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Earthquakes

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Introduction

For details regarding sources of data, the selection of earthquakes and their classification by seismotectonic region, the determination of magnitude, etc., the reader is invited to consult the first number of this annual summary, relating to the year 1966.

Seismic activity in 1969

In the course of the year 1969 the United States Coast and Geodetic Survey (USCGS) published 5,313 preliminary determinations of epicentres (as compared with 5,698 in 1968 and 4,894 in 1967).

In the regional tables we have indicated, on the one hand, the mean magnitude m calculated by USCGS from the amplitudes of body waves recorded at various observatories and, on the other hand, the magnitude M on the Pasadena scale, generally determined from the amplitude of surface waves.

The year 1969 was notable [1, 2, 3, 4][1] for the occurrence of several long series of earthquakes: in the neighbourhood of the Talaud Islands in January-March; in the Atlantic west of Gibraltar from 28 February onwards; in the southern Kuriles and in the Molucca Strait in August; in the Lesser Antilles in December. An earthquake of magnitude 7 was observed for the first time in the northern part of the Red Sea. Apart from this, Africa was affected in 1969 by two other series of shocks which caused damage and loss of life in Ethiopia (March-April) and in the Cape Province in September-October. The total loss of life from earthquakes in 1969 was over 900, not counting the unknown number of victims caused by destructive earthquakes in China.

1. The figures in square brackets refer to the bibliography at the end of this chapter.

The principal destructive earthquakes were as follows:

Region	Serial number	Epicentral region	Magnitude (M)	Date
Continental Europe	None			
Mediterranean regions	**19**	West of Gibraltar	8.0	28 February
	38	Banja-Luka (Yugoslavia)	6.4	26 and 27 October
	45	Albania	5.7	3 April
	78	Alasehir (Turkey)	6.5	28 March
Asiatic ranges	**107**	Iran	5.6	3 January
	126	China	7.6	18 July
	127	China	6.2	25 July
Pacific	**256**	Celebes	7.3	23 February
	519	Peru	6.4	1 October
Continental America	None			
Continental Africa	**595**	Red Sea	7.0	31 March
	597	Sardo (Ethiopia)	6.3	29 March
	617	South Africa	6.5	29 September

Further details on these earthquakes are given below, in the notes following the corresponding regional tables.

Energy release

The number N of earthquakes in each of the indicated ranges of magnitude M was as follows:

M	6.0-6.4	6.5-6.9	7.0-7.4	7.5-7.9	$\geqslant 8.0$
N	126	32	16	4	1

There were fewer large earthquakes (with magnitude equal to or greater than 7.0) in 1969 than in 1968 (21 as compared with 29). The equation $\log E = 11.4 + 1.5\,M$ gives, for the energy released by large earthquakes in 1969, the figure of 800×10^{21} erg (as against $1{,}550 \times 10^{21}$ erg in 1968 and only 200×10^{21} erg in 1967).

The 21 earthquakes of large magnitude which occurred in 1969 are listed in the following table:

Number	Date	Region	M	m
19	28 February	West of Gibraltar	8.0	7.3
161	11 August	Kuriles	7.8	7.1
260	21 November	Sumatra	7.7	6.4
126	18 July	China	7.6	6.2
227	30 January	Talaud Islands	7.5	5.9
327	5 January	Solomon Islands	7.4	6.4

Number	Date	Region	*M*	*m*
145	22 November	Kamchatka	7.3	6.3
256	23 February	Celebes	7.3	6.1
473	17 August	Gulf of California	7.3	6.1
248	5 August	Molucca Strait	7.2	6.1
502	25 December	Lesser Antilles	7.2	6.4
232	3 February	Talaud Islands	7.1	6.1
336	6 January	Santa-Cruz Islands	7.1	6.2
156	19 January	Hokkaido	7.0	6.4
200	21 April	Kyushu	7.0	6.1
239	27 March	Talaud Islands	7.0	6.1
246	11 August	Molucca Strait	7.0	6.1
278	11 February	Banda Sea	7.0	6.0
370	24 January	Fiji Islands	7.0	5.9
408	14 May	Aleutians	7.0	6.2
595	31 March	Red Sea	7.0	6.0

Map of epicentres

The attached map (Fig. 1) gives a general picture of the principal seismic regions of the world. Each epicentre is identified by its serial number in the regional tables. On this map the epicentres are grouped into three categories: first, those of magnitude equal to or greater than 7 (classes *a* and *b* of Gutenberg and Richter); second, those of magnitude between 6 and 6.9 (class *c*); third, those of magnitude less than 6 (class *d*). They are also grouped into three categories, depending on depth of focus: *normal* (depth of focus *h* less than 70 km); *intermediate* (*h* between 70 and 299 km); and *deep* (*h* equal to or greater than 300 km). As a result of our method of selection, the density of epicentres is not strictly comparable between one region and another. However, the classification by magnitude allows us to see immediately how numerous are the earthquakes of magnitude equal to or greater than 6 round the circum-Pacific seismic belt, the zone in which over 75 per cent of the total seismic energy is liberated each year. The epicentres of earthquakes of magnitude less than 6 mark the various seismic zones which coincide with the Alpine chain, and with the rifts in the Atlantic, the Indian and the south-eastern Pacific oceans.

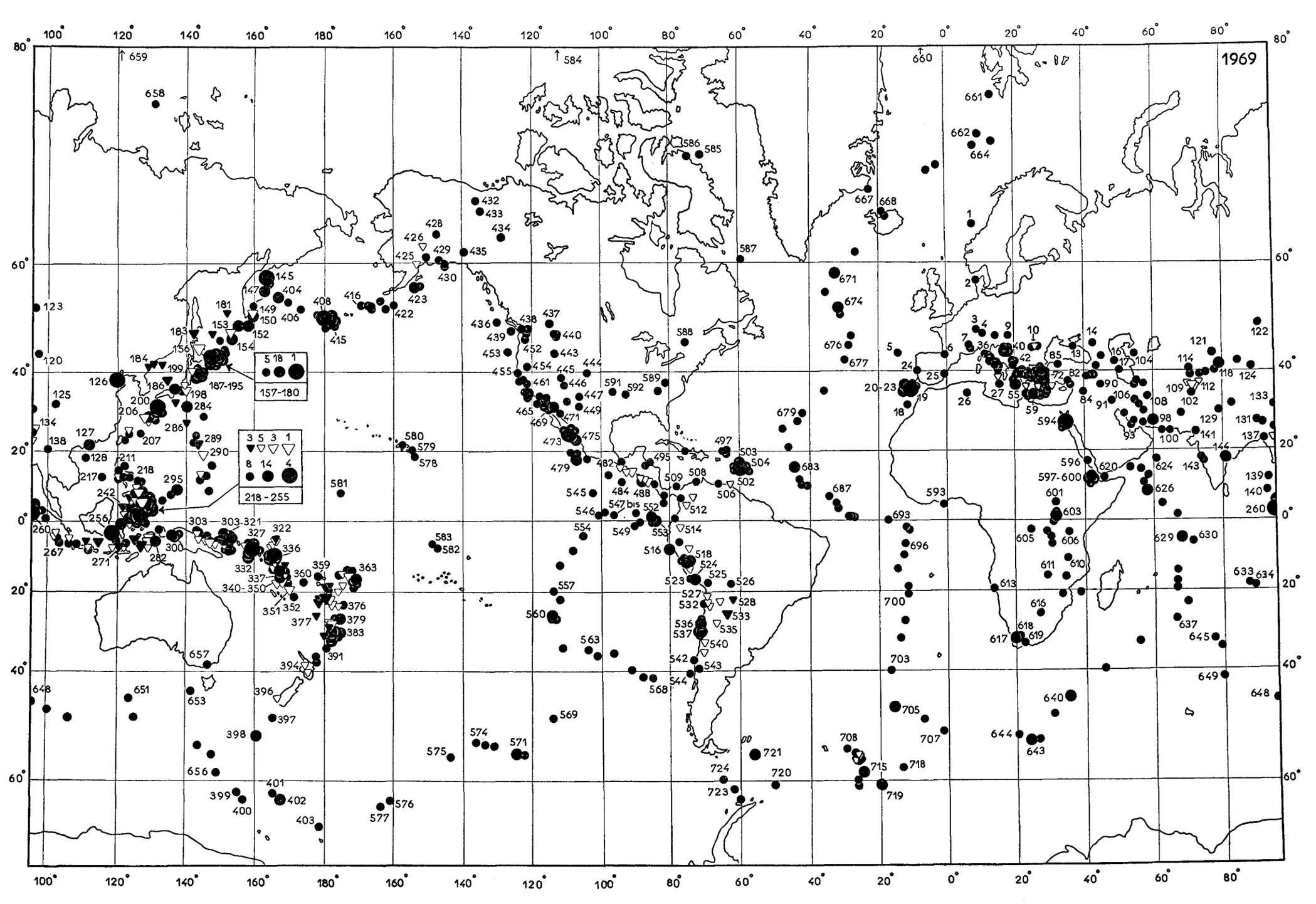

FIG. 1. Earthquakes of 1969, map of epicentres. The numbers marking some epicentres are the serial numbers of the earthquakes in the text.

Regional tables and notes

Continental Europe

Caledonian and Hercynian ranges, Scandinavia, Poland, Czechoslovakia, British Isles, Belgium, Germany, Hercynian France

Region[1]	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	m^2	M^3	
40	**1**	29 September	10.27	65.1° N.	6.6° E.	4.8	—	6
36	**2**	5 April	19.09	57.1° N.	7.2° E.	4.5	—	n^4
36	**3**	26 February	01.28	48.3° N.	9.0° E.	4.4	5.5	27
36	**4**	26 November	22.28	47.9° N.	11.1° E.	—	—	—

1. Number of the region in the classification of Gutenberg and Richter (*Seismicity of the Earth and Associated Phenomena*, 2nd ed., Princeton, N.J., Princeton University Press, 1954).
2. Magnitude m determined by the United States Coast and Geodetic Survey.
3. Magnitude M as determined by various stations (Uppsala, Pasadena, Strasbourg, Kew, Moscow, etc.).
4. The letter n indicates normal depth (focus in the crust or at the base of the crust).

1. Norwegian Sea, off Namsos.

2. North Sea, under the continental shelf at the entrance to the Skagerrak; felt at Farsund (Norway).

3. 'Classic' focus in the Schwabian Jura, already responsible for the severe shock of November 1911 (studied by Gutenberg) and for several other notable shocks, particularly those of 2 and 28 May 1943; damage in the village of Onstmettingen (intensity VII) and in the town of Tailfingen; there were cracks in the walls of several houses which had been damaged by previous earthquakes, falls of chimneys and roof tiles, and some ground fissures; a landslide occurred east of Hechingen; a detailed macroseismic map has been prepared of the epicentral region [5]. The shock was widely felt in western Germany and in Alsace east of the Vosges, most strongly in the north of the department of the Bas-Rhin; many aftershocks. Another earthquake, slightly stronger than that of 1969, was to occur at the same focus on 22 January 1970.

4. One of the several shocks felt in 1969 in the region of Peissenberg (Bavaria); this earthquake swarm is no doubt related to a tectonic feature in the pre-Alpine Molassic trench [6].

Pyrenean-provençal folds, western Alpine arc, Carpathians, Crimea, Caucasus

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
31	**5**	26 July	12.24	43.7° N.	14.5° W.	4.8	—	*n*
31	**6**	24 November	10.51	43.4° N.	0.6° W.	—	—	—
36	**7**	10 May	07.24	45.4° N.	6.5° E.	—	—	—
36	**8**	1 June	23.20	47.1° N.	14.3° E.	4.4	—	*n*
36	**9**	9 February	23.08	47.3° N.	18.0° E.	4.6	4.0	*n*
51	**10**	15 January	08.46	45.7° N.	26.4° E.	4.5	—	135
30	**11**	21 December	19.06	45.6° N.	26.9° E.	4.6	4.7	34
30	**12**	12 April	20.38	45.3° N.	25.0° E.	5.2	5.2	8
30	**13**	12 July	03.05	44.8° N.	37.1° E.	4.4	4.3	39
30	**14**	26 September	07.00	45.9° N.	42.5° E.	5.6	5.0	0
29	**15**	17 June	23.24	43.2° N.	45.3° E.	5.1	5.4	6
29	**16**	15 March	08.26	42.4° N.	49.0° E.	5.0	4.5	46
29	**17**	4 November	20.17	40.2° N.	50.2° E.	5.0	4.3	29

5. Unusual epicentre in the Atlantic west of Spain; it is reasonable to suppose that the epicentre of the earthquake of 26 July 1969 and those of the earthquakes of 22 April 1921 (44° N., 17° W.), of 20 June 1936 (42.5° N., 11° W.) and of 16 October 1938 (43.5° N., 3.5° W.) mark the prolongation along the north coast of Spain and into the Atlantic of the north-Pyrenean front zone, which certain authors regard as a 'transcurrent' fault responsible for the western displacement of the Iberian peninsula [7].

6. Epicentre in the Lacq oil-field, where large amounts of gas are pumped from a depth of 3,500 m; it is possible that this shock may be related to the increasing exploitation of this field; a similar hypothesis was put forward to explain the large earthquake which occurred on 15 May 1951 at an unusual epicentre in the Po valley near an area where there are a number of gas wells [8, 9].

7. Epicentre on the Briançon seismic arc south of Moutiers; intensity IV-V at Saint-Laurent de la Côte, Saint-Martin de Belleville, Saint-Jean de Belleville; these villages had already been affected by the earthquakes of 1855, 1865 and 1930 [10].

8. Niedere Tauern (Austria); felt in Carinthia and Styria (I_0 = V-VI). The seismicity of Austria during the period 1901-68 is the subject of a recent publication [11].

9. Hungary, Lake Balaton region.

10. Intermediate earthquake at the usual focus in Vrancea.

12. Romania; intensity VI in the region of Campulung, subterranean noises and luminous phenomena.

13. Western Caucasus, on the Black Sea coast; focus near that of the earthquake of 12 July 1966 which was strongly felt in the region of Anapa [12, 13].

14. Unusual epicentre east of the Azov sea.

15. Eastern Caucasus.

16. Caspian Sea near the Apsheronskiy peninsula, on the seismic axis linking the

Caucasus with the Kopet-Dag. The seismicity of this region is the subject of a recent study [14]. Note also a study of the seismic activity in the Crimea [15].

Mediterranean regions

Atlantic west of Gibraltar, Alpine zone in Spain, Portugal, Morocco, Algeria, Tunisia, Sicily, Apennines, Northern Italy

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
31	**18**	8 May	20.47	32.5° N.	12.0° W.	4.3	—	*n*
31	**19**	28 February	02.40	36.1° N.	10.6° W.	7.3	8.0	22
31	**20**	28 February	04.25	36.2° N.	10.5° W.	5.7	6.1	*n*
31	**21**	5 May	05.34	36.0° N.	10.4° W.	5.5	5.2	29
31	**22**	6 September	14.30	36.9° N.	11.9° W.	5.7	6.0	*n*
31	**23**	24 December	05.04	36.0° N.	10.4° W.	5.1	—	*n*
31	**24**	21 October	23.10	39.9° N.	8.4° W.	4.7	—	9
31	**25**	23 January	18.28	39.4° N.	0.6° W.	4.3	—	*n*
31	**26**	26 January	14.26	35.4° N.	6.0° E.	4.7	—	31
31	**27**	31 March	03.24	37.7° N.	15.2° E.	—	—	—
31	**28**	2 April	01.38	39.0° N.	15.3° E.	4.8	—	270
31	**29**	29 March	01.43	40.0° N.	15.2° E.	4.6	—	310
31	**30**	14 November	06.48	40.7° N.	15.7° E.	4.7	—	15
31	**31**	17 April	09.12	41.6° N.	13.8° E.	4.6	—	6
31	**32**	2 July	07.55	42.2° N.	12.0° E.	4.4	—	*n*
31	**33**	11 August	13.55	43.2° N.	12.4° E.	4.6	4.7	*n*
31	**34**	9 August	09.21	44.2° N.	11.9° E.	4.1	—	*n*
31	**35**	6 January	22.03	44.1° N.	10.7° E.	4.5	4.3	7
32	**36**	10 January	16.17	44.6° N.	12.0° E.	4.5	4.0	11
36	**37**	9 October	03.31	45.1° N.	7.4° E.	4.2	4.0	*n*

18. Unusual epicentre in the Atlantic between Madeira and the Moroccan coast. **19-23.** The largest earthquake of 1969 occurred in the 'trans-Atlantic' seismic zone which extends from the Strait of Gibraltar to the Azores and which is the site of relatively frequent violent earthquakes [16, 17]; that of 25 November 1941 (37.4° N., 19.0° W.), of magnitude 8.3, was strongly felt in Portugal and Morocco; the earthquake of 27 December 1941, of magnitude $6\frac{3}{4}$, occurred at exactly the same focus (36.0° N., 10.5° W.) as that of 1969, and it seems likely that the great Lisbon earthquake of 1755, which was so destructive in Portugal, Spain and Morocco, occurred in the same neighbourhood (36° N., 9° W.). It may be noted that Sykes has recently determined the focal mechanism of two earthquakes in this zone; in the eastern part of the zone the mechanism is one of compression, while in the neighbourhood of the Azores the movements indicate tension [18, 19].

The earthquake of 1969 was felt up to a distance of 1,300 km, from the Canary Islands to southern France (intensity II at places near Bordeaux and Toulouse); although the focus was at more than 200 km from Cape Saint-Vincent (Portugal) and thus 400 km from the Moroccan coast, the shock caused damage and some

loss of life in Portugal, Spain and Morocco. An isoseismal map has been published [1, Vol. 59, p. 1745].

In Portugal, intensity VI was reached at Lisbon, Coimbra and Setubal; on the Algarve coast, the intensity was reported to have reached VII-VIII; 2 persons were killed and 60 injured by falling debris; there was fissuring of the ground and many houses were dangerously cracked [4, 20, 21].

In Spain, intensity VII was observed at Ayamonte and Isla Cristina on the Gulf of Cádiz, at Moguer and at Morón de la Frontera (2 injured, damage to houses and to the tower of the castle); intensity VI at Sevilla, Tarifa, Badajoz and Cádiz; intensity V at Córdoba, Granada, Ceuta; intensity IV-V at Madrid [22]. The earthquake was the indirect cause of several deaths by heart failure, 11 in Portugal and 5 in Spain [4, 23].

In Morocco, the shock was felt strongly along the whole Atlantic coast and, coming as it did in the middle of the night, caused general alarm; during the preceding 3 days, heavy rains had soaked the soil and the houses of dried brick; several buildings collapsed, leaving 2 dead and 8 injured at Salé, 1 dead at Safi, 1 injured at Casablanca and at Mohammedia, 2 dead and 7 injured in the region of Marrakech [23]. A tsunami was recorded at Casablanca; moving at a velocity of about 600 km/h, the first wave reached the port 40 minutes after the earthquake, with a maximum amplitude of 120 cm. This tsunami was also reported, though with smaller amplitude, in the Gulf of Cádiz, in the Canary Islands and at Lagos (Portugal).

The shock was felt by many ships at sea. The *Fausta*, sailing 2 miles south of Cape Saint-Vincent, felt a violent shock followed by strong vibrations whose amplitude at mast-head was at least 1 m [24]. The *Toubkal* (8,500 tons), at 37°11′ N., 9°12′ W., 170 km from the epicentre, was shaken for at least a minute; the officer on watch, suspecting damage to a propeller, reduced speed. Reports from other witnesses were collected by the harbour master of Casablanca [23, March 1969, p. 3]. See also the report of the captain of the oil tanker *Esso Newcastle* [1, Vol. 59, p. 1746; 25, cards 496 and 497]. Mendès [21] summarizes, in terms of the Rudolf scale, many observations made by ships at sea.

The main earthquake was followed by numerous aftershocks; at least 594 were recorded by Moroccan stations between 1 March and 31 December 1969. The earthquake at 04.25 h (**20**) on 28 February, coming less than 2 hours after the main shock, revived people's anxiety; that of 5 May (**21**) was felt with intensity V at Lisbon, in southern Spain and in Morocco, with intensity IV-V at Kenitra and Mohammedia, IV at Salé, Safi and Casablanca, III-IV at Marrakech [23, May 1969]; the shock of 6 September (**22**), whose focus was 165 km north-west of that of the main shock, was felt with intensity IV at Rabat and Casablanca, as well as in southern Spain and Portugal. On 24 December, a further aftershock (**23**) was felt with intensity III on the Atlantic coast of Morocco, between Kenitra and Casablanca.

The events of 28 February 1969 confirmed that the towns on the Atlantic coast of Morocco lie within a seismic zone where earthquake-resistant measures should be applied, as recommended by J. P. Rothé in 1960 [26].

A seminar was held at the Faculty of Letters in Rabat on the popular beliefs concerning earthquakes. The alarm created among the public by the seismic shocks

that were felt in Moroccan cities in 1969, and its profound social repercussions, may be explained in the light of the mentality and sensitivity of the different social categories. Certain practical conclusions may be drawn regarding the psychological preparation of the public for the adoption of measures of protection against natural disasters, whose successful application depends to a great extent on the spirit and discipline of the public [23, P. Stahl, March 1969, p. 2].

24. Portugal, intensity IV at Coimbra, II-III at Lisbon; premonitory shock on 18 September at 03.14 h.

25. Felt at Valencia (Spain).

In Morocco—apart from the many shocks of Atlantic origin described above (**19-23**)—there was also an earthquake swarm in the middle Atlas in March-April 1969, in the region of Tillouguite (32°04′ N., 6°12′ W.); in 1936, there had been a similar swarm of about 40 shocks of which the strongest, which occurred on 14 May, was of intensity VI-VII and caused some damage; several other shocks have occurred from time to time in the same region since 1936 [23].

There appears to have been only slight seismic activity in Algeria in 1969; only one shock, in the Saharan Atlas near Batna, need be mentioned (**26**).

27. Local shock, probably of volcanic origin; intensity VI on the eastern slopes of Etna; at Giarre and Catania, many people hurriedly left the town by car [27].

A further aftershock of the destructive earthquakes of January 1968 occurred on 18 February 1969 and was felt throughout the Belice Valley (Montevago, Menfi, Sambucca, etc.) but caused no damage [4].

28, 29. Foci under the Tyrrhenian sea at depths of 270 and 310 km; other earthquakes occurred at similar depths in this area on 13 April at 05.45 h (275 km), on 15 April at 00.56 h (300 km), on 12 October at 18.54 h (290 km) and on 23 October at 02.12 h (275 km).

31. Campania (Italy); severe damage at Cassino, Belmonte, Castello and Terelle; slight damage at Pontecorvo, Aquino, Roccasecca, Arce, etc. [3].

32. A series of shocks in the Tolfa mountains, a volcanic region north-west of Rome; the strongest shock reached intensity VII at Civitella Cesi and at Rota, VI at Civitavecchia and Tolfa; some damage was reported, particularly to the castle at Rota; the macroseismic area was only about 3,500 km^2. It should be noted that this region had previously been considered as aseismic [28].

33. Some damage in Umbria and 4 injured; intensity VI-VII at Perugia, Tavernelle, Mugnano, Frontignano [3].

34. Tuscan Apennines; felt near Florence; several aftershocks [3]; other shocks were felt at Florence on 15 February at 08.45 h and 1 May at 22.53 h, causing some considerable alarm [4].

35. Tuscan Apennines; slight damage at San Marcello Pistoiese, Limano, Casoli, Mammiano, Basso, Piteglio; felt in the provinces of Pistoia, Massa, Lucca and Pisa; the epicentral zone was studied by P. V. Ricci [29].

36. Romagna (Italy); intensity V-VI in the region of Forli [30].

37. On the Piedmont seismic arc [10], north of Pinerolo; felt at Torino.

The series of shocks which occurred in 1968 in the Ligurian Apennines (see *Annual Summary*, No. 3, 1968) continued in March 1969, particularly on 2 March at 14.23 h. A detailed study of this earthquake swarm has been published [31].

Dinaric Alps, Ionian Islands, western Greece, Crete, Rhodes

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
31	**38**	26 October	15.36	44.9° N.	17.3° E.	5.3	6.3	*n*
31	**39**	27 October	02.55	44.9° N.	17.0° E.	4.9	5.2	*n*
31	**40**	27 October	08.10	44.9° N.	17.2° E.	5.3	6.4	*n*
31	**41**	31 December	13.18	44.9° N.	17.2° E.	5.1	5.4	*n*
31	**42**	9 August	16.25	42.4° N.	19.3° E.	5.0	5.0	25
30	**43**	26 August	02.15	41.6° N.	20.4° E.	4.9	4.8	42
30	**44**	10 May	21.10	41.3° N.	20.3° E.	4.4	4.3	42
31	**45**	3 April	22.12	40.5° N.	19.8° E.	5.1	5.7	*n*
31	**46**	8 April	15.48	40.5° N.	19.9° E.	5.1	—	*n*
30	**47**	12 October	13.34	39.7° N.	20.5° E.	5.1	5.1	14
30	**48**	13 October	01.02	39.8° N.	20.6° E.	5.6	5.8	8
30	**49**	21 February	18.39	39.2° N.	21.9° E.	4.6	—	41
30	**50**	14 April	05.11	39.0° N.	21.9° E.	4.6	4.6	*n*
30	**51**	16 May	07.26	38.9° N.	21.7° E.	5.2	5.2	20
30	**52**	13 August	04.06	38.5° N.	21.7° E.	4.5	—	*n*
30	**53**	16 June	16.06	38.1° N.	20.2° E.	4.5	5.0	42
30	**54**	7 June	15.31	37.9° N.	20.2° E.	4.6	5.1	39
30	**55**	8 July	08.09	37.6° N.	20.2° E.	5.4	6.0	*n*
30	**56**	13 February	15.09	34.7° N.	22.6° E.	4.6	—	*n*
30	**57**	20 December	17.40	36.6° N.	23.5° E.	4.6	4.3	88
30	**58**	1 December	20.18	35.0° N.	24.2° E.	5.0	4.5	53
30	**59**	12 June	15.13	34.5° N.	25.0° E.	5.8	6.2	25
30	**60**	14 June	13.47	34.3° N.	25.1° E.	5.0	4.9	9
30	**61**	28 September	22.54	34.3° N.	25.1° E.	5.4	5.7	19
30	**62**	31 January	14.40	34.3° N.	26.1° E.	5.1	—	34
30	**63**	26 February	12.35	36.5° N.	27.3° E.	4.8	—	27
30	**64**	16 April	23.21	35.3° N.	27.9° E.	5.2	5.4	45
30	**65**	1 May	20.06	35.2° N.	27.7° E.	4.7	5.2	32
30	**66**	14 May	10.05	35.4° N.	27.7° E.	5.1	5.2	34
30	**67**	25 June	06.11	35.9° N.	27.5° E.	4.7	—	38
30	**68**	6 September	20.30	36.8° N.	28.4° E.	5.1	5.0	70

38-41. On 26 October and the following days, northern Bosnia was affected by several destructive earthquakes, the most severe to occur in Yugoslavia since the Skopje catastrophe of 1963. The first shock (**38**) killed 1 person, injured 200 and caused serious damage to the city of Banja Luka (intensity VII-VIII); it was felt at Zagreb, Trieste, Sarajevo, Beograd and Ljubljana; on 27 October, after a minor shock at 02.55 h (**39**), the strongest shock of the series occurred at 08.10 h (**40**), that is to say 17 hours after the first movement. On the advice of the Ljubljana Geophysical Observatory, part of the city of Banja Luka was evacuated after the first shock; in spite of this, the earthquake of 27 October killed 9 persons, injured 1,100 and caused further severe damage. About 60 per cent of the buildings in the town were destroyed; water, gas and electricity supplies were interrupted; 60,000 people were left homeless. In the upper town, only the famous mosque of Ferhat Pasha remained undamaged [4]. In the surrounding areas, many houses were damaged at Brcko, Jablan, Bukovica and Bakanci. Unesco sent a mission of

experts, who carried out a detailed analysis of the damage caused by these earthquakes [33].

There were several aftershocks; that of 31 December (**41**) claimed victims (1 dead, 5 injured) in Banja Luka and caused some further damage, including the collapse of several buildings which had been damaged in October, particularly the old castle which had been transformed into a museum.

The region of Banja Luka belongs to the Dinarids, whose seismicity is well known, but according to the seismic map of Yugoslavia, the maximum intensity observed previous to 1969 had not exceeded VII [32].

42. Montenegro; intensity VI at Titograd, V at Kotor; felt in Albania with intensity V-VI at Shkodër and Renc, III at Tiranë; strong aftershock at 17.01 h.

Albania was affected by several large earthquakes in 1969:

43. Intensity VI-VII at Kovashica and Shupenzes, VI at Peshkopi, V-VI at Kukës and Domen, V-VI at Debar (Yugoslavia).

44. Intensity V-VI at Librazhd, IV-V at Elbasan, III at Tiranë; also felt at Debar in Yugoslavia.

45, 46. Active focus in southern Albania ('Mallakastra zone'). The earthquake of 3 April was felt over an area of 210,000 km^2 and caused severe damage in Albania in the departments of Fier, Tepelenë, Berat, Vlorë, Skrapar and Përmet; about 1,000 houses were damaged or destroyed; 2,000 were slightly damaged; 1 dead, 61 injured. According to the Tiranë seismological observatory, the epicentre was slightly north of Tepelenë; intensity VII-VIII was observed in Rabije, Izvor, Levan, Cërrile, Kapaj, Osmanzezë, VI-VII at Tepelenë, VI at Fier, Berat, Çorovodë [34]; the shock was also felt in Yugoslavia (intensity IV-V at Ohrid and Struga), in Italy at Bari, Taranto and Brindisi in Puglia, and in Greece (intensity VI at Konitsa, V in Corfu) [3]. Several aftershocks were felt, particularly on 8 April (**46**), when further damage was reported in the epicentral zone at Izvor, Rabije, Luftinje, Gllavë and Osmanzezë (province of Tepelenë) [34]. There were further aftershocks at 18.12 h on 7 July, at 17.27 h on 9 July and at 22.02 h on 28 December.

The Albanian seismic zone continues into Greece, in the province of Ioannina; the earthquake of 12 October (**47**) was felt over an area of 10,000 km^2, with intensity V at Igoumenitsa, IV at Zitsa; after several other premonitory shocks, a stronger earthquake was felt on the following day (**48**) over 320,000 km^2; 40 houses were severely damaged, 1,079 houses, 4 schools and 3 churches suffered moderate damage and there were 2 people injured; damage was also reported from several places in the provinces of Ioannina and Préveza; intensity VII-VIII at Senikon, VII at Raphtanaece, Zitsa, Perama, Eleousa (Ioannina province), Polyvrison (Préveza province), Kouremadion (Thesprotia province); there were several aftershocks, particularly on 27 October at 08.42 h and on 16 December at 11.47 h [35].

The region of the Kremasta reservoir was again the site of several earthquakes (**49-51**) in 1969; a destructive earthquake had occurred in February 1966 after the first filling of the reservoir [13, p. 19-20].

49. At Platanos (Evritania), 10 houses damaged, intensity VI at Neraidha, macroseismic area 8,000 km^2.

50. Intensity VII at Ayios Georgios and Neochorion (Evritania), VI-VII at Ayios Vlasios; macroseismic area 30,000 km^2.

51. Widely felt in Trikkala, Mesolongion, Navpaktos, Aiyion, etc.; several aftershocks in the immediate neighbourhood of the Kremasta dam, particularly on 28 May at 21.53 h (38.8° N., 21.6° E.) and on 12 July at 00.19 h (38.8° N., 21.5° E.).
52. Intensity VI-VII at Molykrion and Navpaktos (Aitolia); macroseismic area 15,000 km^2.
53, 54. Ionian Islands; felt at Valsamata (Kefallinia); many other shocks in the same region.
55. Strong shock with focus in the Ionian sea, widely felt over 310,000 km^2 in the Peloponnisos and the Ionian Islands, with intensity VI-VII at Khavari (Ilia).
58. Felt in Crete, with intensity IV-V at Palaeochora.
59-61. Very active focus south of Crete; numerous aftershocks.
63. Dodecanese, intensity IV at Nisiros.
64-6. Another very active focus east of the island of Karpathos; the main shock (**64**) was preceded at 04.54 h and at 22.55 h on the preceding day by two strong premonitory shocks of magnitude 5.1 and 5.3; many aftershocks.
67. Intensity IV at Olimbos (Karpathos).
68. Intensity III at Livadia (Tilos) [35].

The relation between the seismicity and the tectonics of Greece was recently studied [36].

Eastern Greece, Aegean Sea, western Anatolia

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
30	**69**	27 December	07.31	39.1° N.	23.7° E.	4.6	4.8	31
30	**70**	21 April	20.36	39.5° N.	25.2° E.	4.8	4.8	*n*
30	**71**	3 March	00.59	40.1° N.	27.4° E.	5.6	6.0	4
30	**72**	14 August	21.51	39.6° N.	27.7° E.	4.6	—	21
30	**73**	22 March	18.00	39.1° N.	28.6° E.	4.5	4.4	*n*
30	**74**	23 March	21.08	39.1° N.	28.5° E.	5.6	6.2	12
30	**75**	25 March	13.21	39.1° N.	28.4° E.	5.6	6.4	23
30	**76**	30 April	20.20	39.1° N.	28.7° E.	5.1	5.4	9
30	**77**	7 October	05.09	39.2° N.	28.4° E.	5.0	5.0	14
30	**78**	28 March	01.48	38.6° N.	28.4° E.	6.0	6.5	9
30	**79**	6 April	03.49	38.5° N.	26.4° E.	5.5	5.8	14
30	**80**	14 January	23.12	36.2° N.	29.1° E.	5.5	6.4	*n*
30	**81**	4 March	01.47	37.1° N.	31.1° E.	5.0	—	120

69. Aegean Sea, near the island of Skopelos; intensity IV-V at Volos (Magnisia).
70. Aegean Sea near the island of Ayios Evstratios, at a focus near that of the destructive earthquake of 19 February 1968.
71. Turkey, at the western extremity of the north Anatolian fault, at the focus of the great destructive earthquake of 18 March 1953 [37]; the earthquake of 1969 injured 1 person and destroyed 20 houses at Gönen and was strongly felt at Balikesir, Bursa and Istanbul [3]; felt in the island of Lésvos, with intensity V at Mitilini,

III-IV at Ayios Paraskeve [35]; aftershock on 5 March at 14.41 h, felt at Istanbul and in the island of Lésvos.

72. Felt in the region of Balikesir.

A large number of earthquakes **(73-7)** occurred in 1969 in the region of Demirci. The destructive earthquake at Gediz (28 March 1970) and its aftershocks probably occurred on an eastward extension of the tectonic feature which became active in 1969.

73. Premonitory shock; damage at Demirci, Gördes and Sindirgi; 1,776 houses destroyed, 1,832 others damaged; total damage estimated at U.S.$110,000; the epicentral area was elongated in a NW.-SE. direction [1].

75. Another strong shock, causing further damage at Sindirgi and Demirci [3]. The shocks continued during the month of April; on 30 April a widely felt shock **(76)** injured 15 persons and destroyed 50 houses at Demirci. Between 22 March and 30 May, Kandilli Observatory (Istanbul) recorded 570 aftershocks [1].

77. Another shock at the same focus, strongly felt in north-western Anatolia.

While the tremors continued in the region of Demirci, two other foci became active, one 60 km to the south (Alasehir), the other 180 km to the west (Karaburun).

78. Destructive earthquake in the Alasehir valley; the calculated epicentre is close to the Demirköprü dam on the northern side of the valley. There were 53 dead, 350 injured and 4,000 houses destroyed; the brick-built houses in the towns of Alasehir, Sarigol and Kiraz suffered less damage than the masonry or adobe houses in the surrounding villages; there was fracturing and fissuring in the alluvial plain of the river Koca, an affluent of the Gediz river [1]. The main shock was felt over an area of 500,000 km^2 [35], throughout western Anatolia and in the islands of the Aegean (Lésvos, Khíos, Sámos, Kos, Límnos, Rodhos and Kárpathos). It may be noted that the focus of the Salihli earthquake swarm of 1965 [37] lies only about 20 km west of the epicentral zone of the 1969 earthquake.

79. Karaburun peninsula, opposite the island of Khíos; 443 houses destroyed at Karaburun and at Çesme; some damage in the island of Khíos; intensity VI-VII, with 3 persons injured at Zyphia, V-VI at Khíos, Vessa and Kalamoti; felt over an area of 140,000 km^2 [35], particularly in the islands of Sámos, Náxos, and Límnos. The Karaburun peninsula and the island of Khíos had already suffered considerable damage in the earthquake of 23 July 1949 [38].

80. South coast of Anatolia; 35 houses destroyed at Kas, 8 at Kalkan [3]; felt in south-western Anatolia and in the island of Rodhos (intensity V at Kremaste).

81. Intermediate earthquake, felt at Antalya.

Cyprus, south-eastern Mediterranean, southern Anatolia, Syria, Lebanon, Israel, Egypt, Libya

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
30	**82**	19 May	18.14	37.8° N.	35.1° E.	4.6	—	34
30	**83**	24 May	11.49	36.9° N.	35.4° E.	4.3	—	43
30	**84**	4 September	17.18	35.3° N.	39.1° E.	4.7	—	*n*

82. Taurus mountains, north of Adana.

83. Strongly felt at Adana.

84. Unusual epicentre in the Jebel-el-Bishri (Syria), between Palmyra and the Euphrates valley.

No notable seismic activity was observed in either Lebanon, Israel or Libya.

A very violent earthquake, with focus situated in the northern Red Sea, was strongly felt in Egypt and in Israel (see **595**).

Asiatic ranges

Eastern Anatolia, Transcaucasia, Iraq, southern Iran, Pakistan, western India

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
30	**85**	10 January	16.33	41.6° N.	32.6° E.	4.6	—	18
30	**86**	1 October	20.33	39.3° N.	40.5° E.	4.8	—	40
30	**87**	10 September	12.14	39.2° N.	41.4° E.	5.2	5.3	*n*
30	**88**	25 December	02.07	39.0° N.	42.6° E.	4.9	—	65
30	**89**	14 June	17.45	41.4° N.	43.2° E.	4.7	4.7	26
29	**90**	28 November	01.29	36.8° N.	45.2° E.	4.7	—	16
29	**91**	31 October	08.53	33.2° N.	48.3° E.	5.0	—	50
29	**92**	29 April	04.37	29.6° N.	51.5° E.	5.6	5.0	36
29	**93**	3 November	21.53	26.7° N.	53.7° E.	5.0	—	8
29	**94**	14 April	13.13	27.8° N.	54.7° E.	5.0	5.0	44
29	**95**	28 June	22.32	32.3° N.	56.1° E.	4.7	—	*n*
29	**96**	21 June	16.35	27.4° N.	57.5° E.	5.3	—	65
29	**97**	2 September	13.30	30.2° N.	57.7° E.	5.3	—	20
29	**98**	7 November	18.33	27.9° N.	60.1° E.	6.1	6.7	35
29	**99**	13 February	11.11	25.0° N.	62.9° E.	5.2	5.4	*n*
47	**100**	3 December	02.31	24.7° N.	65.4° E.	4.9	5.0	*n*
47	**101**	20 September	04.48	29.7° N.	68.6° E.	5.2	—	40
47	**102**	15 May	20.39	34.6° N.	70.9° E.	5.6	—	22

85. Paphlagonia, region of Bartin; aftershock of the destructive earthquake of 3 September 1968 [39]; another aftershock occurred on 25 February 1969 at 13.43 h ($m = 4.3$).

86, 87, 88. Foci lying along the eastern part of the north Anatolian fault zone, west of Karliova (**86**), in the region of Varto (**87**) and north of Bitlis (**88**) where the shocks caused slight damage.

90. Kurdistan; felt in north-western Iran.

91. Luristan, Zagros mountains south-east of Kermanshah; slight damage at Malavi, Pole Dukhtar, Kuh-I-Dasht and Haft Gel [2].

93. Southern coast of Iran, south of Lar; first of a swarm of shocks (5 earthquakes of magnitude $m = 5.0$ between 3 November and 1 December).

95. Central Iran, north-west of Kerman.

97. Central Iran, near Kerman.

98. Strong earthquake widely felt in south-eastern Iran, particularly at Zahedan, Khash, Bampur, Chah Bahar, Qasr-e-Qand, Iranshahr [40].
99, 100. Makran coast.

Northern Iran, Turkmenistan, Afghanistan, Hindu Kush

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
29	**103**	26 January	02.25	36.8° N.	54.5° E.	4.8	—	48
29	**104**	6 December	07.03	43.8° N.	54.8° E.	5.8	5.0	*n*
29	**105**	23 November	11.40	38.3° N.	55.5° E.	4.9	5.0	38
29	**106**	11 November	00.30	33.4° N.	55.0° E.	5.0	—	*n*
29	**107**	3 January	03.16	37.1° N.	57.8° E.	5.6	5.2	11
29	**108**	23 August	19.16	33.9° N.	58.9° E.	5.1	5.0	32
48	**109**	10 June	23.30	36.3° N.	70.4° E.	5.2	—	210
48	**110**	5 March	19.33	36.4° N.	70.7° E.	5.9	6.0	210
48	**111**	8 August	06.30	36.4° N.	70.9° E.	5.8	6.0	200
48	**112**	24 November	17.23	37.2° N.	71.7° E.	5.6	—	120

A press report [4], dated 6 April, indicated that an earthquake—which does not seem to have been recorded—killed 2 persons, injured 10 and caused considerable damage (2 villages destroyed) in the region of Bostanabad, 50 km south-east of Tabriz (Iranian Azarbaïjan); an earthquake had already caused severe damage in this region on 10 February 1965.
103. Elburz range, north-east of Tehran.
105. Kopet Dag range, whose seismic activity is well known; aftershocks on 24 November at 15.44 h ($m = 4.8$) and on 25 November at 09.16 *h* ($m = 4.8$).
107. Destructive in the Esfarayen valley, west of Mashhad; 50 killed, 300 injured, 2,000 left homeless; there was much damage along a line running from Esfarayen to Nishapur, through the villages of Bojnürd, Shirvan, Qüchan, Sabzevar and Dahane Oyach, which latter village was destroyed [1, 4]; several premonitory and aftershocks were recorded by the Mashhad observatory.
108. Khorasan, aftershock of the destructive Dasht-e Bāyāz earthquake of 31 August 1968; further aftershocks on 3 September 1969 at 23.29 h (34.2° N., 58.3° E., $m = 4.8$) and on 2 December at 22.46 h (33.9° N., 58.6° E., $m = 5.1$). The earthquake of 1968 and its aftershocks were the subject of several papers in the *Bulletin of the Seismological Society of America* [41, 42, 43, 44]; see also the article by M. Sobouti [45].
109-11. Intermediate earthquakes at the well-known Hindu Kush focus; these earthquakes are generally felt at Kabul; about 10 other shocks of magnitude about 5 occurred at the same focus in 1969.
112. Felt in Tadzhikistan [2]. A study of the seismicity of the Hindu Kush has just been published [46].

Pamir, Soviet central Asia, Tien Shan, Mongolia, Siberia

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
48	**113**	22 March	04.52	38.9° N.	70.6° E.	5.3	5.5	8
48	**114**	9 December	13.41	40.4° N.	70.2° E.	5.0	—	*n*
48	**115**	28 August	03.58	39.1° N.	73.6° E.	5.1	5.8	20
48	**116**	14 September	16.15	39.6° N.	74.9° E.	5.5	5.9	*n*
27	**117**	20 July	04.34	39.8° N.	77.8° E.	5.0	—	*n*
27	**118**	11 February	22.08	41.4° N.	79.2° E.	5.8	6.5	*n*
27	**119**	9 June	18.52	42.0° N.	84.6° E.	4.7	—	36
28	**120**	18 July	13.10	43.3° N.	97.1° E.	4.6	—	*n*
28	**121**	1 May	04.00	44.0° N.	77.9° E.	4.9	—	53
28	**122**	6 April	19.22	50.3° N.	91.2° E.	4.8	—	31
28	**123**	30 October	12.17	52.3° N.	95.6° E.	4.8	—	*n*

118. Numerous aftershocks at the same focus during several months.

The seismicity of the Baïkal region and its relation to the topography and to gravimetric anomalies were the subject of a recent publication [47].

Continental China

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
27	**124**	22 September	16.14	41.4° N.	88.3° E.	5.1	—	*n*
26	**125**	25 September	23.10	32.5° N.	102.2° E.	5.0	—	*n*
27	**126**	18 July	05.24	38.3° N.	119.4° E.	6.2	7.6	*n*
21	**127**	25 July	22.49	21.6° N.	111.9° E.	5.4	6.2	*n*
25	**128**	20 December	02.09	18.4° N.	110.6° E.	5.0	—	*n*

126. One of the most violent earthquakes of 1969; focus in the Gulf of Chihli, off the mouth of the Huang Ho; this earthquake was felt in T'ien-Ching, Pei-Ching (Peking) and as far as the island of Kyushu (Japan); it caused some damage in the areas around the Gulf of Chihli.

127. A further destructive earthquake in China. According to press reports, 3,000 persons were killed, particularly at Shan-t'ou (Swatow) [2, 4], although the calculated epicentre is 600 km south-west of this city.

128. Unusual epicentre near the island of Hai-nan.

Himalaya, Tibet, Yunnan, Burma, Andaman and Nicobar islands

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
26	**129**	22 June	01.33	30.6° N.	79.4° E.	5.4	5.2	19
26	**130**	12 August	00.53	32.3° N.	83.0° E.	4.7	—	39
26	**131**	5 November	20.25	27.7° N.	90.2° E.	5.0	—	13
26	**132**	1 June	08.35	25.8° N.	91.8° E.	5.0	—	20
26	**133**	14 June	03.28	31.7° N.	94.6° E.	5.3	—	*n*
26	**134**	29 August	10.02	26.3° N.	96.1° E.	5.4	—	73
26	**135**	30 September	23.13	25.6° N.	94.7° E.	5.4	—	20
25	**136**	17 October	01.25	23.1° N.	94.7° E.	6.0	6.4	134
25	**137**	25 January	23.34	22.9° N.	92.3° E.	5.2	—	50
25	**138**	2 July	09.59	20.7° N.	99.4° E.	5.0	5.3	*n*
24	**139**	4 December	00.34	12.4° N.	93.7° E.	5.3	—	*n*
24	**140**	30 April	16.34	8.2° N.	93.0° E.	5.0	—	*n*

129. Felt in northern and central Punjab.

132. Felt at Shillong.

A study of the seismicity of Burma and of the seismic zone which extends from the Andaman islands to Java has just been published [48].

Peninsular India

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
27	**141**	24 October	11.45	24.8° N.	72.4° E.	5.3	—	15
26	**142**	27 June	20.05	17.5° N.	73.5° E.	—	4.7	*n*
26	**143**	3 November	23.22	17.3° N.	73.9° E.	—	—	*n*
26	**144**	13 April	15.24	17.9° N.	80.6° E.	5.4	6.0	*n*

142, 143. Aftershocks of the destructive earthquake of 10 December 1967, whose focus was close to the Koyna dam [1, 1969, p. 2389]; the relation between these shocks and the filling of the Koyna reservoir were discussed in previous issues of this summary. Further studies of the Koyna earthquakes have been published [49, 50].

144. Eastern Ghats, near the Godavari valley; some damage was reported from Kottagudem (intensity VI-VII), Borgampad and Bhadrachalam; in the Godavari valley the damage was restricted to alluvial areas; the ancient temple of Parnasala collapsed. In the vicinity of the instrumental epicentre, near Regulagudem, there were some surface manifestations (fissuring, rock falls, changes of water level in wells and springs). The shock was felt strongly at Hyderabad and was noticed as far as Bombay to the west, Bangalore and Madras to the south, Raipur and Cuttack to the north. In contrast with what occurred at Koyna, there was no premonitory shock, but about 40 aftershocks of small magnitude. A detailed study

has been published [51]. The seismicity of the Coromandel coast is not negligible; several shocks have occurred there, notably on 12 October 1959 (15.7° N., 80.1° E.), on 5 December 1963 (17.3° N., 80.1° E.) and on 27 March 1967 (15.8° N., 80.8° E.).

Pacific

WESTERN ISLAND ARCS

Kamchatka, Kuril Islands, Sakhalin

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
19	**145**	22 November	23.09	57.8° N.	163.5° E.	6.3	7.3	*n*
19	**146**	23 December	13.22	57.4° N.	163.1° E.	5.4	5.9	*n*
19	**147**	26 January	15.05	55.8° N.	162.9° E.	5.5	6.0	16
19	**148**	8 June	14.49	53.3° N.	159.7° E.	5.4	5.8	60
19	**149**	16 July	08.16	52.2° N.	159.0° E.	5.8	6.3	70
19	**150**	3 March	14.49	51.6° N.	159.3° E.	5.3	6.0	12
19	**151**	13 June	08.48	49.4° N.	155.5° E.	5.9	6.5	64
19	**152**	22 June	02.33	49.2° N.	158.5° E.	5.6	5.8	*n*
19	**153**	20 August	07.50	47.9° N.	153.6° E.	5.8	6.0	73
19	**154**	4 September	03.08	46.6° N.	153.5° E.	5.4	6.1	*n*
19	**155**	1 August	23.43	45.6° N.	150.9° E.	5.6	6.0	38
19	**156**	19 January	07.02	45.0° N.	143.2° E.	6.4	7.0	204
19	**157**	18 March	16.16	44.1° N.	151.0° E.	5.7	5.5	44
19	**158**	11 August	21.26	43.4° N.	147.9° E.	5.7	—	43
19	**159**	11 August	21.27	43.6° N.	147.8° E.	5.9	—	14
19	**160**	11 August	21.27	43.5° N.	147.8° E.	6.2	—	45
19	**161**	11 August	21.27	43.5° N.	147.4° E.	7.1	7.8	28
19	**162a**	11 August	21.40	43.8° N.	147.5° E.	6.0	—	*n*
19	**162b**	11 August	23.02	43.1° N.	147.8° E.	5.5	6.0	*n*
19	**163**	12 August	03.33	43.1° N.	147.6° E.	5.5	6.2	*n*
19	**164**	12 August	04.53	43.3° N.	147.5° E.	5.7	6.0	*n*
19	**165**	12 August	05.03	43.6° N.	148.0° E.	6.0	6.9	*n*
19	**166**	12 August	05.53	43.7° N.	148.5° E	5.4	6.7	*n*
19	**167**	12 August	09.25	43.1° N.	147.6° E	5.3	6.0	*n*
19	**168**	12 August	09.33	43.6° N.	147.5° E.	5.6	6.0	34
19	**169**	12 August	11.21	43.9° N.	148.7° E.	5.4	6.8	29
19	**170**	12 August	23.05	43.3° N.	147.7° E.	5.0	5.9	*n*
19	**171**	13 August	08.31	44.0° N.	147.7° E.	5.6	5.9	*n*
19	**172**	13 August	22.57	44.0° N.	148.1° E.	5.6	6.2	*n*
19	**173**	14 August	14.19	43.1° N.	147.5° E.	6.1	6.7	*n*
19	**174**	15 August	04.32	43.0° N.	147.9° E.	5.6	6.2	*n*
19	**175**	15 August	10.02	43.1° N.	148.3° E.	4.7	6.0	*n*
19	**176**	16 August	15.15	43.3° N.	147.6° E.	5.7	6.0	60
19	**177**	19 August	08.49	43.8° N.	148.2° E.	5.7	6.4	39
19	**178**	30 August	07.11	43.7° N.	147.8° E.	5.4	6.4	*n*
19	**179**	30 August	08.28	43.6° N.	147.8° E.	5.4	6.3	*n*
19	**180**	29 September	17.58	43.4° N.	147.7° E.	5.4	5.6	32

145. Off the east coast of Kamchatka; the earthquake gave rise to a tsunami whose amplitude reached 52 cm at Shemya, 40 cm at Attu, 27 cm at Adak.
156. Widely felt in northern Hokkaido.
158-79. An exceptional series of earthquakes in the Kuriles trench, north-east of Hokkaido. The series began with 5 premonitory shocks of small magnitude during the preceding 25 hours, then, within 63 seconds, there occurred 4 earthquakes of successively increasing magnitude, the last one being of magnitude 7.8 (**158-61**). Some damage was reported at Shikotan (southern Kuriles); the main shock was strongly felt at Kushiro and Nemuro in Hokkaido, less strongly in northern Honshu and slightly in Tokyo. A tsunami affected the Japanese coast, with a double amplitude of 256 cm at Hanasaki, 109 cm at Hachinohe, 93 cm at Kushiro, 47 cm at Hakodate, etc. [52]. The tsunami was also observed in the Aleutian Islands (60 cm at Attu).

Because of the rapid sequence in which the shocks occurred, it was difficult to make a precise determination of the epicentre of the main shock; the Japanese seismological service gave an epicentre at 42° 42′ N., 147° 37′ E., some distance to the south of that calculated by USCGS, which is given in the above table. Epicentres have been calculated for the 140 aftershocks which occurred during the 48 hours following the main shock [2]; 68 of these aftershocks were of magnitude $m \geqslant 5$.

Japan, Taiwan

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
46	**181**	10 February	06.08	52.0° N.	152.1° E.	4.3	—	500
46	**182**	9 March	11.35	48.1° N.	148.3° E.	5.1	—	390
46	**183**	18 December	13.32	46.3° N.	142.5° E.	5.9	6.5	345
46	**184**	10 April	14.54	42.0° N.	130.9° E.	5.6	—	555
46	**185**	19 November	08.45	41.8° N.	133.7° E.	5.0	—	420
46	**186**	31 March	19.25	38.3° N.	134.6° E.	5.9	6.5	420
19	**187**	8 March	10.20	41.3° N.	139.6° E.	5.7	—	170
19	**188**	20 June	15.37	40.8° N.	142.1° E.	5.4	—	65
19	**189**	12 June	07.41	40.3° N.	143.7° E.	5.1	5.8	*n*
19	**190**	15 April	17.30	39.8° N.	143.4° E.	5.3	6.0	20
19	**191**	22 April	08.11	39.8° N.	143.0° E.	5.5	6.0	36
19	**192**	12 July	19.16	39.7° N.	143.5° E.	5.2	6.1	*n*
19	**193**	18 October	01.13	39.3° N.	141.4° E.	5.3	—	107
19	**194**	16 March	15.54	38.5° N.	142.7° E.	5.4	6.0	40
19	**195**	31 October	07.00	37.1° N.	142.0° E.	5.0	5.8	40
19	**196**	9 April	12.57	36.8° N.	139.6° E.	5.5	—	115
19	**197**	5 April	16.36	36.5° N.	138.2° E.	3.9	4.5	*n*
19	**198**	13 May	14.19	36.4° N.	140.5° E.	5.4	6.1	75
19	**199**	9 September	05.15	35.7° N.	137.0° E.	5.5	6.5	30
20	**200**	21 April	07.19	32.2° N.	131.9° E.	6.1	7.0	40
20	**201**	17 September	18.40	31.1° N.	131.3° E.	6.2	6.8	8
20	**202**	28 July	13.03	30.7° N.	132.5° E.	5.6	5.5	24
20	**203**	10 January	03.20	29.0° N.	130.6° E.	5.5	5.6	*n*
20	**204**	31 December	19.01	28.5° N.	129.1° E.	5.9	6.5	45

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
20	**205**	5 September	22.06	29.0° N.	128.9° E.	4.9	—	105
20	**206**	19 March	13.59	28.8° N.	128.2° E.	5.8	6.0	140
20	**207**	13 December	21.37	23.9° N.	126.5° E.	5.4	5.5	20
21	**208**	12 June	18.59	24.0° N.	122.4° E.	5.3	5.4	*n*
21	**209**	27 July	22.26	24.9° N.	122.5° E.	5.4	—	105
21	**210**	5 September	11.42	22.7° N.	121.7° E.	5.6	5.7	*n*

During the first ten months of 1969, 1,092 earthquakes were felt in Japan [52].

196. Intermediate earthquake felt in the region of Tokyo.

197. The celebrated Matsushiro earthquake swarm, which has been the subject of intense study—see previous issues of *Annual Summary* and recent articles [53, 54]—continued in activity; 349 shocks were felt in the area during the first ten months of 1969 [52].

199. The strongest earthquake to occur in Japan in 1969; 1 killed, 9 injured, 135 houses partly destroyed in the centre of Gifu prefecture (Honshu); many aftershocks.

200. Four injured and slight damage at Miyazaki, where a landslide blocked a road; felt in Kyushu and in parts of Shikoku and Honshu [4].

204. Ryukyu, 5 injured and slight damage at Naze; felt on Yaku-jima Island and in Kagoshima.

An article on the general seismicity of Japan has been published [55].

Philippines, Moluccas, Borneo, Celebes (north of latitude 5° S.)

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
22	**211**	26 March	15.27	16.2° N.	122.2° E.	5.0	5.3	36
22	**212**	6 October	12.48	15.0° N.	120.1° E.	5.6	5.5	60
22	**213**	23 December	14.08	13.8° N.	120.6° E.	5.3	—	120
22	**214**	25 June	00.08	13.5° N.	120.3° E.	5.1	5.7	53
22	**215**	24 June	10.58	13.3° N.	123.0° E.	5.1	5.8	40
22	**216**	10 June	17.15	13.2° N.	121.4° E.	5.4	5.6	40
22	**217**	27 January	14.39	12.5° N.	114.4° E.	5.3	—	*n*
22	**218**	26 May	15.37	11.8° N.	125.8° E.	5.2	5.9	14
22	**219**	21 June	06.36	11.3° N.	125.3° E.	5.3	—	73
22	**220**	21 May	02.56	11.7° N.	125.8° E.	5.2	5.8	25
22	**221**	20 March	19.18	8.7° N.	127.3° E.	6.1	6.2	*n*
22	**222**	2 December	17.57	8.2° N.	126.3° E.	5.7	6.0	100
22	**223**	30 April	21.31	7.5° N.	124.9° E.	5.8	—	35
22	**224**	25 April	13.26	7.3° N.	123.7° E.	4.8	—	660
22	**225**	19 September	01.29	6.1° N.	125.4° E.	5.7	6.0	95
22	**226**	16 July	04.47	5.3° N.	126.8° E.	5.4	—	75
23	**227**	30 January	10.29	4.8° N.	127.4° E.	5.9	7.5	70

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
23	**228**	31 January	00.44	4.2° N.	128.1° E.	5.7	6.6	*n*
23	**229**	31 January	13.48	4.3° N.	128.1° E.	5.4	6.0	*n*
23	**230**	2 February	01.38	3.9° N.	128.2° E.	5.4	6.0	*n*
23	**231**	3 February	19.01	4.4° N.	128.1° E.	5.2	6.0	*n*
23	**232**	3 February	21.41	4.9° N.	127.4° E.	6.1	7.1	*n*
23	**233**	17 February	00.42	3.8° N.	128.4° E.	5.6	6.5	14
23	**234**	20 February	09.55	3.5° N.	128.2° E.	5.7	6.5	*n*
23	**235**	20 February	10.30	3.5° N.	128.4° E.	6.0	6.5	77
23	**236**	20 February	16.58	3.7° N.	128.2° E.	5.3	6.1	50
23	**237**	5 March	13.52	4.0° N.	128.2° E.	5.7	6.2	50
23	**238**	27 March	04.46	3.9° N.	128.5° E.	5.7	6.0	*n*
23	**239**	27 March	12.41	4.8° N.	127.5° E.	6.1	7.0	30
23	**240**	26 February	01.31	4.3° N.	122.1° E.	5.1	—	636
23	**241**	13 December	22.06	4.2° N.	126.3° E.	5.6	—	40
23	**242**	30 January	18.36	4.0° N.	123.0° E.	5.3	—	520
23	**243**	21 July	22.06	2.9° N.	124.7° E.	5.6	—	220
23	**244**	14 December	02.42	2.0° N.	126.9° E.	6.0	6.3	40
23	**245**	12 August	12.21	1.7° N.	126.3° E.	5.8	6.0	30
23	**246**	11 August	23.52	1.7° N.	126.5° E.	6.1	7.0	35
23	**247**	2 March	04.47	1.5° N.	128.1° E.	5.3	—	140
23	**248**	5 August	02.13	1.3° N.	126.2° E.	6.1	7.2	35
23	**249**	25 January	05.19	0.8° N.	126.1° E.	5.9	6.2	24
23	**250**	4 November	22.04	0.1° S.	125.0° E.	5.4	—	*n*
23	**251**	8 November	21.55	1.1° S.	127.0° E.	—	5.9	*n*
23	**252**	2 August	20.12	2.6° S.	126.6° E.	5.6	—	30
23	**253**	21 January	15.16	0.8° N.	120.0° E.	5.6	—	*n*
23	**254**	4 May	17.18	0.0° N.	123.3° E.	5.5	5.5	165
23	**255**	4 February	01.38	0.6° S.	121.7° E.	4.8	6.2	*n*
23	**256**	23 February	00.36	3.1° S.	118.9° E.	6.1	7.3	13
23	**257**	23 February	06.03	3.4° S.	119.0° E.	5.3	5.9	7

211. Luzon (Philippines); intensity IV at Casiguran and Manila, III at Quezon City.

212. West coast of Luzon; intensity VI at Iba.

213. Off the island of Mindoro; widely felt in Luzon, with intensity IV at Manila, Batangas and Iba.

216. Intensity V on Marinduque Island, III at Batangas.

217. Epicentre in the South China Sea, off the coast of Viet-Nam, near those of the earthquakes of 7 October 1965 and 4 February 1966.

218. Island of Samar (Philippines); intensity IV at Catbalogan.

219. Samar Island, intensity IV at Tacloban, III at Catbalogan.

222. Island of Mindanao, intensity IV at Davao and Cagayan de Oro.

225. Mindanao, intensity VI at Davao, V at General Santos.

227-39. There was considerable seismic activity in the area between the Talaud Islands and Halmahera, near the southern end of the great Philippines trench. The strongest shock (**227**) was felt in Mindanao, with intensity VI at Davao where the electricity supply was interrupted, and as far as Samar Island; about 60 shocks

with magnitude *m* greater than 5 were recorded between 30 January and 31 March; the epicentres of the strongest of these lay approximately along a line running NW.-SE. [56].

246, 248. Violent earthquakes in the Molucca sea; felt at Manado (Celebes).

256. Destructive earthquake on the west coast of Celebes, particularly at Madjene; there were 64 dead and 97 injured; 1,287 houses were damaged, several mosques were destroyed; there was severe damage to the port of Madjene as a result of subsidence. There was also damage in the villages of Tjampalagian and Wonomoeljo, which were built on alluvial terrains. In general, wooden houses stood up better than those built of non-reinforced concrete. Between Somba and Parasanga, some roads were blocked by landslides. A tsunami hit the coast, reaching a height of 400 cm at Paletoang and 150 cm at Parasanga and Palili [1]. According to press reports, at least 600 persons were drowned [4]. The earthquake was felt as far south as Makassar.

Indonesia

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
24	**258**	25 June	07.24	4.5° N.	96.7° E.	5.3	5.6	*n*
24	**259**	22 September	01.46	2.9° N.	95.9° E.	5.3	6.0	*n*
24	**260**	21 November	02.05	2.1° N.	94.6° E.	6.4	7.7	20
24	**261**	11 June	04.48	1.1° N.	98.8° E.	5.3	5.8	53
24	**262**	18 August	17.15	2.4° S.	102.2° E.	5.2	—	140
24	**263**	3 October	15.39	3.7° S.	101.9° E.	5.6	—	95
24	**264**	31 August	13.05	4.5° S.	102.3° E.	5.5	—	64
24	**265**	19 April	08.45	6.2° S.	103.9° E.	5.7	5.5	40
24	**266**	14 April	07.00	5.2° S.	104.3° E.	5.7	—	100
24	**267**	7 November	04.30	6.3° S.	105.3° E.	5.8	—	50
24	**268**	2 November	18.53	6.5° S.	107.1° E.	5.4	—	57
24	**269**	21 June	15.12	5.5° S.	109.6° E.	5.6	—	560
24	**270**	2 April	07.24	8.0° S.	110.4° E.	5.6	—	105
24	**271**	15 April	22.15	5.9° S.	113.2° E.	5.6	6.0	575
24	**272**	30 June	07.33	10.4° S.	117.0° E.	5.5	—	15
24	**273**	11 February	13.29	8.3° S.	118.8° E.	5.3	—	80
24	**274**	13 May	14.30	7.2° S.	120.9° E.	5.6	6.3	615
24	**275**	4 May	15.12	8.6° S.	121.4° E.	5.1	—	94
24	**276**	5 January	16.50	8.9° S.	123.5° E.	5.6	—	27
24	**277**	4 August	17.19	5.7° S.	125.3° E.	6.2	6.2	520
24	**278**	11 February	22.16	6.7° S.	126.8° E.	6.0	7.0	450
24	**279**	29 September	16.20	7.2° S.	128.8° E.	5.7	—	145
24	**280**	8 August	20.44	6.1° S.	129.7° E.	5.9	6.2	195
24	**281**	13 April	23.33	6.1° S.	129.9° E.	5.9	6.1	150
24	**282**	24 February	00.08	6.2° S.	131.0° E.	5.8	6.0	40

260. Violent earthquake, felt in the Nicobar Islands and probably in Sumatra.

268. Felt at Djakarta.

275. Intermediate focus in the island of Flores near Ija volcano (8°53′ S.,

121°38′ E.) which began eruption on 27 January, and Amburombu volcano (8°48′ S., 121°11′ E.) which erupted on 27 February [57].

279. Felt at Darwin (Australia).

A general study of seismotectonics and focal mechanism in the Philippines-Indonesia region has been published [58].

Marianas arc, New Guinea, Solomon Islands, Fiji, Kermadec Islands

Polynesian branch: Bonin Islands, Marianas, Guam, Carolines

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
18	**283**	4 November	08.50	33.8° N.	137.1° E.	5.4	—	350
18	**284**	3 September	16.20	31.5° N.	140.2° E.	5.3	6.0	16
18	**285**	27 August	19.23	28.7° N.	143.8° E.	5.4	—	20
18	**286**	11 June	15.11	27.4° N.	139.9° E.	4.8	—	500
18	**287**	28 July	15.37	24.1° N.	142.7° E.	5.2	—	*n*
18	**288**	30 July	03.23	22.4° N.	142.8° E.	5.3	5.5	20
18	**289**	15 August	08.41	21.6° N.	143.0° E.	6.1	6.8	320
18	**290**	17 June	19.26	19.0° N.	145.5° E.	5.8	6.0	205
18	**291**	7 July	04.43	16.5° N.	147.3° E.	5.7	5.7	40
18	**292**	28 September	19.50	13.1° N.	143.7° E.	5.3	—	150
18	**293**	28 April	00.46	13.3° N.	145.1° E.	5.3	—	50
17	**294**	8 January	21.55	11.8° N.	143.1° E.	5.4	—	*n*
17	**295**	27 January	13.15	8.8° N.	137.7° E.	5.5	6.1	5
17	**296**	24 September	00.26	7.7° N.	135.9° E.	4.6	—	18
17	**297**	26 June	07.50	6.5° N.	133.8° E.	4.9	—	30
17	**298**	21 November	07.26	8.1° N.	146.8° E.	4.8	—	*n*

A detailed study of the seismicity of the Bonin-Marianas arc was recently published; many epicentres have been recalculated [59].

New Guinea, New Britain, New Ireland

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
16	**299**	5 July	01.44	3.8° S.	131.5° E.	5.5	5.2	*n*
16	**300**	9 March	13.47	4.1° S.	135.5° E.	5.5	6.6	14
16	**301**	9 March	14.39	4.1° S.	135.6° E.	5.5	6.0	*n*
16	**302**	25 November	21.51	3.5° S.	138.5° E.	5.2	—	50
16	**303**	28 February	15.57	3.4° S.	142.9° E.	5.7	—	80
16	**304**	9 June	06.51	3.2° S.	142.9° E.	5.2	5.6	17
16	**305**	30 October	18.39	2.5° S.	143.5° E.	5.2	—	*n*
16	**306**	7 December	22.32	4.8° S.	143.5° E.	5.3	—	105
16	**307**	15 August	03.37	3.5° S.	144.4° E.	5.4	—	20
16	**308**	24 June	03.29	5.8° S.	146.8° E.	5.6	5.6	110
16	**309**	2 August	04.30	6.5° S.	146.9° E.	5.3	—	17
16	**310**	10 March	06.54	5.6° S.	147.2° E.	5.8	6.3	205
16	**311**	16 November	20.09	6.2° S.	147.9° E.	4.9	—	60
16	**312**	12 November	15.40	6.0° S.	148.8° E.	5.0	—	80

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
16	**313**	20 August	17.22	5.3° S.	149.7° E.	4.8	5.2	30
15	**314**	16 April	01.22	3.5° S.	151.0° E.	5.7	6.4	40
15	**315**	26 August	16.58	5.8° S.	151.2° E.	5.6	6.5	60
15	**316**	12 April	09.05	4.9° S.	151.5° E.	5.1	—	130
15	**317**	28 October	11.49	3.9° S.	151.6° E.	4.9	—	20
15	**318**	14 August	10.58	5.4° S.	152.0° E.	5.6	—	*n*
15	**319**	3 August	00.22	4.2° S.	153.0° E.	5.3	5.7	65
15	**320**	8 September	12.45	5.1° S.	153.4° E.	5.2	5.4	50
15	**321**	5 August	16.32	5.2° S.	153.8° E.	5.4	6.2	70

304. North coast of New Guinea; intensity II-III at Wewak.

308. Eastern New Guinea; intensity IV at Kaiapit, III at Lae and at Popondetta (Papua) [60].

309. Intensity IV at Lae.

310. Felt in eastern New Guinea and as far east as Rabaul.

311. Intensity V in the Siassi Islands, IV at Finschhafen.

312. New Britain; intensity III-IV at Rabaul and Kilengi (5°30′ S., 148°20′ E.).

313. Intensity VI at Talasea, III at Bali (New Britain).

314. Intensity V at Kevieng, Lassul Bay and Rabaul.

315. Intensity V-VI at Bialla (5°19′ S., 151°02′ E.), IV-V at Rabaul and Kilengi.

316. Intensity IV at Au'Una (5°50′ S., 151°02′ E.), II-III at Malmal.

317. Intensity V at Doilene and Lassul Bay, III-IV at Rabaul.

319. Intensity VI at Warangoi (4°30′ S., 152°20′ E.), IV-V at Rabaul, IV at Sumsum (4°45′ S., 152°25′ E.), III-IV at Kieta (Bougainville Island).

321. Intensity V at Kieta, IV-V at Karoola (Buka Island), IV at Rabaul and Warangoi [60].

Mention must also be made of the earthquake swarm which occurred near Esa Ala (d'Entrecasteaux Islands) between 4 and 8 April; people left their villages on Dobu Island and the Bwaioa Penninsula (Ferguson Island); loud noises accompanied each shock; there was surface fissuring between the Oiau crater and the Bodua mission station (Ferguson Island); several hundred shocks were recorded by the seismological station at Esa Ala [60].

Denham has studied the distribution of earthquakes in New Guinea, New Britain and New Ireland, drawing attention to an alignment of foci across the northern Bismarck Sea at latitude 3° S. [61]. The existence of this seismic zone had also been indicated by Rothé [37]; in contrast, the central Bismarck Sea is aseismic.

Solomon Islands, Santa Cruz Islands, New Hebrides, Loyalty Islands

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
15	**322**	31 May	23.56	4.9° S.	154.2° E.	5.5	—	403
15	**323**	6 August	04.38	5.2° S.	154.1° E.	5.7	—	115
15	**324**	7 August	21.03	5.2° S.	154.1° E.	5.9	—	120

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
15	**325**	26 March	04.29	6.4° S.	154.9° E.	5.1	—	88
15	**326**	7 September	08.40	6.6° S.	155.8° E.	5.3	—	170
15	**327**	15 January	13.26	8.0° S.	158.9° E.	6.4	7.4	45
15	**328**	13 January	08.55	8.0° S.	158.9° E.	5.7	5.7	50
15	**329**	28 April	19.39	7.9° S.	158.8° E.	5.7	5.7	77
15	**330**	14 June	03.22	7.9° S.	159.0° E.	6.0	6.0	62
15	**331**	6 September	14.49	8.8° S.	157.8° E.	5.8	6.2	15
15	**332**	6 September	17.08	8.9° S.	157.9° E.	5.8	6.5	10
15	**333**	7 September	03.06	8.9° S.	157.7° E.	5.6	—	*n*
15	**334**	20 May	16.02	9.1° S.	152.4° E.	4.6	—	42
14	**335**	20 January	12.24	10.3° S.	164.6° E.	5.6	6.1	4
14	**336**	6 January	15.39	10.5° S.	164.5° E.	6.2	7.1	32
14	**337**	6 January	17.06	10.7° S.	164.4° E.	5.4	6.1	*n*
14	**338**	26 July	14.45	11.6° S.	165.1° E.	5.5	—	34
14	**339**	1 October	06.26	11.8° S.	167.5° E.	5.0	—	345
14	**340**	30 May	15.38	12.7° S.	168.9° E.	4.2	—	650
14	**341**	16 April	12.20	13.5° S.	166.3° E.	5.6	—	140
14	**342**	16 April	12.19	13.6° S.	166.9° E.	5.7	—	150
14	**343**	10 December	19.53	14.8° S.	167.0° E.	5.4	6.3	20
14	**344**	19 January	18.50	14.9° S.	167.2° E.	6.2	6.6	110
14	**345**	20 July	20.04	15.6° S.	167.8° E.	5.3	5.6	195
14	**346**	8 November	01.41	16.2° S.	167.5° E.	5.7	5.8	23
14	**347**	9 November	09.07	16.3° S.	167.9° E.	5.3	6.0	185
14	**348**	26 November	12.44	16.8° S.	167.7° E.	5.4	6.3	*n*
14	**349**	4 May	12.36	17.4° S.	168.9° E.	5.5	5.7	11
14	**350**	7 December	03.55	18.1° S.	168.2° E.	5.2	5.8	49
14	**351**	13 October	06.56	18.9° S.	169.3° E.	5.9	6.5	245
14	**352**	18 March	03.25	21.4° S.	171.1° E.	5.5	5.8	15

325. Bougainville Island; intensity IV-V at Panguna.

326. Bougainville Island; intensity II-III at Wakunai.

327-30. Very active focus near Santa Isabel Island; the first and strongest shock (**327**) caused damage in Santa Isabel Island; fissures were observed in the reef near Buala; at Tasia, a water-tank was shifted [1]; several of these shocks were felt at Honiara (Guadalcanal).

331-33. Foci south of New Georgia Island; shocks felt on this island and at Honiara; it may be noted that these earthquakes were followed on 28 October by an eruption of the submarine volcano Kovachi (9° S., 158° E.) [62].

334. D'Entrecasteaux Islands; felt at Samarai (Papua).

339-42. Deep and intermediate foci east of the Santa Cruz and Banks islands.

343-50. There is great seismic activity in the New Hebrides; 6,000 shocks are recorded each year by the local seismological network; during 1969, the monthly bulletin published by the Geophysical Observatory at Nouméa gave determinations of 1,696 epicentres in the New Hebrides [63].

The New Hebrides region is of particular interest because of the presence of the

great submarine trench and the fact that the foci of normal, intermediate and deep earthquakes fall on an inclined plane dipping towards the Pacific, contrary to what is observed in all other parts of the circum-Pacific arc. This peculiarity may be attributed to spreading of the ocean floor away from the Indo-Antarctic ridge, with the result that the lithosphere in the Solomon Islands and New Hebrides is sinking beneath the oceanic crust [64].

343. Intensity V at Luganville (Espiritu Santo Island); many aftershocks.

344. Intensity V at Lamap (Malekula Island).

345, 347. Intensity IV at Luganville.

348-51. Felt at Port Vila (Efate Island).

Fiji, Samoa, Tonga

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
12	**353**	28 January	00.27	14.8° S.	173.4° W.	5.2	5.4	13
12	**354**	26 August	20.28	15.4° S.	173.3° W.	5.4	—	55
12	**355**	31 January	14.59	15.5° S.	175.0° W.	5.4	—	260
12	**356**	22 March	05.43	15.5° S.	176.1° W.	5.4	5.6	*n*
12	**357**	31 May	22.24	16.0° S.	172.9° W.	5.2	5.5	15
12	**358**	26 October	06.38	16.2° S.	173.9° W.	5.8	6.5	127
13	**359**	1 January	09.25	16.2° S.	178.4° E.	5.3	—	*n*
13	**360**	31 October	07.27	17.3° S.	174.2° E.	5.1	—	56
12	**361**	1 May	19.05	16.8° S.	174.7° W.	6.0	6.4	205
12	**362**	3 March	16.30	16.9° S.	172.5° W.	5.1	5.9	*n*
12	**363**	29 January	17.44	17.2° S.	171.6° W.	6.0	6.0	*n*
12	**364**	21 September	07.11	17.5° S.	174.7° W.	5.5	—	235
13	**365**	17 March	00.56	17.7° S.	179.9° E.	5.4	5.8	615
12	**366**	24 November	21.31	18.0° S.	178.4° W.	5.4	—	590
12	**367**	22 July	13.48	18.1° S.	172.5° W.	5.4	—	30
12	**368**	14 November	07.37	19.7° S.	175.9° W.	5.5	5.7	210
12	**369**	4 July	06.49	20.0° S.	178.6° W.	4.9	—	650
12	**370**	24 January	02.33	21.9° S.	179.6° W.	5.9	7.0	595
12	**371**	28 April	07.25	22.4° S.	177.7° W.	5.9	6.2	295
12	**372**	10 February	22.58	22.7° S.	178.6° E.	6.0	6.8	675
12	**373**	10 February	23.02	23.1° S.	178.8° E.	5.8	—	670
12	**374**	25 March	13.13	23.5° S.	177.8° W.	5.4	6.4	290
12	**375**	9 June	21.53	23.5° S.	175.0° W.	5.5	5.6	*n*
12	**376**	18 February	05.14	24.0° S.	176.7° W.	5.4	—	100
12	**377**	3 February	08.18	25.7° S.	178.3° E.	5.3	—	655

358, 363, Felt at Apia (Samoa).

Further detailed studies are being made of the Fiji-Tonga-Kermadec seismic arc. The foci of the normal, intermediate and deep earthquakes in this area lie on an inclined plane dipping away from the Pacific, down which is moving the lithospheric plate which is being thrust westward by the spreading of the ocean floor away from the South-East Pacific Rise [65, 66, 67, 68]. A precise bathymetric survey of the Tonga-Kermadec region has recently been made [69].

Kermadec Islands

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
12	**378**	16 May	07.03	27.5° S.	176.6° W.	5.4	5.6	50
12	**379**	19 July	17.56	27.5° S.	176.6° W.	5.0	6.2	*n*
12	**380**	11 January	04.26	28.4° S.	177.0° W.	5.4	6.5	70
12	**381**	11 January	04.47	28.5° S.	176.8° W.	5.1	6.0	70
12	**382**	17 November	00.43	28.9° S.	179.1° W.	4.9	—	345
12	**383**	29 June	10.34	30.5° S.	178.2° W.	5.6	6.0	45
12	**384**	2 September	02.06	31.4° S.	177.0° W.	5.2	6.0	26
12	**385**	28 August	13.54	31.5° S.	177.9° W.	5.3	6.0	30
12	**386**	30 September	17.51	31.9° S.	178.0° W.	5.4	6.3	*n*
12	**387**	31 January	23.31	32.1° S.	179.6° E.	5.2	—	390
12	**388**	30 May	15.55	32.2° S.	178.1° W.	5.2	6.0	35
12	**389**	30 May	16.22	32.3° S.	178.1° W.	5.5	6.2	*n*
12	**390**	3 October	01.33	32.9° S.	178.0° W.	5.7	5.5	25

There was considerable seismic activity in the Kermadec Islands in 1969: 9 earthquakes of magnitude equal to or greater than 6.

New Zealand, Auckland, Macquarie, Balleny islands

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
11	**391**	7 June	05.24	35.4° S.	179.9° W.	4.7	—	46
11	**392**	3 November	08.25	36.6° S.	177.5° E.	5.0	—	14
11	**393**	20 June	20.52	38.0° S.	177.4° E.	—	—	40
11	**394**	17 October	16.24	38.7° S.	175.6° E.	5.0	—	200
11	**395**	23 May	14.29	39.7° S.	175.6° E.	5.7	—	70
11	**396**	2 January	10.25	45.0° S.	167.6° E.	5.3	—	135
11	**397**	23 June	00.17	49.3° S.	164.2° E.	5.3	5.3	27
11	**398**	17 June	23.58	52.6° S.	159.7° E.	6.1	6.7	*n*
45	**399**	16 September	15.34	61.6° S.	154.0° E.	5.3	—	30
45	**400**	11 November	18.01	62.7° S.	156.7° E.	4.9	—	*n*
43	**401**	22 December	08.52	62.0° S.	164.6° E.	5.3	—	*n*
43	**402**	29 June	17.09	62.8° S.	166.3° E.	5.5	6.4	*n*
43	**403**	27 September	15.41	65.0° S.	178.1° E.	4.6	—	*n*

393. This earthquake occurred two days before the eruption of Ruapehu volcano (39°17′ S., 175°34′ E.) in the middle of North Island; some weak volcanic shocks accompanied the eruption [70]. The focus of the intermediate earthquake of 23 May (**395**) is situated at a depth of 70 km under this volcanic region; this earthquake was felt in the southern part of North Island.

396. Felt in South Island; no macroseismic information on this earthquake is yet available.

398. On the Macquarie Island ridge; a study of the structure and seismicity of this region has been published [71].

EASTERN PACIFIC

Aleutians, Alaska, Canada, Rocky Mountains, California

Komandorskiye Islands, Aleutians

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
1	**404**	20 January	14.20	54.9° N.	166.0° E.	6.1	6.1	23
1	**405**	4 April	22.57	54.5° N.	169.4° E.	5.4	—	27
1	**406**	18 October	08.44	52.5° N.	173.5° E.	5.6	5.5	24
1	**407**	3 July	18.01	51.7° N.	178.0° E.	5.1	—	84
1	**408**	14 May	19.32	51.3° N.	179.9° W.	6.2	7.0	21
1	**409**	22 June	10.45	51.5° N.	179.9° W.	6.1	(5.8)	56
1	**410**	3 January	13.28	51.2° N.	179.4° W.	5.8	5.6	29
1	**411**	21 October	20.53	51.3° N.	179.2° W.	5.9	6.0	48
1	**412**	12 September	08.57	51.2° N.	179.2° W.	6.0	6.6	48
1	**413**	12 September	15.00	51.3° N.	179.2° W.	5.6	5.8	53
1	**414**	31 October	11.33	51.3° N.	179.0° W.	6.0	6.5	49
1	**415**	6 November	20.20	51.5° N.	178.9° W.	5.5	5.9	36
1	**416**	31 July	11.23	53.0° N.	170.1° W.	5.3	5.5	37
1	**417**	12 November	19.09	53.0° N.	168.3° W.	5.4	5.9	53
1	**418**	18 June	23.44	52.6° N.	167.9° W.	5.4	5.6	18
1	**419**	25 July	12.54	53.3° N.	167.0° W.	5.0	5.4	42

407, 409. Felt at Amchitka.

408. Strong earthquake; intensity V at Adak and at Amchitka; there was no tsunami.

412. Strong earthquake, preceded by 4 premonitory shocks, all of magnitude greater than 5; felt at Adak and Amchitka. It may be noted that Kiska volcano (51°57′ N., 177°40′ E.) erupted on the same day [72].

Alaska and western Canada

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
1	**420**	19 June	20.24	54.2° N.	164.0° W.	5.0	—	25
1	**421**	20 June	02.37	53.2° N.	162.4° W.	5.7	5.2	44
1	**422**	23 May	13.04	53.4° N.	160.2° W.	5.6	5.3	32
1	**423**	24 November	22.51	56.2° N.	153.6° W.	5.5	6.0	*n*
1	**424**	20 November	23.46	56.6° N.	153.2° W.	5.1	5.6	*n*
1	**425**	21 March	09.46	59.9° N.	152.7° W.	4.5	—	105
1	**426**	16 October	21.00	62.5° N.	151.3° W.	4.0	—	94
1	**427**	6 August	00.38	61.4° N.	150.7° W.	4.8	—	53
1	**428**	17 July	20.51	64.1° N.	147.6° W.	4.9	—	31
1	**429**	18 May	08.44	60.3° N.	146.0° W.	5.4	5.5	6
1	**430**	27 July	21.21	59.4° N.	145.3° W.	5.3	5.5	*n*
1	**431**	11 June	00.58	59.6° N.	144.8° W.	5.3	5.5	5
42	**432**	28 October	00.46	68.2° N.	136.5° W.	4.2	—	*n*
42	**433**	6 May	19.41	66.8° N.	135.2° W.	4.6	—	*n*

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
2	**434**	13 March	18.43	63.5° N.	129.0° W.	4.8	5.0	*n*
2	**435**	22 December	12.24	61.6° N.	140.3° W.	4.6	—	4
2	**436**	18 March	20.31	50.1° N.	130.0° W.	5.0	—	*n*
2	**437**	26 May	23.22	50.0° N.	115.0° W.	5.0	—	*n*
2	**438**	14 February	08.33	48.9° N.	123.1° W.	4.2	—	*n*
2	**439**	13 August	16.12	48.5° N.	126.5° W.	4.6	—	*n*

420. Felt on Unimak Island and at Cold Bay.

425. Intermediate earthquake, felt in Alaska in the Anchorage-Palmer area.

426. Intermediate earthquake, felt in the Anchorage-Talkeetna area.

427. Felt at Anchorage, Palmer and Kenai.

428. Central Alaska, felt at Fairbanks; many other shocks in the same region. Part of the seismic activity in this area is connected with the great Denali fault; a study has been undertaken of the micro-earthquakes occurring along this fault [73].

429, 431. Southern Alaska; felt at Cordova.

432, 433, 435. As happens each year, several minor earthquakes occurred in the Yukon territory, west of the Mackenzie valley.

There was no large earthquake in 1969 on the coasts of Alaska and Canada between 51° N. and 59° N., whose main tectonic feature is the great 'transcurrent' Fairweather fault which came into play at the time of the destructive earthquake of 10 July 1958; in 1968 however, some observations indicated that the micro-seismic activity on this part of the fault system was more intense than at either its northern extension (Denali fault) or its southern extension (San Andreas fault) [74].

437. Rocky Mountains in British Columbia.

438. Vancouver Island region; felt at Vancouver, Victoria, Abbotsford (British Columbia) and over an area of 13,000 km^2 in the north-west of Washington state [1]. A study of seismic risk in western Canada has just been published [75].

Rocky Mountains

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
34	**440**	1 April	16.45	47.9° N.	114.3° W.	4.7	—	10
34	**441**	9 June	08.53	47.9° N.	114.3° W.	4.2	—	5
34	**442**	15 September	00.02	47.9° N.	114.2° W.	4.3	—	19
34	**443**	26 April	10.41	44.2° N.	114.5° W.	4.9	—	13
34	**444**	26 May	01.30	40.4° N.	104.4° W.	4.2	—	*n*
34	**445**	23 May	05.24	39.0° N.	111.9° W.	4.0	—	31
34	**446**	22 January	15.00	37.0° N.	116.0° W.	4.6	—	20
34	**447**	30 January	05.17	34.3° N.	106.9° W.	4.1	—	8
34	**448**	25 December	12.49	33.4° N.	110.6° W.	4.4	—	15
34	**449**	12 May	08.49	31.8° N.	106.4° W.	4.3	—	19

440-2. The three strongest of the many shocks that occurred at this focus in Montana during 1969; the earthquake of 1 April (**440**) was felt over an area of 25,600 km^2, particularly at Big Arm, Dayton and Proctor, at the southern end of Flathead lake, where some chimneys were toppled; 41 shocks were felt in the epicentral region between 1 and 24 April [1]. A further shock was felt over an area of 9,000 km^2 on 9 June (**441**); it was followed by several aftershocks; slight damage at Big Arm on 15 September (**442**).

443. Central Idaho; slight damage at Ketchum and Warm Springs; felt over an area of 24,000 km^2, particularly at Clayton and along the Salmon River [1].

444. Denver region, strongly felt at Commerce City; a further 32 earthquakes with epicentre near Derby were recorded by the observatory at Golden during the first six months of 1969. This seismic activity had commenced in 1962, following the injection of waste waters into the 'Rocky Mountains Arsenal Well'; this activity has continued despite the cessation of these injections; a detailed study has shown that the epicentres are distributed along deep tectonic features which have been 'reactivated' under the Denver basin [76].

446. Natural earthquake in southern Nevada.

447. Epicentre in the Ladrone Mountains (New Mexico); strongly felt at Polvadera and San Acacia, near Socorro [1].

448. Felt at Globe and at Cutter (Arizona).

449. Slight damage in the region of El Paso (Texas); epicentre in the Guadalupe Mountains.

Washington, Oregon, California

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
2	**450**	10 November	07.38	48.5° N.	121.5° W.	4.3	5.0	*n*
2	**451**	1 November	15.44	47.9° N.	121.7° W.	4.1	—	5
2	**452**	9 October	17.07	46.9° N.	121.6° W.	4.4	—	*n*
3	**453**	9 October	07.45	43.7° N.	127.4° W.	4.8	5.5	10
3	**454**	28 March	18.12	41.0° N.	121.5° W.	4.5	—	3
3	**455**	7 February	21.25	40.4° N.	124.5° W.	5.2	—	6
3	**456**	2 October	04.56	38.5° N.	122.7° W.	5.2	5.6	2
3	**457**	2 October	06.19	38.5° N.	122.7° W.	5.1	5.6	2
3	**458**	13 March	03.23	38.0° N.	121.9° W.	4.4	—	8
3	**459**	27 October	10.59	36.8° N.	121.4° W.	4.6	—	13
3	**460**	22 October	22.51	34.8° N.	121.3° W.	5.9	5.9	15
3	**461**	5 November	17.54	34.8° N.	121.2° W.	5.8	6.2	*n*
3	**462**	28 February	04.56	34.6° N.	118.1° W.	4.6	4.3	5
3	**463**	23 January	23.01	33.9° N.	116.0° W.	4.9	5.5	18
3	**464**	27 October	13.16	33.5° N.	117.8° W.	4.5	4.3	6
3	**465**	28 April	23.20	33.4° N.	116.4° W.	5.7	5.9	20
3	**466**	24 October	08.29	33.3° N.	119.2° W.	5.1	5.1	10
3	**467**	8 June	13.59	33.2° N.	116.0° W.	3.8	—	3

450. Washington state; felt at Rockport, Concrete and Mount Vernon.

451. Felt in the Seattle area.

452. Felt in the south-western part of the Mount Rainier National Park (Washington state).

454. Felt over an area of 5,000 km^2, particularly at Burney in the Shasta district of the northern Sierra Nevada; premonitory shock on the same day at 04.53 h (m = 4.0).

455. Epicentre on the extension of the San Andreas fault north of Cape Mendocino; intensity VI at Ferndale, Honeydew, Petrolia, Rio Dell and Scotia; macroseismic area 10,000 km^2 in the Humboldt and Mendocino districts; further shocks at the same focus on 13 May at 07.40 h (m = 4.3, felt at Ferndale), on 28 June at 04.07 h (m = 4.5, felt at Petrolia) and on 1 July at 12.00 h (m = 4.6).

456, 457. Epicentre near Santa Rosa, north of San Francisco Bay; intensity VII-VIII at Santa Rosa; several persons injured by falling objects and by broken glass; damage estimated at U.S.$10 million (chimneys toppled, a score of old houses rendered uninhabitable, great damage to shop windows, etc.); the school at Fremont, built before the enforcement of earthquake-resistant regulations ('Field Act') had to be demolished. Some modern buildings were damaged; gas and water conduits were ruptured. During the five days which followed this earthquake 12 strong aftershocks occurred; their epicentres lay along the southern extension of the Healdsburg fault zone [1].

458. Epicentre in the Antioch area, at the mouth of the Sacramento River; felt at Berkeley, Oakland and San Francisco.

459. On the San Andreas fault near Hollister, where some houses were slightly cracked; strongly felt at Tres Pinos and Paicines [1]. The San Andreas fault is being very closely studied [77].

460, 461. Strong shocks off Arguello Point; felt on the California coast in the districts of San Luis Obispo and Santa Barbara; intensity V at Arroyo Grande, Betteravia, Guadalupe, San Luis Obispo and Surf; several aftershocks.

462. Mojave Desert; slight damage at Palmdale (intensity VI); macroseismic area 12,000 km^2.

463. San Andreas fault, on the eastern slopes of the San Bernardino Mountains; felt over an area of 13,000 km^2, particularly at Coachella, Salton City, Palm Desert and Palm Springs; aftershock on 25 January at 03.00 h (m = 4.8).

464. Felt in the Orange, Los Angeles, Riverside, San Bernardino and San Diego districts; slight damage (intensity VI) at Huntington Beach.

465. San Jacinto fault; strong shock, felt over an area of 80,000 km^2 in southern California, Arizona and Nevada; some damage (intensity VI) at Borrego Springs, particularly in shops; rock falls in the Santa Rosa hills; strongly felt at Coachella, Hemet, Indio, Thermal, San Jacinto, etc.; the shock was also felt on the upper floors of buildings in Los Angeles [1]; aftershock on 19 May at 14.40 h (m = 4.3).

466. Submarine focus near Santa Barbara Island; intensity V in the Los Angeles Beach area; aftershocks on 24 October at 20.26 h (M = 4.7) and on 31 October at 10.39 h (M = 4.8).

467. Imperial Valley near Salton Sea; windows shattered at Salton City; intensity IV at Coachella and North Shore [1].

Mexico, Central America

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
4	**468**	10 June	03.41	31.6° N.	116.2° W.	4.8	5.0	2
4	**469**	20 March	08.17	31.2° N.	114.5° W.	5.4	6.0	20
4	**470**	21 March	04.56	31.2° N.	114.2° W.	5.4	5.7	*n*
4	**471**	12 February	07.29	30.4° N.	112.9° W.	4.7	—	*n*
4	**472**	17 August	20.13	25.3° N.	109.2° W.	5.7	—	*n*
4	**473**	17 August	20.14	25.0° N.	109.5° W.	6.1	7.3	*n*
4	**474**	4 April	19.16	24.4° N.	109.8° W.	5.6	5.8	31
4	**475**	1 November	11.08	23.1° N.	107.9° W.	5.6	6.7	*n*
4	**476**	22 August	10.04	23.3° N.	110.4° W.	5.1	5.3	11
5	**477**	3 July	22.05	19.8° N.	109.3° W.	4.7	4.8	*n*
5	**478**	3 June	03.58	19.1° N.	107.5° W.	5.1	5.7	*n*
5	**479**	23 September	22.37	18.7° N.	107.1° W.	4.9	6.2	*n*
5	**480**	23 June	07.08	18.4° N.	104.5° W.	5.3	5.4	36
5	**481**	3 July	16.59	16.7° N.	98.5° W.	5.2	4.8	26
5	**482**	20 October	15.20	17.3° N.	95.2° W.	5.4	—	87
5	**483**	7 November	01.27	18.1° N.	94.5° W.	4.6	—	46
5	**484**	26 May	05.54	15.8° N.	94.4° W.	5.1	5.3	34
5	**485**	22 June	14.30	16.9° N.	93.6° W.	5.1	—	150
5	**486**	21 April	02.19	14.1° N.	91.0° W.	5.5	6.0	80
6	**487**	28 June	04.34	12.8° N.	89.2° W.	5.2	5.2	70
6	**488**	10 March	08.15	12.3° N.	87.5° W.	5.3	6.0	62
6	**489**	14 March	08.47	12.9° N.	86.8° W.	5.6	5.8	180
6	**490**	13 May	14.16	11.5° N.	86.4° W.	5.6	6.4	80
6	**491**	11 July	07.51	10.3° N.	85.4° W.	5.0	—	*n*
6	**492**	25 April	03.34	7.5° N.	82.1° W.	5.4	5.6	25
8	**493**	27 February	01.33	5.3° N.	82.5° W.	4.9	—	*n*

468. Baja California (Mexico); felt at Ensenada and San Diego.

469, 470. Gulf of California; the 2 strongest of a series of shocks between 20 and 28 March, of which 17 were of magnitude (*m*) greater than 5; the Gulf of California is generally considered to represent a southern extension of the San Andreas fault; in the Gulf, this feature is dislocated by a number of transform faults [78].

472, 473. Double earthquake in the southern part of the Gulf of California; felt at Los Mochis (Sinaloa) and at La Paz (Baja California); several aftershocks.

474. Slight damage at La Paz [4]; aftershock on 18 April at 18.53 h (m = 5.0, further slight damage) [2].

482. Strongly felt at Ixtepec (Oaxaca).

486. Intensity V at San Salvador [2].

487. Felt in the San Salvador area; several other shocks were felt at San Salvador during 1969 [2].

489. Felt in El Salvador and in Nicaragua.

490. Strong intermediate earthquake, widely felt in north-western Costa Rica, particularly at San Ramón, Peñas Blancas, Puntarenas, Liberia. Poas volcano (10° 11′ N., 84° 13′ W.) started eruption on the same day [79].

491. Felt in Costa Rica.

Antilles loop, Venezuela

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
7	**494**	25 February	07.39	15.2° N.	87.5° W.	5.4	5.0	15
7	**495**	27 September	10.43	17.0° N.	85.6° W.	4.3	—	*n*
7	**496**	16 February	23.07	19.9° N.	75.9° W.	4.3	—	*n*
7	**497**	15 October	03.56	19.3° N.	65.4° W.	4.8	—	50
7	**498**	1 August	13.06	18.8° N.	64.4° W.	5.0	—	47
7	**499**	30 June	18.36	20.0° N.	64.1° W.	5.3	—	17
7	**500**	15 May	20.43	16.8° N.	61.3° W.	5.7	5.6	50
7	**501**	1 December	22.13	16.7° N.	60.8° W.	5.6	5.9	40
7	**502**	25 December	21.32	15.8° N.	59.7° W.	6.4	7.2	7
7	**503**	25 December	22.26	15.8° N.	59.7° W.	5.5	6.3	15
7	**504**	25 December	22.31	16.1° N.	59.8° W.	6.0	6.5	8
7	**505**	29 December	00.51	16.2° N.	59.1° W.	5.6	5.8	17
7	**506**	22 October	12.52	10.9° N.	62.6° W.	5.4	—	80
7	**507**	14 December	22.39	11.4° N.	65.1° W.	4.9	—	32
7	**508**	20 October	13.11	10.8° N.	72.5° W.	5.7	5.5	40
6	**509**	23 December	12.20	10.0° N.	78.8° W.	5.0	—	*n*

494. Felt at Tegucigalpa (Honduras).

498. Virgin Islands; felt in Puerto Rico; several other shocks at the same focus were felt in San Juan.

500. Lesser Antilles; felt in Guadeloupe, Antigua and St. Kitts.

502. Strong shock east of the Lesser Antilles arc; intensity VI in Guadeloupe, Martinique and Dominica, V in St. Vincent, IV in Antigua and Barbados; also reported felt at San Juan and at Caracas, at 900 km from the epicentre; a slight tsunami was observed, with amplitude 46 cm at Barbados, 30 cm at Antigua, 12 cm at Dominica. Between 25 and 29 December, 23 aftershocks of magnitude equal to or greater than 5 were recorded [2].

506. Intermediate earthquake with epicentre near Trinidad; felt at Carúpano and Güiria (Venezuela) and at Port of Spain (Trinidad).

507. Felt at Caracas.

508. Felt at Maracaibo and Lagunillas (Venezuela).

509. Off the north coast of Panama; intensity III at Balboa Heights.

South America

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
7	**510**	24 February	22.44	6.8° N.	72.9° W.	5.0	—	150
7	**511**	23 March	11.49	6.2° N.	77.8° W.	5.0	5.5	24
8	**512**	6 November	11.33	5.2° N.	76.2° W.	4.8	—	110
8	**513**	17 December	07.05	0.7° S.	78.0° W.	4.5	—	20
8	**514**	28 May	13.30	2.1° S.	76.9° W.	5.5	5.4	175
8	**515**	5 July	04.55	5.6° S.	77.2° W.	5.2	5.1	37

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
8	**516**	4 February	04.10	8.2° S.	80.2° W.	6.0	6.4	16
8	**517**	2 June	11.07	8.4° S.	74.3° W.	5.0	—	150
8	**518**	24 July	02.59	11.9° S.	75.1° W.	5.9	6.0	1
8	**519**	1 October	05.05	11.9° S.	75.1° W.	5.9	6.4	4
8	**520**	1 October	05.58	11.7° S.	75.1° W.	5.7	—	5
8	**521**	1 October	08.28	11.8° S.	75.0° W.	5.8	—	3
8	**522**	27 February	05.09	13.9° S.	74.3° W.	5.2	—	110
8	**523**	22 December	00.06	16.9° S.	72.9° W.	5.2	—	50
8	**524**	19 July	04.54	17.3° S.	72.5° W.	5.9	6.2	54
8	**525**	22 October	10.21	18.1° S.	71.5° W.	5.4	—	23
8	**526**	18 July	23.17	18.2° S.	63.3° W.	5.6	—	19
8	**527**	8 August	05.12	21.2° S.	68.6° W.	5.4	—	75
8	**528**	15 April	07.11	21.9° S.	61.7° W.	4.0	—	540
8	**529**	31 May	23.54	22.8° S.	66.4° W.	4.6	—	235
8	**530**	13 September	10.52	22.9° S.	68.4° W.	5.4	—	105
8	**531**	21 September	02.00	23.6° S.	68.1° W.	5.5	—	120
8	**532**	10 July	08.42	23.6° S.	69.7° W.	5.4	4.7	50
8	**533**	25 July	06.06	25.6° S.	63.3° W.	5.5	6.2	580
8	**534**	4 August	21.50	26.9° S.	70.9° W.	5.3	5.3	*n*
8	**535**	2 September	03.47	27.7° S.	66.5° W.	5.5	—	175
8	**536**	13 November	07.51	27.8° S.	71.6° W.	5.8	6.0	*n*
8	**537**	26 April	05.58	30.6° S.	71.4° W.	5.6	6.0	*n*
8	**538**	26 April	06.02	30.6° S.	71.5° W.	5.9	6.3	*n*
8	**539**	5 May	13.52	30.8° S.	71.8° W.	5.3	5.5	40
8	**540**	13 December	21.33	32.7° S.	70.0° W.	5.6	—	105
8	**541**	13 June	05.28	34.9° S.	69.9° W.	4.4	—	105
9	**542**	13 January	06.36	37.1° S.	73.6° W.	4.9	5.6	*n*
9	**543**	25 August	02.38	39.2° S.	71.9° W.	4.7	—	13
9	**544**	8 July	14.02	40.3° S.	74.8° W.	4.9	—	34

510. Intermediate focus under the eastern Cordillera; felt at Bogotá and Bucaramanga.

512. Intermediate focus under the central Cordillera; felt at Cali, Manizales and Pereira; several other shocks at the same focus.

513. Within an interval of 8 minutes, two earthquakes caused widespread damage in the region of Saquisili, Pujili and Latacunga (Ecuador); also felt at Quito.

516. Off the northern Peruvian coast; felt in the region of Trujillo and Chiclayo.

Several violent earthquakes occurred in the region of Huancayo in central Peru; that of 24 July (**518**) was accompanied by surface faulting with a throw of 40 cm in an area north-west of the Asuntay and Huaytapallana glacier lakes; there was some damage at Huancayo and several landslides were reported in the Andes; the shock was felt at Ayacucho, Huancavelica and Tarma. According to some reports, the shock caused the collapse of séracs on the Huaytapallana glacier and fissures in the banks of Lake Asuntay, causing a disastrous flood in the Shullcas river. The Huancayo observatory, situated 30 km south-west of the epicentre, recorded more than 220 aftershocks, whose frequency decreased exponentially in the usual way until 1 October, when a further destructive earthquake occurred

(519). The villages of Lampa and Chilifruta were completely destroyed, while 60 per cent of the buildings were destroyed in Comas; 136 persons were killed, 216 severely injured, 1,447 slightly injured; the earthquake affected 24 villages; intensity V-VI was observed at Huancayo. On the fault which had appeared on 24 July, there was a further movement of 120 cm vertically and 70 cm horizontally over a distance of 15 km. Landslides blocked several roads. More than 1,375 aftershocks were recorded by temporary seismological field stations; 9 of these aftershocks were of magnitude (*m*) greater than 5 [1].

523. Some damage at Arequipa.

524. Felt at Arequipa.

528. Deep focus east of the Andes, near the western border of Paraguay.

532. Felt in northern Chile.

539, 540. Felt in central Chile.

541. Felt at Santiago.

542. Felt at Concepción.

543. Felt at Valdivia.

A statistical study has been made of the seismicity of Chile [80] and Santo has published a general review of the seismicity of South America [81].

South-eastern Pacific, Galápagos, Easter Island, Pacific-Antarctic ridge

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
44	**545**	1 June	18.50	8.7° N.	102.6° W.	4.6	5.3	*n*
44	**546**	20 September	15.26	1.8° N.	101.0° W.	5.5	5.8	*n*
44	**547a**	5 June	09.15	2.5° N.	99.7° W.	4.7	—	*n*
44	**547b**	20 January	05.01	2.3° N.	96.6° W.	4.3	—	*n*
44	**548**	30 August	01.26	1.1° S.	90.8° W.	5.5	5.1	*n*
44	**549**	26 June	02.30	2.0° N.	90.5° W.	5.0	5.4	*n*
44	**550**	30 August	05.43	0.6° S.	89.6° W.	4.2	—	*n*
44	**551**	4 April	12.58	1.2° N.	85.2° W.	5.3	5.6	*n*
44	**552**	5 April	23.26	1.2° N.	85.2° W.	5.8	6.2	30
44	**553**	1 October	17.10	0.8° N.	85.0° W.	5.5	6.1	*n*
44	**554**	9 September	15.23	4.4° S.	105.9° W.	5.2	5.3	*n*
44	**555**	24 October	19.46	9.0° S.	108.7° W.	4.5	—	*n*
44	**556**	6 July	10.02	13.3° S.	112.3° W.	4.4	—	*n*
43	**557**	21 February	04.21	20.4° S.	114.0° W.	4.7	—	*n*
43	**558**	10 June	10.39	22.2° S.	112.2° W.	4.8	—	*n*
43	**559**	22 April	04.38	26.7° S.	114.2° W.	5.3	5.7	*n*
43	**560**	22 April	06.31	26.8° S.	114.1° W.	5.6	6.2	*n*
43	**561**	23 September	01.22	27.3° S.	113.4° W.	5.3	5.6	*n*
43	**562**	19 April	19.18	35.0° S.	111.5° W.	4.8	—	*n*
43	**563**	22 March	02.47	35.7° S.	103.7° W.	4.9	—	*n*
43	**564**	25 October	04.06	36.2° S.	101.2° W.	5.2	5.3	*n*
43	**565**	13 June	23.06	36.0° S.	96.1° W.	4.5	—	*n*
43	**566**	9 June	06.18	39.9° S.	91.7° W.	4.6	—	*n*
43	**567**	10 March	21.09	41.2° S.	88.2° W.	4.6	—	*n*
43	**568**	4 August	04.18	41.6° S.	85.3° W.	4.9	—	*n*
43	**569**	1 May	02.45	50.0° S.	114.3° W.	4.9	—	*n*

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
43	**570**	18 August	02.55	56.0° S.	122.7° W.	5.2	5.8	*n*
43	**571**	18 August	01.04	56.0° S.	123.4° W.	5.1	6.4	*n*
43	**572**	20 May	03.08	54.6° S.	130.9° W.	5.2	—	*n*
43	**573**	20 November	17.21	54.4° S.	133.9° W.	5.0	—	*n*
43	**574**	19 December	07.50	54.3° S.	136.8° W.	5.3	—	*n*
43	**575**	1 October	05.47	56.3° S.	143.5° W.	5.0	—	*n*
43	**576**	21 June	06.16	62.5° S.	161.5° W.	5.3	5.8	*n*
43	**577**	3 May	19.57	63.3° S.	164.0° W.	4.7	—	*n*

548. Galápagos; felt in Santa Cruz Island; this earthquake had perhaps some connexion with the activity of the Cerro Azul volcano on Isabela Island.

The epicentres listed in the above table lie along the Pacific-Antarctic ridge; this seismic activity is cited by the proponents of the theory of ocean floor spreading from median rifts.

Hawaii, central Pacific

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
39	**578**	10 May	01.33	19.4° N.	155.1° W.	4.9	—	11
39	**579**	7 May	14.35	20.8° N.	155.4° W.	4.1	4.5	13
39	**580**	25 May	02.38	21.2° N.	157.7° W.	—	—	*n*
39	**581**	3 May	08.22	8.3° N.	175.6° W.	5.2	—	*n*
39	**582**	6 June	17.53	7.7° S.	148.0° W.	4.6	—	*n*
39	**583**	6 August	17.15	7.5° S.	148.3° W.	5.1	—	*n*

Several dozen shocks are felt each year in the Hawaiian Islands. The earthquake of 10 May (**578**) was widely felt in the island of Hawaii; the epicentre is situated in the eastern rift zone of Kilauea volcano [1]. The earthquake of 7 May (**579**) was felt at Hana (Maui Island) and at Kohala, Waimea and Kamuela (Hawaii).

580. Felt on the east coast of Oahu, at Koko Head, Kailua and Kaneohe.

581. Unusual epicentre in the north-western Pacific, probably on a fracture zone running north-east, perpendicular to the main axis of the Darwin Rise [2].

582, 583. Epicentres in the neighbourhood of the Line Islands; several shocks were already located in the same area in 1968.

Continental America

Canada

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
42	**584**	16 October	18.47	80.8° N.	112.1° W.	4.5	—	*n*
42	**585**	10 March	11.35	72.5° N.	71.6° W.	4.0	—	*n*
42	**586**	6 March	17.03	72.2° N.	74.4° W.	4.6	—	*n*
34	**587**	24 November	21.14	60.6° N.	58.8° W.	5.0	—	*n*
34	**588**	10 October	00.07	46.2° N.	75.1° W.	3.9	—	21

584. Arctic Ocean; an earthquake occurred at the same focus on 24 July 1964.
588. Felt in Canada at Ottawa, Montreal and at Massena in the state of New York. The St. Lawrence valley is known for its seismicity; a study on seismic risk in eastern Canada has been published [75].

United States of America

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
34	**589**	20 November	01.00	37.4° N.	81.0° W.	4.3	4.8	3
34	**590**	13 December	10.19	35.1° N.	83.0° W.	—	—	*n*
34	**591**	2 May	11.33	35.2° N.	96.3° W.	4.6	—	*n*
34	**592**	1 January	23.35	34.8° N.	92.6° W.	4.2	—	12

589. Appalachian Mountains; slight damage in the south of West Virginia and in the Giles district (Virginia); widely felt in Georgia, Ohio, Kentucky, Maryland, North Carolina, South Carolina, Tennessee, Virginia and West Virginia [2]. A general study of the seismicity of the Appalachians has been published [82].
590. A further shock in the Appalachians, felt at Franklin, Sylva and Columbus (North Carolina), Greenville and Pickens (South Carolina).
591. Felt over an area of 130,000 km^2 in Oklahoma; slight damage at Wewoka [1].
592. Felt over an area of 60,000 km^2 in Arkansas, southern Missouri and at Memphis (Tennessee); intensity V at Little Rock (Arkansas).

A general map of seismic risk in the United States has been published by Algermisson [83].

South America (east of the Andes)

None.

Continental Africa, Indian Ocean, Australia

West Africa, Red Sea, African rifts, South Africa

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
37	**593**	9 February	18.29	5.5° N.	0.1° W.	4.9	—	*n*
37	**594**	24 March	11.54	27.5° N.	33.8° E.	5.2	5.3	21
37	**595**	31 March	07.15	27.7° N.	33.9° E.	6.0	7.0	*n*
37	**596**	26 September	04.54	16.4° N.	41.0° E.	5.1	5.5	25
37	**597**	29 March	09.15	12.0° N.	41.3° E.	5.8	6.3	*n*
37	**598**	29 March	11.04	12.0° N.	41.3° E.	5.6	6.0	4
37	**599**	29 March	11.07	12.0° N.	41.2° E.	5.3	5.8	*n*
37	**600**	5 April	02.18	12.2° N.	41.2° E.	6.2	6.1	17
37	**601**	5 April	15.23	4.4° N.	31.5° E.	—	4.7	*n*
37	**602**	15 July	16.33	3.5° N.	31.4° E.	5.5	—	30
37	**603**	22 April	21.59	1.9° N.	31.5° E.	6.0	—	28
37	**604**	29 April	19.54	0.8° S.	30.7° E.	5.0	—	*n*
37	**605**	9 September	16.46	2.6° S.	24.7° E.	5.2	—	*n*
37	**606**	26 December	17.23	3.2° S.	35.8° E.	4.0	—	*n*
37	**607**	22 May	21.15	3.6° S.	28.9° E.	5.0	—	*n*
37	**608**	14 April	16.45	5.0° S.	30.1° E.	—	5.0	*n*
37	**609**	10 August	01.02	7.6° S.	30.8° E.	4.8	—	*n*
37	**610**	9 April	16.48	11.1° S.	34.6° E.	4.2	—	32
37	**611**	21 August	14.41	16.5° S.	28.5° E.	3.3	—	*n*
37	**612**	12 September	00.07	16.7° S.	34.3° E.	—	4.2	*n*
37	**613**	24 March	12.55	19.7° S.	13.1° E.	—	4.6	*n*
37	**614**	17 March	19.15	21.6° S.	38.7° E.	4.8	—	*n*
37	**615**	20 April	23.51	21.3° S.	33.2° E.	4.1	—	26
37	**616**	30 August	15.52	26.9° S.	26.9° E.	5.5	—	14
37	**617**	29 September	20.03	32.9° S.	19.7° E.	5.9	6.5	*n*
37	**618**	5 October	05.01	33.1° S.	19.6° E.	5.8	—	*n*
37	**619**	11 September	21.45	33.5° S.	21.9° E.	5.4	—	*n*

593. Epicentre near Accra (Ghana); the Accra region is known to be seismic, destructive earthquakes having occurred there in 1862, 1906 and 1939. Recent research has shown that the north coast of the Gulf of Guinea is marked by fractures which appear to be extensions of the 'Romanche' and 'Chain' fracture zones in the equatorial Atlantic [84, 85].

594, 595. From 24 March onwards, activity started at a new focus in the northern part of the Red Sea and continued increasing until 31 March, when there was an earthquake of magnitude 7, followed by many aftershocks during the month of April. The main shock (**595**) was studied in the field: landslides, rock falls and fissures were observed in the Shakis Islands, near the epicentre; there was some damage to the lighthouse, where electric cables were ruptured. On the west coast of the Red Sea at Hurghada, there was some damage, particularly to a power station and to some hotels [86]. The shock was widely felt in Egypt, in Sinai—where slight damage was done to the Monastery of St. Catherine and at Sharm-el-Sheik—and in Israel. In Cairo, 1 person was killed and several injured, and 1 person killed

in Beni-Suef; a mosque collapsed at Asyüt. This is the first large earthquake to occur in the region of Hurghada, and illustrates the difficulties that may be met with in the seismic zoning of Egypt. In 1967, there was considerable seismic activity in the Red Sea at about 20° N., and again in 1969 at about 27½° N., on the northward extension of the Red Sea median trench.

597-600. The Afar depression in Ethiopia was the site of several destructive earthquakes in March and April 1969. According to Gouin, the epicentres were aligned in an east-west direction along latitude 12° N., between longitudes 41.11° E. and 41.18° E. The earthquake of 29 March (**597**) caused destruction at Sardo oasis; 25 persons were killed, mostly children; 170 persons were injured, some of whom died later. The village, which had been built around 1936, consisted mainly of masonry houses with reinforced concrete joists and floors; the complete destruction of these houses was due to the absence of proper ties; in contrast, the nomads' huts built of bamboo, with roofs of corrugated iron on rafters, stood up much better. Near Sardo, there was severe damage to bridges and embankments along the road from Assab to Dessye. The earthquake of 5 April (**600**) caused surface faulting 8 km east of Sardo, with a throw of 70 cm vertically and about 50 cm horizontally [87, 88, 89].

605. Congo, 400 km west of the great lakes.

606. Eastern rift; several other shocks occurred in the same region.

610. Lake Nyasa; intensity III at Mzuzu.

611. One of the many shocks at Kariba [90], where the seismic activity due to the filling of the reservoir had reached its maximum in 1963 (see previous issues of *Annual Summary*); a general study of this seismic activity has been made [91].

612. Lower Zambeze valley; intensity V at Cholo (Malawi).

613. Unusual epicentre off the coast of south-west Africa.

616. Witwatersrand; many other shocks in the same area.

617. The Cape Province fold zone and the Karoo have been the site of recent tectonic movement and their seismicity is far from negligible [92]; however, the earthquake of 29 September is the strongest that has occurred in South Africa in historical times. Severe damage was caused to the towns of Tulbagh, Wolseley, Ceres and Prince Alfred; 9 persons were killed and several dozens injured; some forest fires started after the earthquake [4]. The macroseismic area was 650,000 km^2, including Cape Town, Durban and Springbok. Damage to well-built houses was greatest in the Groot Winterhoek valley, along a line joining two faults running NE.-SW. (Saron fault and Groenhof fault). Damage to older buildings of poor quality was greater in valleys where there are thick alluvial deposits; the total damage was estimated at U.S.$24 million [1, report of Geological Service, Pretoria]. A strong aftershock (**618**) on 5 October caused further landslides in the Tulbagh area.

619. Widely felt in Cape Province; slight damage at Heidelberg.

Madagascar

None.

Gulf of Aden and Indian Ocean

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
37	**620**	24 October	10.12	11.9° N.	44.9° E.	4.8	—	25
33	**621**	5 December	11.38	14.5° N.	53.3° E.	4.8	—	*n*
33	**622**	11 May	00.18	14.3° N.	56.7° E.	5.1	—	32
33	**623**	22 April	22.34	13.0° N.	58.2° E.	5.7	5.2	*n*
33	**624**	8 January	06.03	17.4° N.	60.3° E.	4.7	—	*n*
33	**625**	29 March	13.48	10.4° N.	56.8° E.	5.6	5.5	*n*
33	**626**	14 December	18.37	8.2° N.	58.5° E.	6.0	6.0	*n*
33	**627**	9 August	13.40	4.6° N.	62.5° E.	5.2	—	*n*
33	**628**	18 June	17.11	1.6° N.	66.7° E.	5.0	—	23
33	**629**	22 September	01.40	5.6° S.	68.1° E.	5.1	6.0	14
33	**630**	12 July	05.57	6.0° S.	71.4° E.	5.3	5.0	*n*
33	**631**	21 April	17.58	14.4° S.	66.5° E.	4.8	—	*n*
33	**632**	2 February	19.53	17.2° S.	66.5° E.	5.2	—	*n*
33	**633**	14 February	06.14	17.8° S.	87.3° E.	5.3	—	*n*
33	**634**	3 January	03.56	18.2° S.	88.1° E.	5.3	—	*n*
33	**635**	8 May	17.50	19.8° S.	66.1° E.	5.3	—	*n*
33	**636**	16 August	10.05	24.0° S.	69.6° E.	5.5	—	*n*
33	**637**	20 March	20.46	27.5° S.	66.0° E.	5.5	—	*n*
33	**638**	6 November	18.57	34.6° S.	55.2° E.	5.1	—	*n*
33	**639**	10 July	04.31	39.6° S.	45.8° E.	4.6	—	*n*
33	**640**	24 July	12.41	45.4° S.	35.0° E.	5.7	6.0	*n*
33	**641**	9 April	11.43	49.1° S.	30.8° E.	5.8	—	23
33	**642**	23 August	19.05	53.5° S.	25.9° E.	5.2	—	*n*
33	**643**	26 October	21.39	53.4° S.	23.5° E.	5.9	6.5	*n*
33	**644**	18 June	04.04	52.7° S.	20.2° E.	—	—	*n*

626-9. Epicentres lying along the Carlsberg Ridge.

633, 634. Epicentres on the Ninety-East Ridge.

635. Rodriguez fracture zone.

A study of earthquake mechanism on the Indian Ocean median ridge has been published [18].

Indian-Antarctic ridge

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
33	**645**	24 July	16.24	33.5° S.	77.7° E.	4.7	—	*n*
33	**646**	21 July	10.35	35.3° S.	78.6° E.	5.2	—	*n*
33	**647**	22 December	19.48	41.6° S.	80.0° E.	5.3	—	*n*
33	**648**	10 October	02.36	46.0° S.	95.8° E.	5.2	5.2	*n*
33	**649**	2 March	06.25	47.4° S.	100.1° E.	5.0	—	*n*
33	**650**	24 September	05.33	48.8° S.	106.6° E.	—	—	*n*
33	**651**	3 November	03.30	45.8° S.	123.2° E.	5.2	—	*n*
33	**652**	15 March	14.58	49.5° S.	125.0° E.	5.0	—	*n*

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
33	**653**	5 May	14.15	44.2° S.	141.4° E.	—	—	25
45	**654**	5 April	06.53	54.7° S.	143.8° E.	5.2	—	*n*
45	**655**	4 July	22.54	55.9° S.	147.2° E.	4.9	5.8	*n*
45	**656**	1 September	08.14	58.9° S.	149.1° E.	5.1	5.6	*n*

The seismic zone defined by the epicentres listed above corresponds to the median rift of the Indian-Antarctic ridge; the spreading of the sea floor away from this median rift appears to be pushing, towards the north and the north-east, the lithospheric plate of which Australia is the main element; the movement of this plate would explain the formation of the mountain range in New Guinea and the seismic activity of the Solomon Islands and the New Hebrides.

Australia

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
38	**657**	20 June	11.15	38.6° S.	146.0° E.	4.8	—	19

657. Felt in the state of Victoria, particularly at Melbourne, and in New South Wales; slight damage at the epicentre, which was situated in the Gippsland Hills fault zone, whose seismic activity is well known. A study of the seismicity of south-eastern Australia has been published [93].

Atlantic

Arctic Ocean, Spitzbergen, Jan Mayen

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
40	**658**	7 April	20.26	76.5° N.	130.8° E.	5.5	5.6	*n*
40	**659**	27 January	06.37	80.8° N.	121.9° E.	5.0	5.0	37
40	**660**	8 July	02.36	82.9° N.	6.0° W.	4.1	—	*n*
40	**661**	10 November	18.15	77.1° N.	13.9° E.	4.6	5.0	*n*
40	**662**	21 April	22.27	74.2° N.	9.7° E.	5.0	4.5	*n*
40	**663**	21 January	21.09	73.7° N.	13.7° E.	4.6	—	7
40	**664**	28 May	03.57	73.5° N.	8.2° E.	4.9	5.0	*n*
40	**665**	18 December	19.00	71.7° N.	2.7° W.	4.6	—	*n*
40	**666**	5 March	22.41	71.1° N.	5.6° W.	4.8	—	*n*
40	**667**	28 April	16.55	69.3° N.	22.1° W.	4.1	—	*n*

667. Eastern Greenland, near the entrance to Scoresby Sund, a fjord which perhaps represents the western extension of the great Jan Mayen fault.

Iceland and median ridge (North Atlantic north of 40° N.)

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
40	**668**	5 May	21.47	66.8° N.	18.2° W.	5.2	5.2	*n*
40	**669**	26 August	22.47	66.3° N.	17.7° W.	4.8	—	*n*
32	**670**	21 April	17.18	61.9° N.	26.7° W.	4.1	—	*n*
32	**671**	20 September	05.08	58.3° N.	32.2° W.	5.6	6.3	*n*
32	**672**	22 June	05.07	55.6° N.	35.2° W.	4.7	—	*n*
32	**673**	24 September	04.20	52.6° N.	31.8° W.	5.2	5.7	*n*
32	**674**	24 September	03.58	52.5° N.	31.8° W.	5.2	6.0	*n*
32	**675**	2 January	12.13	47.5° N.	27.9° W.	4.7	—	*n*
32	**676**	6 December	17.17	45.1° N.	28.1° W.	4.5	—	*n*
32	**677**	1 January	22.26	42.5° N.	29.4° W.	4.6	—	*n*

668. Many other shocks of magnitude less than 5 occurred at the same focus.
671. The main shock was preceded by a series of shocks of increasing magnitude on 19 September at 20.54 h (m = 4.5) and at 23.21 h (m = 4.6), and on 20 September at 00.20 h (m = 4.4), at 00.56 h (m = 5.0), at 01.07 h (m = 5.0) and at 01.13 h (m = 5.2).

Azores, Canaries

No notable earthquake in 1969.

Atlantic median ridge (south of 40° N.)

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
32	**678**	21 July	17.38	35.2° N.	35.9° W.	4.9	4.8	*n*
32	**679**	18 July	00.00	29.7° N.	42.9° W.	5.0	—	*n*
32	**680**	21 January	08.05	28.7° N.	43.6° W.	5.2	5.6	*n*
32	**681**	19 April	08.16	25.2° N.	46.7° W.	5.0	—	*n*
32	**682**	21 July	07.10	21.0° N.	45.7° W.	4.7	—	22
32	**683**	24 September	18.03	15.2° N.	45.8° W.	5.8	6.4	*n*
32	**684**	4 June	20.35	11.9° N.	43.8° W.	4.9	—	*n*
32	**685**	6 August	15.41	10.8° N.	43.2° W.	5.2	5.0	*n*
32	**686**	5 June	20.39	10.7° N.	41.0° W.	5.2	5.1	*n*
32	**687**	20 July	10.46	7.2° N.	34.3° W.	4.3	5.0	*n*
32	**688**	22 September	13.47	5.0° N.	32.6° W.	5.7	5.5	*n*
32	**689**	6 November	13.21	3.9° N.	32.4° W.	5.0	—	*n*
32	**690**	11 August	13.33	1.0° N.	28.5° W.	5.0	—	*n*
32	**691**	13 December	03.19	1.0° N.	28.0° W.	5.6	5.5	*n*

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
32	**692**	22 September	22.02	0.5° N.	26.2° W.	4.8	5.0	*n*
32	**693**	1 October	17.46	0.0° N.	17.4° W.	5.0	—	*n*
32	**694**	11 June	06.51	2.5° S.	12.2° W.	5.0	—	*n*
32	**695**	7 November	16.41	2.8° S.	12.1° W.	5.3	—	*n*
32	**696**	9 June	09.35	7.0° S.	12.7° W.	4.9	—	*n*
32	**697**	11 January	11.58	10.2° S.	13.2° W.	4.9	5.3	*n*
32	**698**	23 January	05.16	14.2° S.	14.5° W.	4.8	—	*n*
32	**699**	25 February	14.05	19.3° S.	12.1° W.	5.3	5.3	*n*
32	**700**	27 June	09.00	21.0° S.	11.6° W.	5.0	—	*n*
32	**701**	17 May	05.51	28.3° S.	12.9° W.	4.9	—	*n*
32	**702**	12 June	15.46	32.4° S.	14.0° W.	5.1	—	*n*
32	**703**	1 September	04.35	39.6° S.	16.2° W.	—	—	*n*
32	**704**	8 August	12.46	47.5° S.	15.7° W.	5.0	—	*n*
32	**705**	8 August	11.08	47.7° S.	15.8° W.	5.9	6.0	*n*
32	**706**	16 June	19.53	50.1° S.	7.0° W.	4.6	—	*n*
32	**707**	5 August	06.13	55.2° S.	1.5° W.	5.1	—	*n*

695. North of Ascension Island; several aftershocks of magnitude greater than 5. A general article on the seismicity of the Atlantic median ridge has been published [94].

Southern Antilles, Antarctic Peninsula

Region	Number	Date	Time (GMT)	Co-ordinates		Magnitude		Depth of focus (km)
				Latitude	Longitude	*m*	*M*	
10	**708**	22 June	10.47	55.3° S.	29.4° W.	5.2	5.4	36
10	**709**	19 September	03.39	55.9° S.	27.8° W.	5.4	—	65
10	**710**	2 January	17.50	56.0° S.	27.5° W.	5.9	—	81
10	**711**	6 April	20.08	56.3° S.	26.9° W.	5.8	—	93
10	**712**	12 June	20.28	56.5° S.	25.3° W.	5.5	5.5	9
10	**713**	18 January	03.02	56.8° S.	26.8° W.	5.9	5.9	140
10	**714**	27 April	12.59	57.7° S.	25.4° W.	5.7	5.5	42
10	**715**	26 November	18.26	58.8° S.	24.7° W.	5.4	6.0	*n*
10	**716**	27 May	12.18	59.9° S.	26.5° W.	5.1	5.4	19
10	**717**	18 July	14.13	60.5° S.	26.0° W.	5.7	—	40
10	**718**	24 November	04.31	58.2° S.	13.8° W.	4.8	—	*n*
10	**719**	1 October	19.53	60.8° S.	19.7° W.	5.6	6.0	*n*
10	**720**	25 April	21.00	60.6° S.	51.1° W.	4.6	—	*n*
10	**721**	27 September	09.04	60.9° S.	56.0° W.	5.8	6.0	*n*
10	**722**	21 February	06.32	62.9° S.	60.2° W.	5.2	—	23
10	**723**	7 June	04.03	61.4° S.	62.3° W.	5.3	—	*n*
10	**724**	20 July	12.13	60.0° S.	65.3° W.	5.1	—	*n*

722. Deception Island; seismic activity started on 14 February and increased in intensity up to the time of the eruption of the volcano on the island, which occurred at 00.43 h on 21 February; the most violent shock, which was recorded by many stations (**722**) occurred several hours after the beginning of the eruption; the British and Chilean bases on the island were destroyed by the shocks, by falling volcanic bombs and by ice avalanches triggered by the earthquakes. Their personnel had to be evacuated by helicopter [95, 96, 97]. There had been an earthquake at the same focus on 4 December 1967, also accompanied by a violent eruption; a further shock had been recorded on 17 September 1968 [2].

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Tsunamis

The information contained in this chapter has been kindly supplied to Unesco by the International Tsunami Information Center (ITIC) in Honolulu (United States of America).

Celebes, 23 February

*Earthquake data (see also 'Earthquakes', **256**)*	Origin time (GMT): 00 h 36 m 56.6 s. Position: 3.1° S., 118.9° E. Magnitude: $m = 6.1$; $M = 6.9$ (USCGS), $6\frac{3}{4}$-7 (Pasadena), 7.2 (Berkeley). Depth of focus: 13 km.
Effects	A local tsunami generated on the west coast of Celebes caused at least 600 deaths and demolished 4 villages [Antara News Agency].
Warning action	None (local tsunami).

North Atlantic Ocean (west of Portugal), 28 February

*Earthquake data (see also 'Earthquakes', **19**)*	Origin time (GMT): 02 h 40 m 32.5 s. Position: 36.1° N., 10.6° W. Magnitude: $m = 7.3$; $M = 8.0$ (USCGS), 8 (Pasadena), 7.9 (Berkeley), 8.2 (Golden), $7\frac{1}{4}$ (Palisades). Depth of focus: 22 km.

Tsunami data

Time observed (GMT)	Maximum wave amplitude in centimetres, peak to trough	Place of observation
03.02	10	Tenerife (Canary Islands)
04.05	23 (5th wave)	Cádiz (Spain)
05.35	48 (8th wave)	Chipiona (Spain)
06.30	31 (5th wave)	Bonanza (Spain)
05.51	20 (7th wave)	Faro de Olhão (Portugal)
09.40	45 (14th wave)	Leixoes (Portugal)
04.34	70 (1st wave)	Pedroucos (Portugal)
04.45	25 (1st wave)	Praça do Commercio (Portugal)

Cabo Ruivo and Cantareira, Portugal, recorded the tsunami with amplitudes less than 10 cm. The tsunami reached an amplitude of 120 cm at Casablanca (Morocco), according to reports received by the Smithsonian Institution's Center for Short-lived Phenomena.

Warning action None (Atlantic Ocean).

Kuril Islands, 11 August

Earthquake data (see also 'Earthquakes', 161)

Origin time (GMT): 21 h 27 m 39.4 s.
Position: 43.5° N., 147.4° E.
Magnitude: m = 7.1 (USCGS); M = 7.8 (Pasadena), 7.6 (Berkeley), 7.8 (USCGS).
Depth of focus: 28 km.

Tsunami data

Time observed (GMT)		Maximum wave amplitude in centimetres, peak to trough	Place of observation
	—	260	Nemuro, Hokkaido (Japan)
	—	132	Urakawa, Hokkaido (Japan)
22.20	11 August	137 (2nd wave)	Shoya (Japan)
22.43	11 August	141 (2nd wave)	Yuzhno-Kurilsk (U.S.S.R.)
01.25	12 August	24	Wake Island
01.30	12 August	110 (5th wave)	Hachinohe, Honshu (Japan)
01.50	12 August	94 (7th wave)	Kushiro, Hokkaido (Japan)
02.17	12 August	49 (2nd wave)	Midway Islands
03.38	12 August	24	Kwajalein Island
05.00	12 August	43	Kahului (Hawaii)
06.03	12 August	23	Hilo (Hawaii)
20.45	12 August	40	La Libertad (Ecuador)

Many other Pacific basin mareograph stations recorded this tsunami with amplitudes less than 20 cm.

Warning action A tsunami watch was issued by the ITIC Tsunami Warning Center and later cancelled when it was determined that it was a minor tsunami.

East coast of Kamchatka, 22 November

Earthquake data (see also 'Earthquakes', 145)

Origin time (GMT): 23 h 09 m 37.2 s.
Position: 57.8° N., 163.5° E.
Magnitude: m = 6.3; M = 7.1 (Pasadena), 7 (Berkeley), 7¼ (Golden).
Depth of focus: 33 km.

Tsunami data

Time observed (GMT)	Maximum wave amplitude in centimetres, peak to trough	Place of observation
—	52	Shemya (Aleutian Islands)
—	40	Attu (Aleutian Islands)
—	27	Adak (Aleutian Islands)
07.52 23 November	37 (6th wave)	Kahului (Hawaii)

The tsunami was recorded with an amplitude of less than 20 cm at the tide stations at Hilo, Honolulu and Nawiliwili (Hawaii); Midway Island; Wake Island; Pago Pago (Eastern Samoa).

Warning action A tsunami warning was issued for the western Aleutian Islands by the Alaska Regional Warning System and a tsunami watch was issued by the ITIC Tsunami Warning Center in Honolulu for the remainder of the Pacific. The warning and watch were cancelled as soon as the tsunami was determined to be minor.

Leeward Islands, 25 December

Earthquake data (see also 'Earthquakes', 502)

Origin time (GMT): 21 h 32 m 27.3 s.
Position: 15.8° N., 59.7° W.
Magnitude: m = 6.4; M = 7.0 (Pasadena), 7.6 (Golden).
Depth of focus: 7 km.

Tsunami data

Time observed (GMT)	Maximum wave amplitude in centimetres, peak to trough	Place of observation
—	46	Barbados
—	30	Antigua
—	12	Dominica

Warning action None (Atlantic Ocean).

Storm surges

The information in this chapter has been compiled for Unesco by the Institute of Coastal Oceanography and Tides, Birkenhead, Cheshire (United Kingdom).

Texas (United States), 13-14 February

Strong, persistent easterly winds, gusting up to 45 m/s, were generated by an intense low-pressure centre in the Gulf of Mexico blocked by a strong high-pressure ridge extending from the Great Lakes to Florida. Hurricane force winds and torrential rains were generated by a north/south oriented squall line that formed on the evening of 13 February and moved eastwards to the Texas-Louisiana border early on 14 February.

Tides reached over 2.75 m above normal in Galveston Bay, Texas. Marinas, pleasure boats, docks, piers and homes were severely damaged; water was 1 m deep in 50 houses in Baytown. Total damage due to the surge was estimated at U.S.$5 million.

Further north, the only road link between Corpus Christi and Port Aransas was closed after high tides had washed over the bridge approach. The strong winds (18-27 m/s) affected the Louisiana coast; tides, everywhere 60-90 cm above normal, caused extensive flooding especially in the lower sections of the town of Cameron. Mississippi also experienced minor flooding along most of its coast, with tides 1 m above normal.

Shantung peninsula (China), 23 April

Correspondents of the Center for Short-lived Phenomena of the Smithsonian Institution reported a major surge on the north coast of the Shantung peninsula on 23 April 1969. The worst surge for 80 years was generated by unusually strong north-easterly winds blowing almost directly onshore. Sea level reached more than 6.5 m above normal, affecting 70 km of coastline. The wind-driven water moved rapidly inland and, in a few hours, water stood

1 m deep 20 km from the shore-line. Houses collapsed and crops were submerged over an area estimated at 1,100 km^2, affecting 100,000 people. Wintry conditions accompanied the storm and rescue operations were hampered by sub-zero temperatures and a snow-storm.

Hurricane Camille (United States), 14-18 August

Hurricane Camille formed near the island of Grand Cayman in the Caribbean from a tropical wave which had originated near the African coast on 5 August. On the morning of 14 August reconnaissance aircraft reported that a vortex was developing and on that afternoon a low-pressure area was identified, with a minimum of 991 mb and maximum winds of 22 m/s. It was immediately apparent that conditions were very favourable for a rapid intensification of the storm. When Camille approached the western tip of Cuba on the afternoon of 15 August, the pressure at its centre had already fallen to 964 mb, with winds over 45 m/s. As the storm moved north-west (Fig. 2) it continued to deepen and by the afternoon of 16 August, aircraft reported a central pressure of 908 mb, the lowest sea-level pressure ever reported by an aircraft in an Atlantic hurricane. However, on the evening of 16 August a central pressure of 905 mb was recorded, with winds exceeding 65 m/s while the hurricane continued to move north-north-west at 25 km/h.

Early in the afternoon of 17 August the hurricane was less than 150 km from the mouth of the Mississippi River, with maximum surface winds estimated at more than 90 m/s. It was then clear that Camille was to be one of the major storms of this century. Hurricane warnings were issued along the coast from Louisiana to Florida and low-lying areas were evacuated.

The centre of the hurricane passed over the Mississippi coast near the towns of Clermont Harbor, Waveland and Bay St. Louis at 2030 CST on Sunday, 17 August. Maximum winds near the coast-line could not be measured but analysis of structural damage suggested velocities approaching 90 m/s (175 knots). The highest storm surge ever recorded (7.50 m above normal) occurred at Pass Christian and more than 150 km of the coast experienced a major surge (Fig. 3).

Camille continued inland on a northerly course, producing heavy rain, more than 150 mm in many places, although the surface winds rapidly weakened. On 19 August, as the remnants of the storm turned eastward, torrential local rain fell on the eastern slopes of the Allegheny mountains causing disastrous flash floods. Camille moved out into the Atlantic on 21 August, quickly regaining tropical storm intensity; however, after meeting a cold front it rapidly declined in intensity.

Camille was one of the most disastrous hurricanes ever recorded, causing more deaths (256) and equalling Hurricane Betsy of 1965 in total damage, estimated at U.S.$1,280 million. The storm surge was mainly responsible for this. The old mansions along the Mississippi coast between Pass Christian and Biloxi, which had withstood hurricanes for more than 100 years were, with very few exceptions, totally or substantially destroyed. In the Pass Christian-Long Beach area, nothing remained within 100 m of the coast-line, houses having been swept off their foundations and splintered into tiny pieces. Docks and shipping were severely damaged or destroyed over a long stretch of coastline. In the mouth of the Mississippi, strong northerly winds (see Table 1) pushed the surge over the levees on both sides of the river, inundating the area with the water trapped by the levees. In the delta 1,500 homes were

destroyed or severely damaged, 8,000 head of cattle drowned and citrus groves destroyed. Almost 100 vessels, ranging from tugs and barges to ocean freighters, grounded or sank in the Mississippi river. Thanks to the timely evacuation of the delta area, there were relatively few casualties.

TABLE 1. Hurricane Camille, 15-18 August 1969

Station	Date	Minimum pressure		Wind (m/s)		Height of storm surge above normal (cm)
		(mb)	Time (CST)	Fastest mile	Gusts	
Florida						
Apalachicola	17					90
Pensacola	17	1 000	17.55		33 SE.	190
Alabama						
Mobile	17	996	21.56	21 SE.	34 SE.	225
Mississippi						
Pascagoula	17	990	22.45		38 ESE.	365
Biloxi	17	980	23.15	38 ESE.	60 SE.	510
Louisiana						
Boothville	17	959	18.40		50	455
Slidell	17	968	22.40			160
Pilottown	17	950	18.00			365
Port Sulphur	17	981	19.00	28	42 NW.	80
New Orleans	17	983	21.15	24 N.	40 N.	

East coast of the United Kingdom, 29 September

At 12.00 GMT on 27 September 1969, north-westerly winds over the North Sea (which had produced a small surge) were giving way to a weak ridge of high pressure crossing the British Isles from the west. A depression of 998 mb was moving towards Scotland and deepening; by 06.00 GMT on 28 September this depression had reached 59° N., 13° W. and deepened to 970 mb. South-westerly gales of 18-20 m/s created a 60 cm surge on the north-west coast of Scotland.

The depression then moved ENE. at 25 knots, passing just north of Scotland and reaching the coast of Norway about midnight on 29 September. Behind the depression, severe north-westerly gales in the northern part of the North Sea caused a further surge on the east coast of Scotland.

This surge moved southwards along the east coast of Great Britain, producing the highest water levels ever recorded between the Tyne and the Humber; they exceeded the maximum levels of 1953 by 24 cm at North Shields and by 21 cm at Immingham. Further south, the north-westerly winds were weaker and the time of highest surge tended to occur before high tide (Table 2).

Danger levels were exceeded by 45 cm at Tyne, 52 cm at Immingham and 67 cm at Lowestoft. Nevertheless, relatively little damage was caused although there was extensive

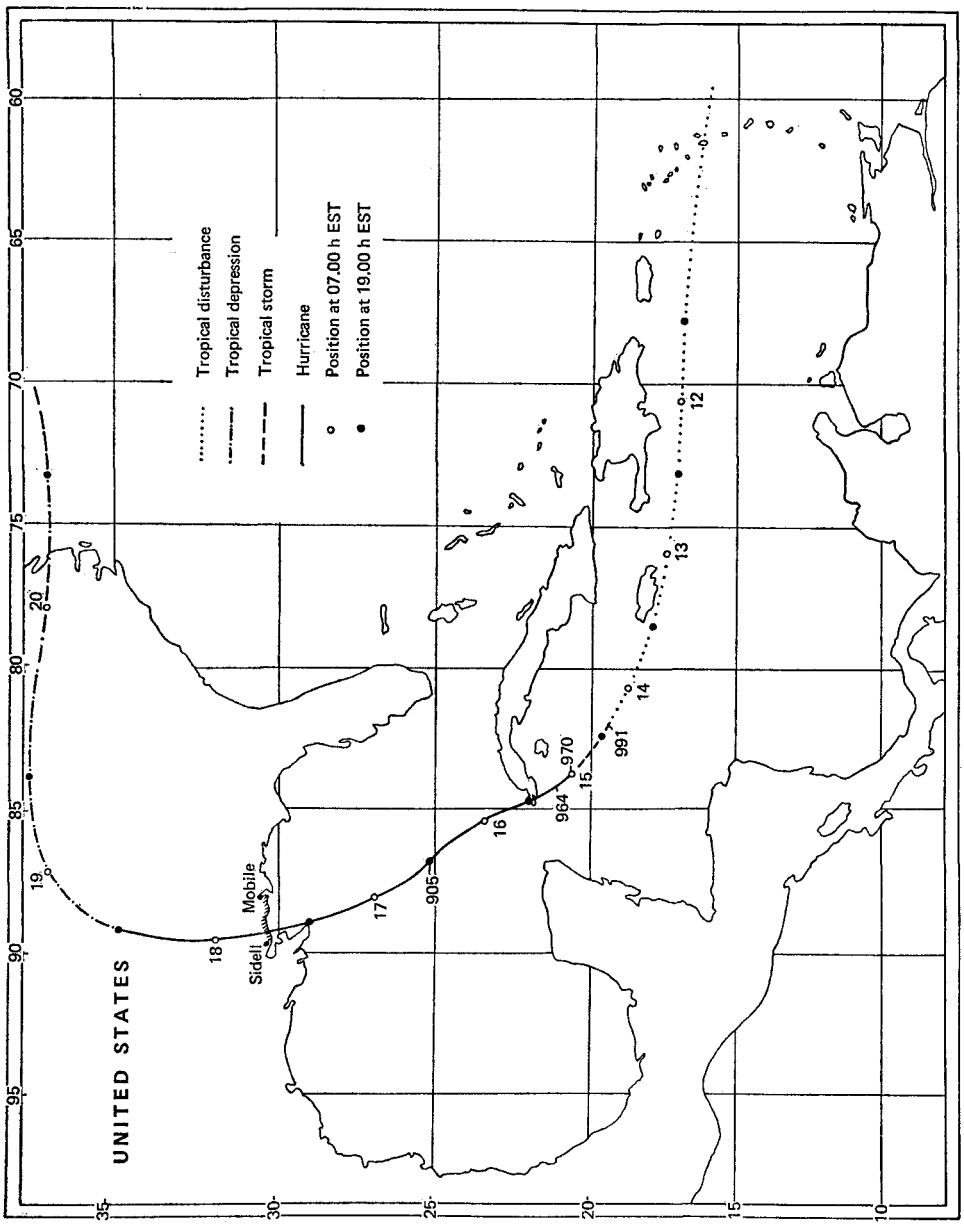

FIG. 2. The storm track of Hurricane Camille, 12-20 August 1969. Central pressures are shown in millibars. (EST = GMT − 5 h.)

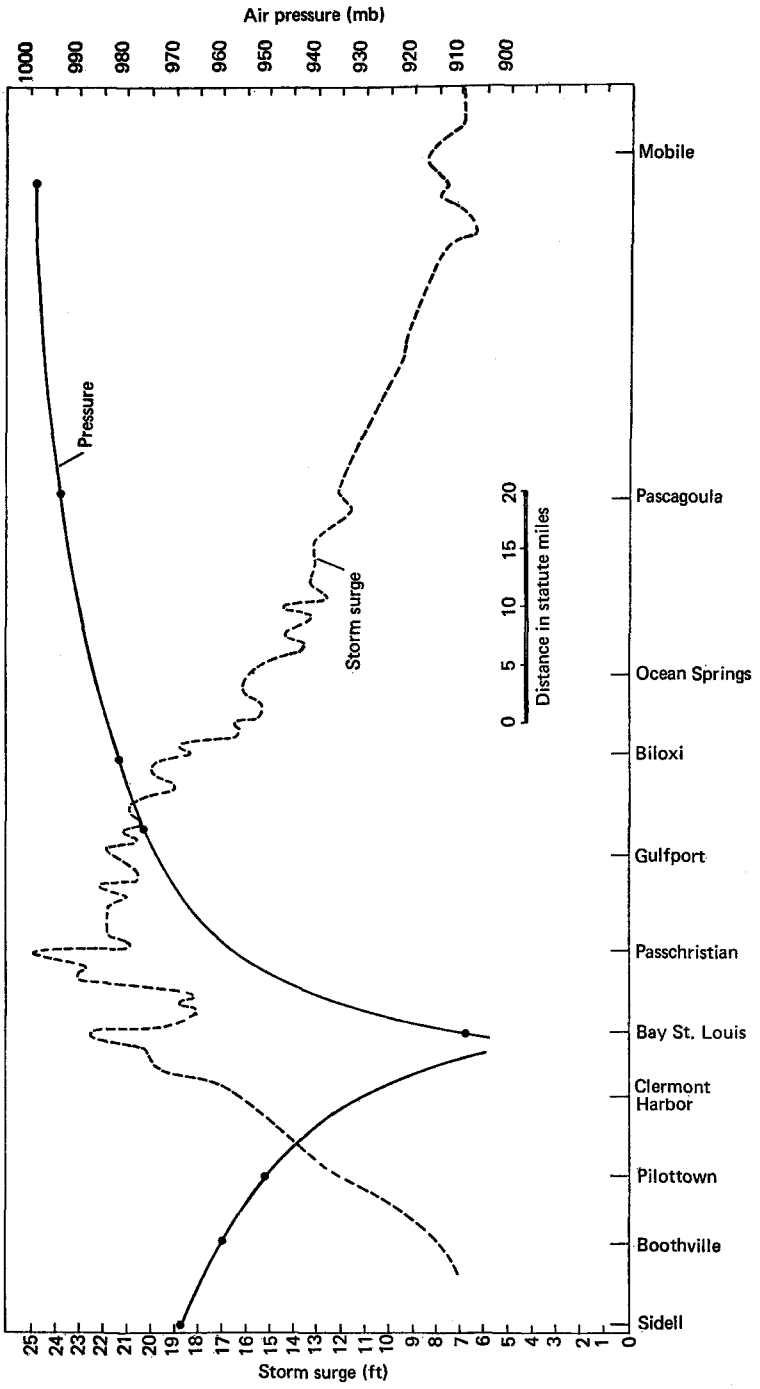

FIG. 3. The maximum water levels reached during Hurricane Camille along the Gulf Coast of the United States of America. *Source*. Simpson, Sugg *et al.*, 1970.

flooding in the port of Hull; there was minor flooding along much of the coast and several industrial riverside properties in Great Yarmouth suffered damage.

TABLE 2. East Coast of United Kingdom, 29 September 1969

Port	High water			Maximum surge	
	Time (GMT)	Height (cm)	Observed minus predicted (cm)	Time (GMT)	Amplitude (cm)
Stornoway[1]	19.45	245	24		64
Wick	01.10	237	55		73
Aberdeen	02.50	292	79	05.00	88
Blyth	04.55	360	79		
Tyne	04.58	355	97	01.00	112
Sunderland	05.06	360	94		
Scarborough	06.02	385	125		
Immingham	07.22	470	118	04.30	152
Grimsby	07.32	435	112		
Hull	07.30	500	137		
Boston	07.00	515	88		
King's Lynn	07.45	505	94		
Great Yarmouth	11.00	212	106		
Lowestoft	10.32	255	140	07.00	149
Harwich	13.50	295	76	08.00	173
Southend	14.10	360	64	10.00	225
Dover	12.38	405	103		

1. Data for 28 September.

Andhra Pradesh (India), 5-8 November

In mid-May a cyclonic storm crossed the coast of Andhra Pradesh and caused unprecedented floods with heavy loss of life and property in the districts of Krishna, Guntur and Godavari. The storm took a toll of over 600 human lives and thousands of head of cattle. Although there may have been some surge damage the primary damage was due to the very heavy rainfall, over 700 mm being reported in a 6-day period.

In the post-monsoon season this coast was again severely hit by a cyclonic storm moving in from the Bay of Bengal. The storm crossed the coast of Andhra Pradesh near Coringa shortly after noon (the time of low tide) on 7 November. The storm surge produced water levels 3 m above normal, the sea-water penetrating 3 km inland from the port of Kakinada. Between Kakinada and Coringa, the sea reached as much as 8 km inland, the depth of inundation by sea water being up to 1.50 m. Fishing boats were either damaged or deposited inland, the coastal flood bank was severely damaged and completely washed away in many places. Thousands of people were left homeless and marooned; 200 people died and all crops in the flooded area were destroyed by the sea-water.

Other events

Dublin (Ireland), 17 January. Strong south-easterly winds of 18 m/s, gusting to 29 m/s in Dublin Bay, produced a surge of 80 cm which, combined with high tide and fairly high waves, caused local flooding in Dublin.

China (Taiwan). In late September and early October, typhoons Elsie (26 September) and Flossie (2-5 October) hit the island with high winds and heavy rainfall. Very serious floods caused damage estimated at U.S.$875 million. The extent of the surges is unknown.

Honduras, 3 September. Hurricane Francelia, moving almost due west across the southern Caribbean, crossed the central American coast on 3 September at the head of the Gulf of Honduras. Gale force winds occurred over British Honduras from Belize southward; hurricane force winds and high tides were confined to a small area of the coast just north of the hurricane centre. Torrential rains were the main cause of flooding, the Belize river rising to over 11 m above normal.

Venice (Italy), November/December. The danger of flooding in the city of Venice was emphasized again on 23-27 November, when for several days the sea level substantially exceeded the predicted level, with a maximum of 102 cm above prediction at midnight on 25 November. Again, on 4-8 December, sea level remained high for a long period, reaching 53 cm above the predicted high tide on the evening of 7 December.

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Volcanic eruptions

Introduction

The information contained in this section is based, by kind permission, on data appearing in the *Bulletin of Volcanic Eruptions*, published jointly by the Volcanological Society of Japan and the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), and on reports issued by the Smithsonian Institution's Center for Short-lived Phenomena, Cambridge, Mass. (United States).

The information is presented by geographical region; in each region, individual volcanoes are cited in the order in which they appear in the *Catalogue of the Active Volcanoes of the World*, published by IAVCEI. The name of each volcano is followed, in parentheses, by its reference number (if any) in this catalogue, by its geographical co-ordinates and, in some cases, by the name of the country or territory in which it is situated.

Against the dates of the principal events appear symbols indicating the character of the eruptions, followed in most cases by a short explanatory text. In cases of uncertainty or of incomplete information, a question mark (?) follows the symbol. The intensity of the eruption is indicated by a letter in parentheses: (*l*) = slight; (*m*) = moderate; (*g*) = great.

The symbols have the following meanings:

- Eruption in a central crater
- Eruption in a parasitic crater
- Eruption from a radial fissure
- Normal explosion
- *Nuées ardentes*
- Lava flow
- Mud flow (lahar)
- Eruption in a crater lake
- Extrusion of a lava dome
- Phreatic explosion
- Submarine eruption
- Solfataras, vapours
- Destruction of arable land
- Casualties

List of eruptions

ALEUTIANS

Kiska, 51°57′ N., 177°40′ E.

12 September ↑ ≈ (*l*)
Eruption of ash and lava on Little Kiska Island. Ended 15 September.

CENTRAL AMERICA

Telica (14, 4-4), 12°36′ N., 86°52′ W. (Nicaragua).

February ○ ↑ (*l*)
On 10 February, white clouds were observed, issuing from the north-eastern side of the crater. During the following days activity increased in intensity, with the emission of some ash clouds. From 19 February onwards, this activity decreased, and had ceased by the end of the month.

May ○ ↑ (*m*)
Activity started again on 14 May, and on the following day there was a short but violent ash eruption. Activity ceased on 18 May.

August ○ ↑ (*l*)
After several days of intermittent activity, a large ash cloud was seen on the northern side of the crater on 19 August. Activity ceased soon thereafter.

Rincón de la Vieja (14, 5-2), 10°50′ N., 85°21′ W. (Costa Rica).

22 April ↑ (*l*)
Ash eruption, with cloud reaching about 3,000 m. Strong fumerole activity appears to have continued until May, particularly in Quebrada Grande on the slopes of the volcano.

Arenal, 10°27′ N., 84°42′ W. (Costa Rica).

September ≈
Fresh lava flow towards the west and south-west, advancing at about 1.5 m per day and cutting the road from La Fortuna to Pueblo Nuevo.

Poas (14, 5-4), 10°11′ N., 84°13′ W. (Costa Rica).

3 May ○ ⁝ (*l*)
Vapour cloud reaching a height of 1,500 m over the crater. This was followed by slight ash eruptions on 13 and 15 May, accompanied by local earthquake shocks. Strong fumerolic activity continued until the end of the month, together with pulsating emissions of gases and pyroclastic material through the crater lake.

SOUTH AMERICA

Ubinas (15, 4-2), 16°21′ S., 70°54′ W. (Peru).

June (*l*)
Intense fumerole activity and gas emissions commenced in early June, the latter causing damage to crops in the immediate vicinity of the volcano. There was a slight but steady ash emission during the first week of July.

ANTARCTICA

Deception Island (19-3), 62°56′ S., 60°34′ W.

21 February ○ ⁝ ↑ → (*m*)
After 7 days of gradually increasing seismic activity, a violent eruption occurred at 00.43 h on 21 February, with the emission of an ash and steam cloud reaching a height of 3,000 m. The Chilean base on the island was destroyed and the British station heavily damaged by falling volcanic bombs and a mud flow. A reconnaissance by ship at the beginning of March revealed that a rift had been cut through the glacier to a depth of about 70 m, and that Kroner Lake, which used to be landlocked, was open to the sea. The mudflow was about 2 m deep and appeared to have been rapid-moving (30-50 km/h). The largest mud-flow occurred to the north of Penfold Point; it carried large blocks of glacier ice and bedrock blocks weighing several tons as far as the coast. Intense fumerole activity continued for several days in the Fumerole Bay area.

NEW ZEALAND

Ruapehu, 39°17′ S., 175°34′ E.

21 June ○ ⁝ → (*l*)
At 12.25 h (GMT) on 21 June (00.25 h on 22 June, NZST), a violent ash eruption occurred, expelling enough water from the crater lake to lower its level by about 5 m. A lahar, generated

by hot water from the lake or by hot ash avalanches mixed with snow, descended the northern slopes of the volcano and travelled about 15 km down the Whakapapaiti and Whakapapanui rivers. Airborne ash deposits extended 15 km to the north-west of the crater. The eruption was preceded by moderate-to-strong volcanic tremor, which, however, began only 20 minutes before the eruption. The eruption lasted only a few hours.

MELANESIA

Kovachi (5, 5-6), 9°01′ S., 157°57′ E. (Solomon Islands).

28 October $\nearrow (m)$

This submarine volcano started eruption on 28 October, producing water fountains and a large quantity of pumice which drifted on the surface to distances exceeding 100 km. This activity died down in mid-November but was subsequently renewed and continued intermittently until the end of the year.

MARIANAS

Farallon de Pajaros, 20°20′ N., 144°32′ E.

12 March $\nearrow (l)$

A fishing boat reported explosions and discolouration of the sea surface. Acoustic waves were recorded by hydrophone stations at Eniwetok, Wake and Midway.

KAMCHATKA

Bezymianny (10, 0-25), 55°58′ N., 160°35′ E.

October $\bigcirc \uparrow \rightarrow (l)$

After two months of increasing seismic activity, a small explosive eruption began on 11 October and continued until 25 October. The eruption cloud reached a height of 2,000 m; small glowing avalanches were observed on the east flank of the dome; there was light ash-fall over an area of 400 km^2. A further eruption occurred on 3 November.

JAPAN

Suwanose-zima (8, 2-3), 29°32′ N., 129°43′ E. (Ryukyu Islands).

23 April }
11 May } ○ ↑ (*l*)

Slight eruptions of andesitic ash.

Kutinoerabu-zima (8, 2-5), 30°26′ N., 130°13′ E. (Ryukyu Islands).

5 February }
10 March } ○ ⁝ (*l*)

Minor phreatic eruptions of cinders and ash.

Sakura-zima (8, 2-8), 31°35′ N., 130°39′ E. (Kyushu).

February-October ○ ↑ (*l*)

This volcano continued in intermittent activity throughout the year. Explosions of andesitic cinders and ash took place in the summit crater of Minami-dake as follows:

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Number of explosions	0	1	2	0	2	1	0	6	9	1	0	0	22

O-sima (8, 4-1), 34°44′ N., 139°23′ E. (Izu Islands).

January-July ○ ↑ (*l*)

Eruptions of Strombolian type occurred at the summit crater of the central cone Mihara-yama between 19 January and 9 April, on 7-8 and 12 May, and on 3-4 and 15-16 July.

PHILIPPINES

Canlaón (7, 2-2), 10°25′ N., 123°08′ E. (Negros Island).

11-15 October ○ ↑ ⇝ (*l*)

A slight ash eruption on the evening of 11 October was followed on 14 October by a somewhat stronger one which sent an ash cloud to a height of 4,000 m. There were some mud-flows on the upper slopes of the volcano, and a road was blocked near Magallón by a flow of sulphuric sands.

Taal (7, 3-7), 14°01′ N., 121°00′ E. (Luzon).

29 October ○ ⁝ ↑ ≈ (*m*)
The eruption began at 06.15 h (local time), forming a small crater high on the northern slope of the 1968 eruption cone. After an early phreatic phase lasting about 48 hours, the eruption evolved into one of typical Strombolian character, with the discharge of pyroclastics from the main crater and the extrusion of lava from sub-terminal outlets at the base of the 1968 cone. This phase continued until 20 November, gradually building up a new cone which overtopped that of the 1968 eruption; intense activity on this and the following days included lava fountaining to about 300 m and explosive discharges which gradually demolished the newly built cone. The eruption ended on 4 December. For further details, see *COMVOL Letter*, Vol. IV, Nos. 2 and 3, 1970.

Didicas (7, 4-2), 19°04′ N., 122°10′ E. (Babuyan Island).

21 March ○ ⁝ (*l*) †
Phreatic eruption from a new explosion crater in the northern part of the island, with the ejection of mud, steam, ashes and andesitic tephra. This activity continued until the end of March, after which it became intermittent, the last reported eruption occurring on 21 August. Two persons were killed while fishing near the volcano on 21 March.

INDONESIA

Merapi (6, 3-25), 7°33′ S., 110°27′ E. (Java).

8 January ○ ↑ → ≈ (*m*) †
This eruption began at 02.30 h (local time), with the emission of *nuées ardentes* to the south-west as far as the village of Pakel, 13 km from the crater. The lava dome built up by the 1967 eruption collapsed, and lava flows reached villages in the Magelang area. Mud and sand came down the Tjode river and damaged about 180 houses in the centre of Jogjakarta. Ash and lava emission continued until 25 January. At least 3 persons were missing and 2,000 rendered homeless by the eruption.

Amburombu (6, 4-10), 8°49′ S., 121°11′ E. (Flores).

27 February ○ ↑ (*l*)
Possible slight ash eruption.

Ija (6, 4-11), 8°53′ S., 121°38′ E. (Flores).

27 January ↑ (*l*)
Ash eruption; ended 26 February.

WESTERN MEDITERRANEAN

Etna (1, 1-6), 37°44′ N., 15°00′ E. (Sicily).

June-July ○o ↑ ≈ (*l*)
Lava fountaining in the north-east crater, and lava flows from a fissure in the western side of the north-east cone. Rhythmic gas emissions from a new vent (Bocca Nuova) on the same slope.

CENTRAL PACIFIC

Kilauea (13, 2-3), 19°26′ N., 155°18′ W. (Hawaii).

22 February ○o ≈ (*l*)
Gas-rich lava flowed from *en échelon* fissures cutting across the western edge of the Alae crater pit. Lava flows cut the scenic road in three places and followed the road for 2.5 km down the mountain slope. The rate of eruption slowed after 24 hours and the eruption ceased on 24 February. It resumed, however, on the following day, from a double fountain north-east of Alae, and lava poured into this crater for about 60 hours, forming a new lava lake of volume about 7 million m^3.

24 May ○o ≈ (*l*)
Brief eruption, lasting 24 hours, from another fissure on the east rift.

27 May ○o ≈ (*m*)
Eruption from a double vent situated on a fissure north-west of Alae crater, continuing with varying intensity for 7 months. Several lava flows extended more than 5 km, and one reached the sea. A broad elongated shield of pumice was piled up downwind of the vents to a height of 60 m. The total volume of lava emitted had reached 67 million m^3 by the end of the year.