beyond doubt the existence of one or several seismic foci in the Eastern Cordillera to the east and east-northeast of Manila, which are responsible for the shocks which most affect the capital. Less evident it is, that these foci are on a line of fracture which has the same direction as, and is in fact the continuation of, the one which runs from Lake Bay across Taal Volcano to Balayan Bay, since there is question of a region entirely unexplored by geologists. Still the existence of such fracture line is very probable, especially if we remember that one of the principal systems of tectonic lines of the Archipelago follows approximately the same SSW–NNE direction.

The seismicity of the zone extending from Balayan Bay to Baler Bay along the Taal-Volcano Line, is among the highest to be found in the Archipelago. Besides the great earthquakes mentioned, no less than 115 disturbances of less intensity (IV–V) have been recorded as originated in it during the last twenty-five years. Of this number the greater part belongs, however, to the region between Lake Bay and Balayan Bay, as not a single seismic station exists, either within the cordillera, or on the Pacific coast, in sufficient proximity to the seismotectonic line. Consequently, of the earthquakes which had their centers in the east-northeast, only such are on record as were of great extension and sufficiently strong to be perceptible in Manila, Santa Cruz (Laguna), and Baler.

The existence and probable extent of the seismotectonic line of Taal Volcano being established, it follows that this line must be the most dangerous to Manila. But not all the disturbances originating in it affect the capital in the same way. Those which have their epicenter between Lake Bay and Balayan Bay, are characterized by relatively long duration and rather slow undulations which latter, however, are of large amplitude, as we have pointed out on many occasions. But those which proceed from the northeastern part of the line are of a dangerous nature, owing to the rapidity of the movements and the apparent changes in their direction, which latter are undoubtedly the result of various, separate trains of seismic waves. Hence, though distance and intensity be the same, the latter class of earthquakes makes a much greater impression than those whose origin lies in the southwestern part of the fault line.

Guided by the experience which he has gathered as well as by the data furnished by historical accounts, the writer has repeatedly pointed out that part of the Eastern Cordillera which lies to the east and east-northeast of Manila as the region in which

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originate the earthquakes most dangerous to the capital of the Archipelago. The first time when he ventured to express this idea was in 1895, when he investigated the prevailing directions of 211 seismic disturbances which had been recorded at the Manila Observatory since 1869.[1]

The Southwestern Line.—This seismotectonic line appears to start near northwestern Mindoro, between Cape Santiago and the Lubang Islands, and runs almost parallel to the southwestern coast of Luzon as far as the latitude of Cape Bolinao. It is quite probable that it follows the irregular submarine scarp which exists off the coasts of Cavite and Zambales Provinces and close to them, where the soundings suddenly increase from less than 250 to more than 2,000 meters.

As having had their origin in the Southwestern Line, between the Lubang Islands and Cape Bolinao, we find in the Earthquake Catalogue the following earthquakes: 1852, 1872 (two), 1878, 1880, 1902, a total of six, whose intensities varied between degrees VI and IX of the De Rossi-Forel scale. In the catalogue they bear the numbers 49, 84, 90, 107, 118, and 185. The greater part of these disturbances were felt with equal intensity along the coasts and within the provinces of Cavite as well as of Bataan and Zambales. The earthquake of 1872, No. 84, alone appears to have had a very small meizoseismic area. The number of less severe shocks found in the lists covering the period 1880–1911 is 59, account being taken only of those whose extension and intensity were of sufficient magnitude to allow of approximately determining the center of disturbance.

The Eastern Line.—In addition to the two lines discussed thus far, there appears to exist a third which possibly traverses the entire Archipelago, near the one hundred and twenty-second meridian east, from the Batanes Islands to the west of Mindanao.[2] To the northeast of Manila it crosses the Taal-Volcano Line underneath Baler Bay, and continues southward between the eastern coast of Luzon and Polillo Island, and crosses the isthmus of Atimonan, passing east-southeast of Banahao Volcano and in the direction of the west-end of Marinduque Island.

The visible, geographical characteristics of this line, as far as it lies in southern Luzon, are certainly remarkable. After crossing the Taal-Volcano Line, this fault passes very close to the northwestern extremity of the deep marine through which skirts the coasts of Mindanao, the Visayas, and southeastern Luzon. Then it passes through the strait which separates the small island of Polillo from the coast of Luzon, in the direction toward Lamon Bay and the isthmus of Atimonan. This entire region is remarkable for the abrupt changes in the directions of the tectonic lines: on the said isthmus, the Eastern Cordillera appears as if it had been suddenly twisted westward; while Polillo Island as well as some smaller islands in Lamon Bay preserve a SE–NW direction, which is more in harmony with the tectonic lines of the Camarines. The whole area occupied by Lamon and Baler Bays looks like a discontinuation or break in the general tectonic lines which would sweep in an immense arc, first in the direction SE–NW, and then S–N, from the Camarines to the northeastern end of Luzon: thus giving the impression that the great indentation east of Luzon formed by these two bays, has some connection with the vast and progressive subsidence which resulted in the formation of the great trough mentioned. The latter is possibly still deepening, as would seem to be indicated by the frequent earthquakes along its entire western slope and near its northwesternmost portion which ends in Baler Bay.

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[1] "La Seismología en Filipinas," pp. 107 and 108. "Report on the Seismic and Volcanic Centers of the Philippine Archipelago," p. 25. "Volcanoes and Seismic Centers of the Philippine Archipelago," p. 77.

[2] Contributions to the Physiography of the Philippine Islands. By H. G. Ferguson (division of mines, Bureau of Science). Earthquakes of the Batanes Islands and Southern Formosa. By Rev. Miguel Saderra Masó, S. J. (Monthly Bulletin of the Weather Bureau, March, 1909.)

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The mountain masses which constitute the extinct volcano Banahao seem to lie slightly west of this seismotectonic line, though they are undoubtedly related to it. On the other hand, Marinduque Island must be a short distance east of it, as is shown by the large number of seismic disturbances which actually appear to have their epicenter between this island and Mindoro. This center of activity possibly marks the point of intersection of the line under discussion, with another which probably runs from Masbate Island toward Verde-Island Passage, between Luzon and Mindoro.

With the Eastern Line are connected the following earthquakes: (*a*) Those whose centers lie near the eastern coast of Luzon, east of Lake Bay and Banahao Volcano; (*b*) those which originate on or near the isthmus of Atimonan; (*c*) those which have the seat of disturbance between the islands of Mindoro and Marinduque. The principal earthquakes proceeding from this line occurred in 1730, 1743, 1830, 1869, 1873 (two), 1880, 1884, 1895 (two), and 1901; the corresponding catalogue numbers being 25, 26, 46, 71, 94, 95, 115, 131, 163, 164, and 180. The number of less severe shocks is 41 for the period 1880–1911.

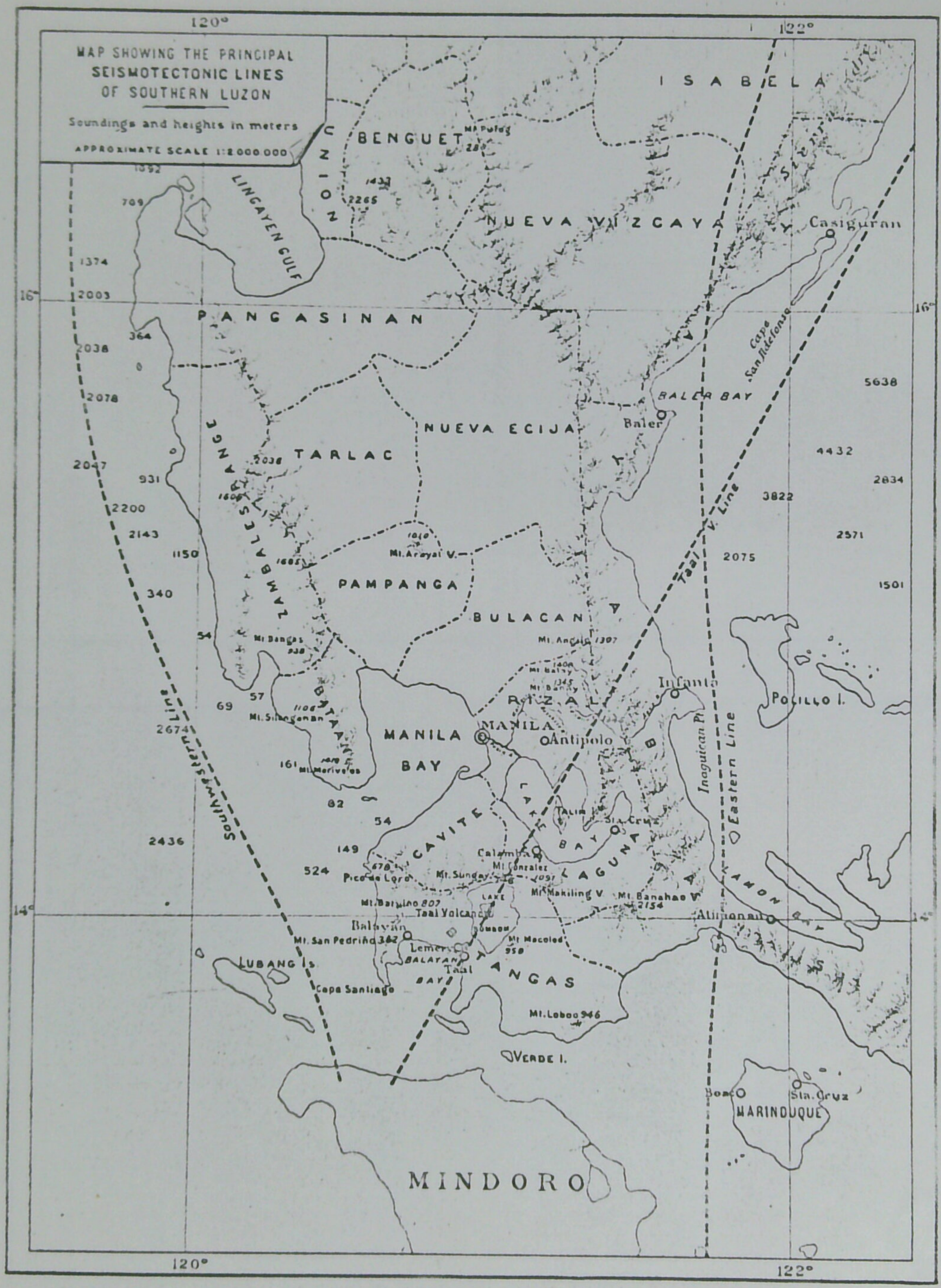
The earthquakes originating in this line have frequently been characterized by a very small area of activity, which included only the eastern portions of Laguna and Tayabas Provinces, the northeast of Mindoro, and Marinduque Island. In this regard they might be classed with volcanic earthquakes, though many of them had their origin evidently at rather large distances to the north, east, or south from the extinct volcano Banahao. It has likewise been observed that the seismic waves seem to experience some difficulty in propagating themselves in the direction of the nearby cordillera of the Camarines.

The Zambales Line.—The cordillera of Zambales seems to constitute likewise a seismotectonic line, but of very secondary character. The disturbances for which the latter is responsible, are more remarkable for their wide extent than for their intensity. They are felt mainly in the alluvial plains of Bataan, Pampanga, and Tarlac Provinces. A line of fracture starts from the western part of Balayan Bay, passes east of the westernmost mountains of Cavite Province [1] and probably continues east of the cordillera of Zambales, and terminates in Lingayen Gulf.

[1] G. I. Adams, loc. cit.

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Plate XV.



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LINEAS SEISMOTECTÓNICAS DEL SUR DE LUZÓN.

En notas precedentes se procuró localizar diferentes focos ó epicentros séismicos de Filipinas, tales como los de las Islas Batanes y norte de Luzón, del oeste de Mindanao, de la parte oriental de Mindanao é Islas Visayas y de Camarines; resumiendo al mismo tiempo los datos más recientes sobre la fisiografía y geología de las regiones donde existen los mencionados centros. La presente nota versará sobre los epicentros (tomados éstos en el sentido más amplio que se da hoy á esta palabra), que principalmente afectan á Manila y las vecinas provincias. En lugar de señalar y describir independientemente cada uno de ellos, como otras veces, haremos un ensayo de determinación de las principales líneas seismotectónicas, ó de fractura, que parecen cruzar la parte meridional de Luzón y de donde proceden los más violentos terremotos que de tiempo en tiempo la conmueven.

Para localizar estas líneas hemos revisado no solamente los documentos séismicos con que se formó el "Catálogo de Terremotos Violentos y Destructores de Filipinas",[1] sino también las listas de otros temblores de tierra de menos intensidad publicadas en los Boletines Mensuales del Observatorio y en "La Seismología en Filipinas."

Las líneas seismotectónicas que pueden determinarse en la parte meridional de Luzón son tres principales: Una en dirección próximamente SSW–NNE, que partiendo del seno de Balayán, pasa por el volcán Taal, por el W de la Isla Talim y sale al Pacífico por la costa oriental al ENE de Manila: á ésta le damos el nombre de *Línea del volcán Taal.* Otra parece partir del extremo NW de Mindoro y se prolonga en dirección SSE–NNW dentro del mar de la China, á poca distancia de las costas de Cavite y de Zambales: puede designarse con el nombre de *Línea del SW de Luzón.* Una tercera corre á lo largo de la costa oriental de Luzón, en dirección aproximada N–S, desde la bahía de Baler,[2] atraviesa el istmo de Atimonan y probablemente sigue hasta el mar de Joló, por el W de Marinduque, Romblon y Panay: á ésta llamaremos *Línea del Este.*

Todas estas líneas van representadas en el mapa que acompaña el texto inglés, Plate XV. En su descripción nos detenemos principalmente en la del Taal, por ser la más peligrosa para Manila. Además de estas líneas seismotectónicas existen en la región volcánica del Sur de Luzón otros focos séismicos de poca importancia donde se originan temblores de tierra volcánicos.

Línea seismotectónica del Volcán Taal.—Durante las grandes erupciones del Volcán Taal se ha observado que los terremotos que las acompañan tienen su máxima intensidad no sólo en la isla del volcán sino también en una zona inmediata, que se prolonga, unas veces hacia el SSW, en dirección al seno de Balayán, y otras hacia el NNE, hasta el lago de Bay. Así por ejemplo, en la erupción de 1749 desarrollaron principalmente su energía en toda la zona situada al NNE, entre los lagos de Bombón y de Bay, produciendo grandes grietas y hundimientos en toda ella. Recientemente en 1911 la zona más castigada fué la de SSW del volcán, entre el lago de Bombón y el seno de Balayán.

[1] Catalogue of Violent and Destructive Earthquakes in the Philippines. Manila, 1910.

[2] Por falta de nombre propio designamos con el nombre de Bahía de Baler todo el extenso recodo entre la Punta Inaguican y el Cabo San Ildefonso.

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Tales hechos, así como los caracteres fisiográficos y geológicos que presenta la región aludida, han sugerido á los geólogos Messrs. Adams y Pratt de la División de Minas del Bureau de Ciencias, la idea de que la fractura geológica en que ha surgido el Volcán Taal corre proximamente de SSW á NNE:[1] esto es, que partiendo del seno ó bahía de Balayán sigue á lo largo del valle del río Pansipit, hacia el mismo volcán, y después continúa en dirección al NNE, pasando por el E del Pico Gonzalez, hacia la parte occidental de la laguna de Bay.

La prolongación de esta línea por el SSW seguiría casi paralela á la costa NW de la Isla Palawan, hacia el estrecho de Balabac y parte NE de Borneo. Su prolongación hacia el NNE, dentro ya del lago de Bay, pasa por el estrecho que separa la Isla Talim de la península de Antipolo después atraviesa la cordillera oriental de Luzón por el distrito de La Infanta y continúa dentro del Pacífico por la bahía ó seno de Baler y se acerca luego paralelamente á la costa SE de las Provincias de La Isabela y Tayabas (Principe). La existencia de semejante línea seismotectónica desde el SSW del Taal hasta el Pacífico la persuaden tanto la apariencia y las condiciones fisiográficas externas como los pocos datos geológicos que se conocen; también parece confirmarla la situación de los principales epicentros séismicos de la parte sud de Luzón, según se verá en las siguientes líneas.

La parte SSW del volcán, entre éste y el seno de Balayán, está constituída por el valle ó depresión, por donde corre el río Pansipit, único desagüe del lago Bombón. Todo el suelo de esta depresión es de toba volcánica y rocas basálticas, excepto el lecho y desembocadura del río, donde se ha depositado alluvión. No están acordes los geólogos en si esta abertura constituía antes un brazo de mar que comunicaba con el lago de Bombón, el cual con el tiempo se cerró y rellenó en parte con los productos volcánicos. Mr. Adams juzga que más bien debe haber sido formada por el mismo río Pansipit. Los terremotos de la última erupción abrieron en esta depresión multitud de grietas, todas en la misma dirección SSW–NNE. Su longitud varía entre y uno y siete kilómetros: en dos de ellas, una á cada lado del valle, el labio de la parte del valle quedó más de un metro más bajo que el opuesto. Las grietas se formaron principalmente en el fondo del valle, y solo dos en sus vertientes, una al E y otra al W.[2] Además se renovaron algunos geyseres y se formaron conos de lodo cerca de la costa del mar, pero dentro de la zona agrietada, en un sitio donde existen fuentes termales, las cuales suelen aparecer y desaparecer á intervalos largos y desiguales. Parece por consiguiente cierto que por el valle del Pansipit corre una línea de fractura que se extiende desde el volcán hasta el seno de Balayán.

Pasemos á la prolongación de la línea hacia el NNE del volcán. Su continuación á través de la zona relativamente baja que separa los lagos de Bombón y de Bay está demostrada: 1.° Por las grietas y hundimientos producidos durante la erupción volcánica de 1749, las cuales, según los historiadores, se prolongaron en dirección NNE de uno á otro lago. 2.° Por una grieta que se abrió en la erupción de 1911, en la misma dirección, la cual pudo seguirse en una longitud de 3 kilómetros. 3.° En el reciente reconocimiento geológico del SW de Luzón, hecho por el mencionado geólogo, Mr. Adams, se saca la conclusión de que la parte oriental del Pico Gonzalez es un verdadero escarpe ó labio occidental elevado de una fractura geológica: el labio oriental debe estar debajo de la capa de toba que cubre toda la región. Queda por consiguiente fuera de duda que en la zona de terreno que media entre los dos lagos de Bombón y Bay existe en dirección NNE una fractura geológica de importancia. Su misma configuración parece además confirmarlo; en gran parte se presenta como un ancho valle entre el monte Gonzalez y

[1] Geological Reconnaissance of Southwestern Luzon. By G. I. Adams, Philippine Journal of Science, Vol. V, No. 2. The Eruption of Taal Volcano, January 30, 1911. By W. E. Pratt. Ibid., Vol. VI, No. 2.

[2] W. E. Pratt, loc. cit.

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los últimos estribos occidentales del volcán Maquiling, donde existen algunos conos secundarios pertenecientes á este grupo volcánico.

Á partir de esta zona la fractura atraviesa la parte occidental del lago de Bay por entre la Isla Talim y el extremo meridional de la península ó cordillera de Antipolo. La punta S de esta península y la punta N de Talim no están en perfecta oposición, sino que la primera queda al W y se adelanta algo hacia el S, mientras que la secunda queda al E y se adelanta á su vez hacia el N; de tal manera que el estrecho paso entre ellas corre proximamente de SSW á NNE, como indicando que su formación fué debida á una falla que lleva la misma dirección. Entra luego en el vallecito de Morong, cuyos bordes occidentales, correspondientes á la montaña de Antipolo son muy escarpados; y atraviesa después la cordillera oriental hasta llegar á la costa del Pacífico por el N de Infanta.

La parte de cordillera oriental atravesada por esta supuesta línea de fractura presenta una topografía é hidrografía muy confusa y enmarañada, de tal manera que no es fácil definir cual de los muchos macizos montañosos que en ella se distinguen, con rumbos muchas veces encontrados, constituye la verdadera cordillera. Los principales ríos llaman la atención por sus cursos irregulares, con cambios muy bruscos de dirección. Así el río Agos, que desemboca en el Pacífico al N de Infanta, atraviesa casi toda la cordillera y llega á la costa con rumbo al NE, mientras que tanto su origen como los de sus principales afluentes, el Lenatin y el Limutan, se halla al NW, formando así una V que abraza una de las montañas más altas de la cordillera. Casi lo mismo sucede con el Bosoboso el cual corre primero hacia el N y dobla después bruscamente al W y por fin al S. Cuando se pueda reconocer geológicamente esta región es muy posible se encuentren pruebas de grandes trastornos geológicos, que ahora solo se sospechan á causa de sus irregularidades topográficas.

Dentro ya del Pacífico esta línea seismotectónica atraviesa diagonalmente el extenso seno de Baler y vuelve luego á acercarse paralelamente á las costas de Casiguran donde tanto éstas como la cordillera oriental ó Sierra Madre tienen el mismo rumbo SSW–NNE.

Los datos séismicos que parecen confirmar no sólo la existencia de una línea de fractura al SSW y NNE del volcán Taal, sino también la extensión que le damos á través de la cordillera oriental, hasta adentro del Pacífico son muy numerosos y citaremos solamente los principales. Tuvieron probablemente su origen en la línea descrita con dislocaciones tanto al NNE como al SSW del volcán Taal, comprendiendo así gran parte de la línea de fractura, los terremotos de 1645, 1658, 1716, 1728, 1749, 1754, 1771, y 1873, que en nuestro Catálogo[1] llevan los Nos. 12, 17, 23, 24, 27, 28, 33, 91. Los terremotos de 1675, 1852, 1869, 1877, 1889 y 1901 correspondientes á los Nos. 19, 51, 70, 104, 144, y 181, lo tuvieron evidentemente al SSW del volcán, entre éste y la Isla de Mindoro, ó sea en el extremo SSW de la fractura. En la parte de la línea que cae al NNE del Taal, desde el lago de Bay hasta el Pacífico, se originaron los siguientes terremotos: 1824, 1862, 1863, 1874, 1880; Nos. 43, 44, 56, 58, 59, 98, 100, 116, y 117: todos estos terremotos tuvieron su área meizoséismica en la cordillera oriental y sus estrivaciones correspondientes al E y ENE de Manila, excepto el señalado con el No. 117, que comprendió solamente la parte SW del lago de Bay con sus riberas.

Puede por consiguiente asegurarse que todos los terremotos que han causado algún daño á la ciudad de Manila tuvieron su origen hacia el E ó ENE por donde pasa esa línea seismotectónica. El más desastroso de todos, el de 1645, parece fué debido á dislocaciones simultáneas en esta línea y en la del E, de que hablaremos luego, la cual desde las Islas Batanes y Babuyanes, probablemente se prolonga hacia el S á lo largo de las Provincias de Cagayán y de La Isabela, hasta venir á cruzarse con el del Taal en el seno de Baler.

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[1] Catalogue of Violent and Destructive Earthquakes in the Philippines. Manila, 1910.

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Del terremoto de 1863 es casi cierto que tuvo su epicentro al ENE de Manila, en la cordillera oriental, y de sus efectos el Sr. Centeno halló aún en 1880 muy vivo recuerdo entre los habitantes de la Infanta.

Respecto á los terremotos de Julio de 1880, los mejor estudiados, por el Sr. D. A. Centeno ingeniero de minas, es evidente que dos de ellos debieron originarse en la misma línea ó falla, uno al E y otro al ENE de Manila: así resulta por lo menos al examinar las isoseistes trazadas por el dicho Ingeniero. De las tres elipses que demarcan el área meizoséismica de los tres terremotos principales, dos se hallan cortadas por esta línea seismotectónica, próximamente en la dirección de sus ejes cortos. En ambos casos sin embargo puede explicarse esta anomalía por la naturaleza de los terrenos de aluvión existentes al W y al NW, en las cuales las ondas séismicas desarrollaron aparentemente mayor violencia que á lo largo de la cordillera.

Los datos precedentes dejan fuera de duda la existencia de uno ó varios focos séismicos en la cordillera oriental al E y ENE de Manila, donde se originan los terremotos y temblores de tierra que más afectan la capital. Que los tales focos estén en una fractura que siga la misma dirección y sea continuación de la que se extiende desde el lago de Bay hasta el seno de Balayán á través del volcán Taal ya no es tan evidente, por tratarse de una región completamente inexplorada por los geólogos. Una tal línea de fractura sin embargo es muy verosímil si se tiene en cuenta que uno de los principales sistemas de líneas tectónicas del Archipiélago sigue próximamente la misma dirección SSW–NNE.

La seismicidad de la zona que se extiende desde el seno de Balayán al de Baler, atravesada por esta línea seismotectónica, es de las mayores del Archipiélago: además de los grandes terremotos antes citados, han ocurrido durante los últimos 25 años 115 temblores de menor intensidad (IV–V). La mayor parte de este número corresponde sin embargo á la parte comprendida entre el lago de Bay y el seno de Balayán, por no existir ni en la cordillera, ni en la costa oriental estación séismica alguna cercana á la línea seismotectónica. De esta parte ENE solo se conocen temblores que tuvieron grande extensión y fueron perceptibles en Manila, Santa Cruz (Laguna), y Baler.

Demostrada la existencia y probable extensión de la línea seismotectónica del Taal, se sigue naturalmente que ésta debe ser la más peligrosa para Manila. Sin embargo, no todos los terremotos en ella originados se hacen sentir igualmente en la Capital. Los que tienen su epicentro entre el lago de Bay y el seno de Balayán se distinguen en Manila por su duración relativamente larga y por la notable lentitud de las ondulaciones, las cuales suelen ser por otra parte de grande amplitud. En muchas ocasiones hemos llamado la atención sobre este fenómeno. Los originados en la parte NE de la línea son de carácter peligroso, por la rapidez de los movimientos, con cambios aparentes de dirección, producidos sin duda por diferentes sistemas de ondulaciones: de tal manera que en igualdad tanto de distancia como de intensidad impresionan mucho más que los del SW.

Tanto por la experiencia que de esto tenemos como por los datos que nos suministra la historia, en muchas ocasiones hemos designado la cordillera al ENE y E de Manila como el sitio donde originan los terremotos más peligrosos para la capital del Archipiélago. La primera vez que emitimos esta idea fué en 1895 al examinar las direcciones dominantes de 211 diferentes temblores de tierra registrados en el Observatorio desde 1869.[1]

Línea seismotectónica del SW de Luzón.—Esta parece arrancar del NW de Mindoro, entre el Cabo Santiago y las islas de Lubang, siguiendo luego casi paralela á la costa SW de Luzón hasta la latitud ó altura de Cabo Bolinao. Probablemente esta línea sigue

[1] "La Seismología en Filipinas," págs. 107 y 108. "Report on the Seismic and Volcanic Centers of the Philippine Archipelago," pág. 25. "Volcanoes and Seismic Centers of the Philippine Archipelago," pág. 77.

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el escarpe irregular submarino que existe á lo largo de las costas de Cavite y de Zambales y á poca distancia de ellas, donde la sonda salta de menos de 100 á más de 1,000 brazas (220 á 2,200 metros). Semejante escarpe ó pendiente brusca se encuentra también á lo largo de las costas de Ilocos é indica probablemente una línea seismotectónica que afecta aquellas provincias.

Como originados en esta línea del SW de Luzón, desde las islas Lubang al Cabo Bolinao, encontramos en nuestro Catálogo los siguientes terremotos: 1852, dos en 1872, 1878, 1880, 1902; total seis terremotos comprendidos entre VI y IX de la escala De Rossi-Forel y señalados en el Catálogo con los Nos. 49, 84, 90, 107, 118, 185. La mayor parte de estos terremotos se sintieron con igual intensidad á lo largo de las costas y provincias tanto de Cavite como de Bataan y Zambales. Solamente el de 1872, correspondiente al No. 84, parece haber tenido un área meizoséismica muy reducida. El número de temblores de menor importancia que encontramos en las listas de 1880–1911, son 59, entrando solo en cuenta los de extensión é intensidad suficientes para poder determinar con alguna aproximación su epicentro.

Línea seismotectónica del E de Luzón.—Además de las dos mencionadas parece existir otra que tal vez atraviesa todo el Archipiélago, cerca del meridiano 122° E desde las islas Batanes [1] hasta el W de Mindanao. Al NE de Manila se cruza con la del Taal en el seno de Baler y sigue hacia el S por entre la costa oriental de Luzón y la isla Polillo, atraviesa el istmo de Atimonan por el ESE del volcán Banahao, en dirección á la parte W de la isla de Marinduque.

Los caracteres geográficos exteriores de esta línea en la parte correspondiente al S de Luzón no dejan de ser singulares: después de cruzarse con la del Taal, pasa muy cerca del extremo NW de la profunda fosa marina que bordea las costas de Mindanao, Visayas, y SE de Luzón: entra luego en el estrecho que separa las costas de Luzón de la pequeña isla Polillo en dirección á la bahía de Lamón é istmo de Atimonan. Toda esta región es notable por los cambios bruscos que sufren las líneas tectónicas; en el istmo la cordillera oriental parece torcer súbitamente hacia el W; mientras que tanto la isla Polillo como otras más pequeñas de la bahía de Lamón conservan una dirección SE–NW, más en armonía con la dirección de las líneas tectónicas de Camarines. Toda el área ocupada por los senos de Lamón y Baler aparece como una discontinuación ó fractura de la línea general tectónica que formaría un grande arco SE–NW y luego S–N desde Camarines hasta el extremo NE de Luzón; como si este grande seno del E de Luzón tuviera relación con el inmenso y progresivo hundimiento que dió por resultado la gran fosa antes citada, la cual es posible esté aún en formación, según son frecuentes los temblores de tierra en todo su borde occidental y en su extremo NW que termina en el citado seno de Baler.

Los grandes macizos que constituyen el volcán extincto Banahao parecen quedar algo al W de la línea seismotectónica, si bien forman sin duda parte de ella. La isla de Marinduque por el contrario queda algo al E á juzgar por gran número de terremotos que realmente parecen tener el epicentro entre esta isla y la de Mindoro. Este epicentro puede muy bien corresponder al cruce de la línea que nos ocupa, con otra que probablemente corre desde Masbate hacia el estrecho de Isla Verde, que separa Luzón de Mindoro.

Corresponden á esta línea del E los terremotos cuyo epicentro se hallaba: (*a*) cerca de la costa oriental de Luzón, al E del lago de Bay y del volcán Banahao; (*b*) en ó cerca del istmo de Atimonan; (*c*) entre las islas de Marinduque y Mindoro. Los principales ocurrieron en 1730, 1743, 1830, 1869, 1873, 1880, 1884, 1895, and 1901, y llevan

[1] "Contributions to the Physiography of the Philippine Islands. By H. G. Ferguson (division of mines)." "Earthquakes of the Batanes Islands and Southern Formosa. By Rev. Miguel Saderra Masó, S. J." (Monthly Bulletin for March, 1909.)

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en el Catálogo los Nos. 25, 26, 46, 71, 94, 95, 115, 131, 163, 164, y 180. El número de otros de menor importancia es de 41 en el período 1880–1911.

Los terremotos originados en esta línea se han distinguido con frecuencia por lo pequeño de su área de acción, afectando solo unas veces la parte oriental de las provincias de La Laguna y de Tayabas, otras el NE de Mindoro, ó la isla de Marinduque; de manera que bajo este respecto podrían considerarse como volcánicos, por más que muchos de ellos tuvieron evidentemente su origen á bastante distancia al N, E, y S del volcán extincto Banahao. Además se nota que las ondas séismicas con dificultad se propagan hacia la inmediata cordillera de Camarines.

Línea de Zambales.—La cordillera de Zambales parece constituir también una línea seismotectónica, pero muy secundaria. Los temblores en ella originados se distinguen más por su extensión que por su intensidad: siéntense principalmente en los terrenos de aluvión de las provincias de Bataan, Pampanga, y Tarlac. Existe una línea de fractura [1] que partiendo del W del seno de Balayán pasa por el E de los montes más occidentales de la provincia de Cavite y probablemente continua al E. de la cordillera de Zambales y termina en el golfo de Lingayén.

[1] G. I. Adams, loc. cit.

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Seismological Bulletin, No. 9, a.

September, 1911.

No.	Rate.	Character	Instrument and Component	Beginning P.	Beginning S.	Beginning L.	Maximum range of motion Hour.	Maximum range of motion A.	Maximum range of motion T.	F.	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
	1	At 8h 38m Earthquake, III at Lacag (NW of Luzon). – (At 3h 21m Eqke., III at Guam (Marianas Islands).									
208	1	I_d	V.	12 40 22		12 40 39	12 40 43	0.09	2.4	12 43	Vertical Component 0.07 mm.
209	1	I_d	V.	23 44 15		23 44 32	23 45 08	.34	2.4	23 49	V. C. 0.11 mm.
210	2	I	H. WSW			8 01 48				8 30	
211	2	I_v	H. WSW	16 34 47		16 36 37	16 38 18	.05	6	16 55	Eqke., IV Agusan River Valley, aftershock.
	3	At 6h 37m Eqke., III at Butuan (N of Mindanao).									
212	5	I_v	V.	10 08 48		10 10 08	10 13 00	.02	7.6	10 25	Eqke., VII in the western and central part of Leyte.
			H. WSW	10 08 48		10 10 02	10 12 03	.12	9.6	10 31	
	5	At 15h 02m Eqke., III at Ormoc (W of Leyte).									
213	5	I	H. WSW			17 25 03				17 43	
			V.	9 01 04		9 06 15	9 07 02	.04	2.4	9 27	V. C. 0.01 mm.
			H. NNW	9 01 06		9 06 21	9 06 27	.12	7.2	9 26	
214	6	I_r	H. WSW	9 01 06		9 06 22	9 08 21	.20	7.8	9 33	
			W. N	9 00 57		9 06 07	9 07 06	.04	2.8	9 28	
			W. E	9 00 57		9 06 08	9 06 17	.11	4.8	9 32	
215	6	I_v	H. WSW	10 14 47		10 16 27	10 17 41	.07	8.1	10 36	Eqke., IV Agusan River Valley, aftershock.
216	7	I_d	V.	6 47 09		6 47 33	6 47 41	.05	2.4	6 50	V. C. 0.03 mm.
	7	At 20h 02m Eqke., III at Catbalogan (W of Samar).									
	8	At 4h 57m 10s Eqke., V at Ormoc (W of Leyte).									
217	8	I	V.	18 40 55		18 41 10	18 41 25	.03	2.4	18 43	V. C. 0.02 mm.
	9	At 0h 13m Eqke., IV at Ormoc (W. of Leyte).									
218	9	I	H. WSW	6 52 43						7 19	

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Seismological Bulletin, No. 9, b.

September, 1911.

No.	Date.	Character.	Instrument and Component	Beginning P. h. m. s.	Beginning S. h. m. s.	Beginning L. h. m. s.	Maximum range of motion Hour h. m. s.	A. mm.	T. s.	F. h. m.	Remarks.
219	9	I	V.	18 57 57		19 02 58	19 03 04	.04	2.4	19 12	V. C. 0.04 mm.
			H. WSW	18 58 02		19 02 58	19 03 13	.04	9	19 14	
220	9	I_d	V.	19 47 21		19 47 40	19 47 46	.07	2.4	19 50	V. C. 0.04 mm.
221	10	I_d	V.	14 51 06		14 51 24	14 51 34	.02	2	14 54	V. C. 0.01 mm.
222	11	I	W. E	4 24 58		4 25 34	4 25 56	.01	3.6	4 27	
223	12	I	V.	2 35 33		2 35 47	2 35 55	.02	2.4	2 38	
	12	At 3h 05m Eqke., III in the western and central part of Leyte.									
	12	At 14h 38m 15s Eqke., III at Ormoc (W of Leyte).									
	12	At 17h 36m Eqke., II at Vigan (NW of Luzon).									
	12	At 18h 54m 10s Eqke., III at Ormoc (W of Leyte).									
224	12	I_r	V.	21 03 32	21 06 41	21 10 52	21 12 26	.01	6	21 22	
			H. WSW	21 03 32	21 06 55	21 10 52	21 12 21	.05	6.9	21 30	
	13	At 18h 54m Eqke., IV at Ormoc (W of Leyte).									
	13	At 23h 35m Eqke., III at Hamblon.									
	14	At 23h 53m Eqke., III Agusan River Valley.									
225	14-15	I	V.	23 50 58						0 01	
226	15	I	V.	0 06 19						0 27	
227	15	I	H WSW	21 30 18						22 15	
			W E	21 30 18						22 12	
228	17	I_r	V.	11 38 49	11 42 50	11 47 42	11 50 40	.03	8	12 35	
			H. NNW	11 38 45	11 42 44	11 47 27	11 48 13	.21	7.5	12 31	
			W. N	11 38 39	11 42 42	11 47 41	11 52 53	.01	8	12 39	

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Seismological Bulletin No. 9, c. September, 1911.

No.	Date.	Character	Instrument and Component	Beginning P. h. m. s.	Beginning S. h. m. s.	Beginning L. h. m. s.	Maximum range of motion Hour h. m. s.	Maximum range of motion A. mm.	Maximum range of motion T. s.	F. h. m.	Remarks.
229	17	I_v	H. WSW	12 43 37		12 55 52	12 57 09	.14	8.7	13 33	
	17	At 16h 37m 50s Eqke., II at Cuneo (W of Leyte).									
	18	At 4h 32m Eqke., II at Butuan (N of Mindanao).									
	18	At 5h 30m 05s Eqke., IV in the western and central part of Leyte.									
230	18	II_v	V.	21 35 40		21 37 07	21 37 50	.84	2.4	22 07	V. C. 0.07 mm. Eqke., IV at Aparri
			W. E	21 35 40		21 36 50	21 39 25	.97	3.6	22 09	(NE of Luzon).
	20	At 6h 07m Eqke., II at Guam (Marianas Islands).									
231	20	I_d	V.	13 35 26		13 35 44	13 36 04	.16	2.4	13 40	V. C. 0.07 mm.
										15 54	
232	21	I	V.	15 22 25						16 20	
			H. WSW	15 22 26							
233	21	I_v	V.	21 57 54		21 59 12	21 59 56	.05	2.4	22 06	V.C. 0.01 mm. Eqke., IV in the western
			W. E	21 57 54		21 59 00	21 59 24	.03	4	22 06	and central part of Leyte.
	21	At 22h 43m Eqke., III at Tacloban (NE of Leyte).									
234	22	I	W. E	13 13 30						13 38	
	23	At 2h 19m Eqke., II at Tacloban (NE of Leyte).									
235	24	II_d	V.	6 45 18		6 45 37	6 46 23	1.18	2.4	6 51	V. C. 0.99 mm.
236	24	I_d	V	11 57 13		11 57 55	11 58 09	.06	2.4	12 26	V.C. 0.01 mm.
237	25	I_v	W. E	2 57 20		2 58 30	2 59 37	.05	4	3 22	Eqke., V. Agusan River Valley.

M. Saderra M.

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Latitude: 14° 34' 41" N. Longitude: 120° 58' 33" E. Gr.

Time of the one hundred and twentieth meridian east of Greenwich. Midnight = 0h

Seismological Bulletin No. 10, a. October, 1911.

No.	Date	Character	Instrument and Component	Beginning P.	Beginning S.	Beginning L.	Maximum range of motion Hour.	Maximum range of motion A.	Maximum range of motion T.	F.	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
	2	At 2h 50m Earthquake, III at Guam (Marianas Islands).									
	5	At 4h 21m Eqke., II at Tacloban (NE of Leyte).									
238	5	I	V.	10 28 35						10 38	
239	5	I	V.	14 30 45						14 47	
240	6	I_v	V.	18 35 54						18 54	Agusan River Valley.
			W. E	18 35 54						18 55	
241	6	I_r	V.	22 31 20		22 35 45	22 38 12	0.01	10	23 04	
			W. E	22 31 21		22 35 32	22 37 07	.01	8.8	23 08	
			V.	12 48 45		12 52 24	12 54 26	.02	9	13 26	
242	7	I_r	H. NNW	12 48 45		12 52 04	12 55 22	.07	8.4	13 20	
			W. E	12 48 45		12 51 26	12 53 44	.01	11.2	13 23	
	12	At 13h 56m Eqke., III at Laoag (NW of Luzon).									
	13	At 5h 37m Eqke., III, Agusan River Valley.									
			V.	5 37 56		5 38 51	5 40 40	.07	2.4	5 52	V. C. 0.01 mm. Eqke., III at Aparri (NE of Luzon).
243	13	I_v	H. NNW	5 37 59		5 39 04	5 41 21	.07	6	5 56	
			W. E	5 38 00		5 38 56	5 40 33	.05	2.8	5 50	
			V.	10 41 45	10 46 24	10 51 26				11 29	
244	13	I_r	H. NNW	10 41 45	10 46 30	10 51 57	10 53 37	.04	8.4	11 32	
			W. E.	10 41 45	10 46 39	10 52 06	10 54 01	.01	14.4	11 30	

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Seismological Bulletin No. 10, b. October, 1911.

No.	Date	Character	Instrument and Component	Beginning P. h. m. s.	Beginning S. h. m. s.	Beginning L. h. m. s.	Maximum range of motion Hour h. m. s.	A. mm.	T. s.	F. h. m.	Remarks.
245	14	I	H. NNW	0 41 00						0 50	
246	14	I_d	V.	7 41 08		7 41 14	7 41 16	.52	2	7 44	V. C. 0.38 mm.
247	14	I_r	V.	11 02 30		11 03 17	11 04 28	.06	2.4	11 15	V.C. 0.01 mm. Eqke., IV, N Luzon.
248	14	I_r	V.	20 34 55		20 40 45	20 44 15	.01	7.2	21 41	
			H. NNW	20 34 55		20 40 51	20 44 37	.05	6.6	21 33	
249	15	I_r	V.	7 31 41	7 37 48	7 42 09	7 43 22	.01	7.2	8 30	
			H. NNW	7 31 41	7 38 03	7 42 13	7 43 24	.13	7.2	8 28	
250	15	I_r	V.	15 35 47		15 38 23	15 40 02	.02	11.2	16 03	
			H. NNW	15 35 47		15 38 44	15 40 38	.07	7.5	16 08	
251	16	II_d	V.	13 27 27		13 28 01	13 28 13	1.20	2.4	13 51	V. C. 0.42 mm.
			W. E	13 27 24		13 28 03	13 28 28	.36	4.8	13 54	
252	17	I	H. NNW	17 26 52						17 57	
253	17	I	W. E	20 01 00						20 20	
	18	At 0h 17m Eqke., II at Tacloban (NE of Leyte).									
254	19	I_r	V.	4 08 39		4 09 01	4 09 05	.03	2.4	4 11	V.C. 0.02 mm. Eqke., III at Baguio (NW of Luzon).
255	20	I_d	V.	22 07 42		22 08 10	22 08 15	.18	2.4	22 13	V.C. 0.09 mm.
256	21	I_r	V.	1 53 02		2 00 22	2 01 40	.02	9.6	2 38	V.C. 0.05 mm.
			H. NNW	1 53 08		2 00 22	2 01 08	.39	10.2	2 31	
			W. E	1 53 00		2 00 22	2 00 52	.19	6.4	2 40	
	22	At 22h 15m Eqke., III at Guam (Marianas Islands).									
257	23	I_d	V.	0 52 00		0 52 24	0 52 28	.02	2	0 54	V. C. 0.01 mm.
258	23	I_r	V.	4 01 46		4 03 24	4 03 38	.24	2.4	4 10	V. C. 0.15 mm.

Manila Observatory.—Philippine Islands.
Seismological Bulletin No. 10, c.

October, 1911.

No.	Date.	Character	Instrument and Component	Beginning P.	Beginning S.	Beginning L.	Maximum range of motion. Hour	A.	T.	F.	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
259	24	I_d	V.	2 09 18		2 09 36	2 09 54	.26	2.4	2 13	V.C. 0.24 mm.
260	24	I_r	V.	8 17 23		8 22 51	8 25 59	.01	7.6	8 51	V.C. 0.01 mm.
			H. NNW	8 17 24		8 23 01	8 24 33	.24	7.2	8 56	
	26	At 14h 45m Egke., III at Butuan (N of Mindanao).									
261	26	I_v	H. NNW	19 54 11		19 56 12	19 58 22	.06	7.5	20 18	Egke., IV, east Mindanao.
262	27	I_v	H. NNW	5 31 51		5 33 50	5 36 06	.05	6.6	5 52	Egke., IV, east Mindanao.
	27	At 11h 30m Egke., III at Butuan (N of Mindanao).									
263	28	I_v	V.	17 37 56		17 38 19	17 38 37	.58	2.4	17 46	V.C. 0.28 mm. Egke., III at Baguio (NW of Luzon).
264	30	I	H. NNW			21 11 02				21 35	
265	31	I_d	V.			19 11 41	19 11 43	.07	2.4	19 15	V.C. 0.03 mm.

Horizontal Pendulums (H.): period of oscillation, NNW-SSE pendulum, T = 8.4 seconds; WSW-ENE pendulum, T = 8.2 seconds.

M. Saderra M.

Manila Observatory.- Philippine Islands.

Latitude: 14° 34' 41" N.; Longitude: 120° 58' 33" E. Gr.

Time of the one hundred and twentieth meridian east of Greenwich. Midnight = 0h.

Seismological Bulletin No. 11, a. November, 1911.

No.	Date	Character	Instrument and Component	Beginning P.	Beginning S.	Beginning L.	Maximum range of motion. Hour	A.	T.	F.	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s	mm.	s.	h. m.	
266	1	I	V.	5 25 42						5 37	
267	1	I_d	V.	16 06 09		16 06 27	16 07 45	0.61	2.4	16 13	V.C. 0.42 mm.
268	2	I	V.	6 58 55						7 15	
			H. NNW	6 58 59						7 18	
			H. WSW	6 58 59						7 16	
269	2	I_d	V.	13 35 26		13 35 51	13 36 11	.14	2.4	13 40	V.C. 0.09 mm.
270	6	I	V.	3 10 49		3 12 25	3 14 28	.02	6.4	3 27	
			W. N	3 10 54		3 12 18	3 16 24	.04	8.2	3 25	
271	6	II_v	V.	23 26 56		23 27 21	23 28 54	1.97	2	23 42	V.C. 1.25 mm. Eqke., IV in Pangasinan and Benguet Provinces.
			W. N	23 26 56		23 27 20	23 28 54	.93	7.6	23 39	
272	9	I	V.	12 28 27						12 56	
273	11	I_d	V.	1 51 54		1 52 11	1 52 14	.20	2.4	1 55	V.C. 0.06 mm.
274	11	I_v	V.	5 45 02		5 46 50	5 47 13	.04	2.4	5 56	Eqke., III at Tacloban (NE of Leyte).
275	11	I	V.	20 49 17		20 50 14	20 51 12	.04	3.6	20 56	V.C. 0.02 mm.
276	12	I_d	V.			1 30 01	1 30 04	.02	2.4	1 32	
277	14	I_u	V.	0 23 11	0 30 51	0 36 21	0 38 47	.01	15.2	1 40	
			H. NNW	0 23 11	0 30 48	0 35 35	0 40 55	.04	10.8	1 26	
			H. WSW	0 23 11	0 30 53	0 35 28	0 37 17	.04	9.3	1 24	
			W. E	0 22 52	0 30 42	0 36 30	0 37 04	.07	9.6	2 02	
278	17	I_d	V.	9 35 42		9 35 54	9 36 16	.14	2.4	9 40	V.C. 0.15 mm.

Manila Observatory.-Philippine Islands.
Seismological Bulletin No. 11, for November, 1911.

No.	Date	Character	Instrument and Component	Beginning P. h. m. s.	Beginning S. h. m. s.	Beginning L. h. m. s.	Maximum range of motion Hour h. m. s.	Maximum range of motion A. mm.	Maximum range of motion T. s.	F. h. m.	Remarks.
279	17	I_d	V.	13 44 50		13 45 01	13 45 17	.10	2.4	13 49	V. C. 0.06 mm.
280	17	I_d	V.	20 07 20		20 07 32	20 07 39	.07	2.4	20 11	V. C. 0.08 mm.
281	18	I_d	V.	13 10 32		13 10 43	13 11 01	.05	2.2	13 14	V. C. 0.05 mm.
282	19	I_r	V.	10 12 00						10 40	V. C. 0.01 mm.
			H. WSW	10 12 00						10 38	
			W. E	10 12 00						10 50	
	19	At 22h 50m Egke., III at Tacloban (NE of Leyte).									
	20	At 2h 16m Egke., III, Cuyo Island.									
283	20	I_d	V.			18 00 51	18 00 53	.02	2.4		V. C. 0.01 mm.
284	20	I_r	V.	18 01 31		18 02 02	18 02 12	.05	2.4	18 06	V.C. 0.03 mm. Egke., III at Nueva Caceres (SE of Luzon).
285	21	I_r	V.	15 40 03		15 43 58	15 44 09	.08	2.4	16 00	
			H. NNW	15 40 02		15 43 52	15 45 59	.04	6	16 01	
			W E	15 39 56		15 43 55	15 44 05	.10	3.8	15 59	
286	22	II_v	V.	3 23 34		3 24 24	3 24 54	1.95	2.4	4 29	V. C. 1.02 mm. Origin near the extreme
			H. NNW	3 23 36		3 24 27	3 25 20	2.07	7.8	3 55	NE Luzon.
287	22	I_d	V.	22 02 04		22 02 30	22 02 37	.04	2.4	22 05	V. C. 0.02 mm.
288	23	I_r	V.	7 14 38	7 18 37	7 22 04	7 22 16	.06	2.4	7 48	
			H. NNW	7 14 43	7 17 58	7 22 05	7 22 22	.33	7.5	7 47	
			H. WSW	7 14 43	7 18 14	7 22 09	7 24 06	.27	7.8	7 55	
			W. N	7 14 42	7 18 12	7 22 00	7 24 24	.08	6.4	7 57	
			W. E	7 14 42	7 18 12	7 22 04	7 22 38	.35	5.6	7 54	

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Seismological Bulletin No. 11, c. November, 1911.

No.	Date	Character	Instrument and component	Beginning P.	Beginning S.	Beginning L.	Maximum range of motion Hour	Maximum range of motion A.	Maximum range of motion T.	F.	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
289	24	I_d	V.	12 41 52		12 42 03	12 43 25	.03	2.2	12 45	V. C. 0.01 mm/m.
	26	At 2h 03m Eqke., II at Tacloban (NE of Leyte).									
290	26	I_d	V.	10 31 10		10 31 24	10 31 25	.08	2.4	10 34	V. C. 0.02 mm/m.
291	27	I_d	V.	21 32 13		21 32 19	21 32 20	.12	2.4	21 34	V. C. 0.03 mm/m.
292	28-29	I	V.	23 52 04						C 40	
			W. E	23 51 27						O 32	
	29	At 20h 24m Eqke., III at Aparri (NE of Luzon).									
293	30	I_L	V.	13 54 28		13 55 00	13 55 08	.07	2.4	13 57	V. C. 0.06 mm/m.

Strong pulsations from 9h of the 3rd to 12h of the 11th due to a wide barometric depression in the Pacific Ocean, which on the 6th reached at the least distance of 390 miles from the eastern coast of Luzon.

M. Saderra M.

Manila Observatory.-Philippine Islands.

Latitude: 14° 34' 41" N.; longitude: 120° 58' 33" E. Gr.

Time of the one hundred and twentieth meridian east of Greenwich. Midnight = 0h.

Seismological Bulletin No. 12, a.

December, 1911.

No.	Date.	Character	Instrument and Component	Beginning P	Beginning S	Beginning L	Maximum range of motion Hour	Maximum range of motion A	Maximum range of motion T	F	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
	2	At 2h 40m Earthquake, III at Aparri (NE of Luzon).									
	4	At 16h 56m 35s Eqke., II at Butuan (N of Mindanao).									
294	5	I_v	V.	12 26 04		12 26 50	12 27 05	0.02	2.4	12 29	Vertical Component 0.02 mm. Earthquake, IV at Aparri (NE of Luzon).
295	6	I_d	V.	19 01 06		19 01 17	19 01 19	.16	2.4	19 04	V. C. 0.06 mm.
296	7	I_d	V.			0 26 04	0 26 09	.03	2.4	0 28	V. C. 0.01 mm.
	8	At 3h Eqke., II at Butuan (N of Mindanao).									
	8	At 21h 24m 15s Eqke., III at Butuan (N of Mindanao).									
297	10	I_d	V.	5 07 33		5 07 47	5 08 11	.01	2.4	5 14	V. C. 0.02 mm.
			W. N	5 07 32		5 07 48	5 08 12	.01	2.4	5 14	
298	10	I_d	V.	7 32 24		7 33 17	7 33 38	.08	2.4	7 38	V. C. 0.03 mm.
299	10	I	H WSW	18 05 00						18 25	
			W. N	18 05 00						18 28	
			V.	19 07 06	19 14 53		19 32 06	.02	16		
			H. NNW	19 07 08	19 15 00		19 32 37	.12	13.2		
300	11	I_u	H WSW	19 07 08	19 15 03		19 32 00	.16	14.7		
			W N	19 07 10	19 15 06		19 32 36	.09	12		
			W E	19 07 10	19 15 24		19 31 47	.05	16		

Manila Observatory. – Philippine Islands.

Seismological Bulletin No. 12. b.

December, 1911.

No.	Date	Character	Instrument and Component	Beginning P. h. m. s.	Beginning S. h. m. s.	Beginning L. h. m. s.	Maximum range of motion Hour h. m. s.	Maximum range of motion A. mm.	Maximum range of motion T. s.	F. h. m.	Remarks.
			V.	19 46 27		19 48 50	19 50 54	.01	7.2	20 38	V. C. 0.01 mm.
			H. NNW	19 46 27						20 17	
301	11	I_r	H. WSW	19 46 27						20 19	
			W. N	19 46 26		19 48 37	19 50 33	.06	9.6	20 27	
			W. E	19 46 26		19 49 00	19 50 54	.03	9.6	20 25	
302	12	I_v	V.	0 05 01		0 05 31	0 05 36	.04	2.4	0 07	V. C. 0.02 mm. Epke., IV at Cuyo.
			V.	17 05 09						17 33	
			H. NNW	17 05 08						17 31	
303	13	I_r	H. WSW	17 05 08						17 33	
			W N	17 05 02						17 34	
304	13	I_d	V.	20 30 20		20 30 35	20 30 39	.02	2.4	20 33	V. C. 0.01 mm.
			V.	6 37 42						7 03	
305	14	I_r	H. WSW	6 37 42						7 15	
			W N	6 37 44						7 06	
			W E	6 37 44						7 21	
			V.	5 04 15		5 05 07	5 05 32	.80	2.4	5 15	V. C. 0.05 mm. Northeastern Luzon.
306	16	II_v	W. E	5 04 13		5 05 04	5 06 44	.37	.5	5 18	
			V.	3 36 37?							
			H. NNW	3 36 37?							
307	17	I_u	H. WSW	3 36 37?							
			W. N	3 36 00?							
			W. E	3 36 00?							

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Seismological Bulletin No. 12 c.
December, 1911.

No.	Date	Character	Instrument and Component	Beginning P.	Beginning S.	Beginning L.	Maximum range of motion Hour.	Maximum range of motion A.	Maximum range of motion T.	F.	Remarks.
				h. m. s.	h. m. s.	h. m. s.	h. m. s.	mm.	s.	h. m.	
			V.	4 07 31?		4 25 24?	4 35 18	.01	18	5 28	
308	17	I_u	H. WSW	4 08 53?		4 23 41?	4 35 26	.05	17	5 20	
			W E	4 07 00?		4 23 56?	4 35 20	.01	16.2	5 25	
309	18	I_u	V.	20 04 38		20 05 28	20 05 49	.04	2.4	20 09	V. C. 0.02 mm. Northern Luzon.
310	19	I_d	V.	22 56 49		22 56 59	22 57 02	.05	2.4	22 59	V. C. 0.03 mm.
			H. WSW	14 00 50						14 50	
311	20	I	W N	14 00 48						15 17	
312	22	I_d	W. N	11 40 07		11 40 34	11 41 20	.01	3.2	11 45	
313	23	I_d	W. N			7 56 00	7 56 42	.01	3.6	7 58	
			V.	17 11 14		17 15 34	17 16 17	.01	7.2	17 54	
314	30	I_r	W. N	17 11 14		17 15 34	17 16 48	.01	7.2	17 45	
			W. E	17 11 14		17 15 56	17 18 40	.01	8	17 47	
315	30	I_d	V.	23 04 42		23 05 19	23 05 57	.06	2.4	23 09	V. C. 0.02 mm.
			V.	14 12 44	14 17 10	14 20 59	14 22 05	.03	12.2	15 26	V. C. 0.02 mm.
			H. NNW	14 12 44	14 17 12	14 20 59	14 22 18	.19	10	15 22	
316	31	II_r	H. WSW	14 12 44	14 17 08	14 20 56	14 22 07	.43	10.8	15 24	
			W. N	14 12 40	14 17 08	14 20 48	14 22 11	.04	9.2	15 31	
			W. E	14 12 40	14 17 12	14 20 57	14 22 00	.12	11	15 42	

M. Saderra M.