PUBLICATIONS

of the

DOMINION OBSERVATORY

OTTAWA

CANADIAN WEST COAST EARTHQUAKES, 1951-1954

Reprinted from
Vol. XVI Nos. 3, 9 and 13
and Vol. XVIII No. 3

CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES
Observatories Branch

1967

CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS
DOMINION OBSERVATORIES

PUBLICATIONS

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BY

W. G. MILNE AND F. LOMBARDO

EDMOND CLOUTIER, C.M.G., O.A., D.S.P., OTTAWA, 1953
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W. G. Milne and F. Lombardo.

ABSTRACT

Three station triangulation of local earthquakes in the British Columbia Coast regions was initiated in August, 1951, making use of short period Benioff and Willmore seismographs. The three stations were located at Victoria and Alberni on Vancouver Island and at Horseshoe Bay on the mainland. Seventy-four earthquakes were recorded in a five months' period and it was possible to determine epicentres for 27. Some indications were given of areas of localized activity but it is expected that at least another year's operation will be required before such areas are at all clearly defined. Tables of epicentres and times are given and the stations and equipment are described.

INTRODUCTION

In June of 1948 a Benioff vertical short-period seismograph was set up at the Dominion Astrophysical Observatory in Victoria to add to the Milne-Shaw horizontal instruments then in service. The main purpose of the additional instrument was to record the local earthquakes which were assumed to be occurring in the vicinity of Vancouver Island, British Columbia. Between that date and January of 1951, 199 earthquakes were recorded as having originated along the strip of coast from the northern Queen Charlotte Islands south to Oregon. This total was sufficiently great to warrant an increase in the seismograph stations in the area.

It was decided that a triangulation network consisting of two stations in addition to Victoria should be set up in 1951. The two stations were to be equipped with three-component, short-period, Willmore-Sharpe seismometers recording on Sprengnether recorders. This present report deals with the setting-up of such a system, and the earthquakes recorded in 1951. Subsequent reports are proposed each year to carry along a complete seismic history of the area. In addition, a past seismic history of the area is being prepared. It is hoped that this will be sufficiently complete to warrant publication in the near future.

THE NEW STATIONS

The expanded program in British Columbia was made possible by the completion of the field work of the rockburst project[1]. In that work a technique had been developed for housing seismograph stations in portable buildings and two of the buildings with the necessary seismometers and recorders became available in the spring of 1951. After being overhauled in Ottawa the buildings were crated and shipped to British Columbia by rail. All instruments for the two new stations were transported to the west coast by truck.

Alberni

With the co-operation of the School Board of District 70, Port Alberni, a location behind the Old Gill School in Alberni was made available for one of the new seismic

[1] Hodgson, J. H., "A Seismic Survey in the Canadian Shield", Publications of the Dominion Observatory, in preparation.

stations. This location is on a large flat outcrop of basic volcanic rock. The recording hut foundation construction was carried out without difficulty. The seismometer hut was erected 150 feet distant on the same outcrop. At Alberni where it rains a great deal in the fall and winter good water-proofing is needed for the hut. The necessity of a location some distance from a main road was emphasized in December, when a bridge was washed out on the main highway and heavy traffic was diverted over the secondary road passing within a hundred yards of the seismograph. The records were greatly disturbed at busy times.

The station at Alberni commenced operation on August 17th and was cared for during the summer by a student assistant. In September a local operator was trained to carry on the work. Each week the records are mailed to Victoria for reading at the Dominion Astrophysical Observatory.

Horseshoe Bay

At the Horseshoe Bay location permission was granted by the North West Telephone Company to erect a seismic station on a ledge on the mountain overlooking Horseshoe Bay, West Vancouver. The ledge is an outcrop of granitic rock, possibly granodiorite. The exposed surface is about 10 feet square sloping down at about a thirty degree angle. Before the hut foundation could be poured with concrete, a solid cement floor was built. A trolley system was devised to carry concrete, in buckets, up the steep slope. To allow for the unusually slow process of placing the concrete, a retarder or slow set was added to the ready-mix concrete. The foundation and piers were poured on top of the solid floor. A seismometer hut was erected approximately 80 feet from the recorder hut. At this station the traffic noise is negligible. However, a car-ferry docking in the bay area disturbs the records for some three minutes four times a day. It would appear that the boat actually rams into the piles driven into the floor of the bay, and this sets up a vibration in the ground. At Horseshoe Bay the seismometer hut is in a group of trees and following a heavy snowfall the seismometers are disturbed by what is thought to be big clumps of snow falling from the tree branches.

Operation of the Horseshoe Bay station was carried on for a few months by one of the Department's technicians, who in turn trained a local operator. As at Alberni, the records are mailed to Victoria to be interpreted.

Instrumental Arrangements

A word about the seismometers might be included, for little literature is available on the Willmore-Sharpe instrument. The original instrument was designed by Willmore for use in South Africa. With his permission copies were made for the Canadian government by the Sharpe Instrument Company of Toronto. They were first used in the recording of rockbursts in Eastern Canada[1] where they proved very successful. The seismometer design is a moving coil suspended by tension springs in the field of a strong pot-type magnet. Vertical and horizontal instruments are identical except that the vertical has an extra flat spring in its suspension system. The free period of the moving coil is 1/4 to 1/3 second; damping is slightly less than critical. The seismometer is operated with a

galvanometer whose free period is of the order of 1/20 second. The system is extremely sensitive to short period vibrations such as those set up by an earthquake within a two-hundred kilometre radius. However, it is felt that the overall period is too short and experiments are being conducted to lengthen this period. The recording device is a standard Sprengnether microseismic recorder.

Time control for all three stations is obtained through the local CBC Vancouver broadcasting station, CBU, which transmits the 18 hours GMT radio signal from CHU, Ottawa. The regular shortwave CHU channel cannot be received on the west coast. The CBC signal is carried to Vancouver from Ottawa by land-line which undoubtedly introduces some lag in the signal, but because all three stations use the same radio signal no difference in relative time need be taken into account. This time lag on the Ottawa-Vancouver land line is being measured.

The pertinent information on the three British Columbia stations is given in Table 1.

TABLE 1

Victoria:	August 1st to December 31st inclusive
(V)	φ = 48° 31′ 14″ N.
	λ = 123° 24′ 56″ W.
	Benioff short-period vertical seismograph.
Horseshoe Bay:	August 6th to December 31st inclusive
(HB)	φ = 49° 22′ 39″ N.
	λ = 123° 16′ 33″ W.
	Willmore-Sharpe north-south, east-west, and vertical component short-period seismographs.
Alberni:	August 11th to December 31st inclusive
(A)	φ = 49° 16′ 14″ N.
	λ = 124° 49′ 18″ W.
	Willmore-Sharpe north-south, east-west, and vertical component short-period seismographs.

EPICENTRE LOCATIONS

Table 2 lists the earthquakes recorded on the network stations from August 6 until the end of 1951. Those earthquakes which have been recorded on all three stations have been located as accurately as possible. The few tremors which appear to be associated with the edge of the continental shelf in the Pacific Ocean are not as precisely located as are those within the triangle of the stations. However, the Pacific earthquakes are occasionally located by the United States Coast and Geodetic Survey epicentre program. Those earthquakes south of Victoria, and out of the triangle, cannot be precisely located from Canadian data alone.

TABLE 2—1951 EARTHQUAKES

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-phase			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′					kms			
1	Aug. 8	12 43 07	49	129	.....	12 44 05	12 44 04·4	.....	.....			U.S.C.G.S. location
2	Aug. 8	14 13 08	49	129	.....	14 14 06	14 14 08·1	.....	.....			U.S.C.G.S. location
3	Aug. 9	.....	.....	.....	.....	.....	20 49 24·0	.....	35			
4	Aug. 10	.....	.....	.....	.....	.....	15 28 14·0	.....	28			
5	Aug. 13	18 07 36·6	49 07·5 or 49 05	123 42·0 or 122 58	II	18 07 48·3	18 07 43·8	.....	71	44		Straits of Georgia off Nanaimo or off Ladner, B.C.
6	Aug. 13	22 30 29·5	.....	.....	I	22 30 49·5	22 30 36·9	.....	.....			Same area as No. 5 probably
7	Aug. 13	.....	.....	.....	.....	23 44 30·8	.....	.....	24			
8	Aug. 17	.....	.....	.....	.....	.....	5 30 05·2	.....	.....			
9	Aug. 17	23 40 43·9	49 13·2	122 35·8	III	23 40 59·8	23 40 51·4	23 41 09·9	102	43	163	North of Fraser River, west of Port Coquitlam, B.C.
10	Aug. 18	11 35 04·9	48 38·2	122 40·5	I	11 35 14·4	11 35 20·3	11 35 32·4	57	94	173	Orcas Islands
11	Aug. 18	18 37 10·5	48 37·5	122 56·7	I	18 37 17·1	18 37 25·0	18 37 35·8	36	88	154	Orcas Islands
12	Aug. 20	9 53 56·4	48 02·9	123 42·2	I	9 54 04·4	9 54 21·0	9 54 21·5	56	154	156	West of Port Angeles
13	Aug. 22	10 22 52·2	48 41·8	123 39·8	I	10 22 57·2	10 23 05·7	10 23 10·0	25	80		On South Vancouver Island
14	Aug. 22	.....	.....	.....	.....	13 39 01·1	13 39 02·6	13 38 45·6	.....			Off west coast of Vancouver Island
15	Aug. 23	7 54 06·9	48 29·8	124 57·7	III	7 54 26·2	7 54 33·0	7 54 21·4	118	166	88	Western Juan de Fuca Strait
16	Aug. 23	.....	.....	.....	.....	.....	14 33+	.....	.....			May not be seismic
17	Aug. 25	14 01 07·3	43 37·4	123 32·2	II	14 01 10·2	14 01 21·9	14 01 26·8	14	88	119	Bamberton blast (?)
18	Aug. 27	.....	.....	.....	.....	.....	23 10 37·7	.....	.....			
19	Sept. 5	.....	.....	.....	.....	.....	.....	0 20 30·5	.....			Very near Alberni
20	Sept. 5	.....	.....	.....	.....	.....	6 03 48·5	.....	.....			
21	Sept. 6	4 28 37·3	48 40·6	123 23·5	III	4 28 40·9	4 28 50·2	4 28 58·1	21	78	127	South of Coal Island
22	Sept. 10	(12 54 04·6)	(48·4)	(129·2)	I	12 55 02·8	.....	12 54 50·8	423		326	Off west coast of Vancouver Island
23	Sept. 13	4 54 46·7	49 13·8 or 50 04	126 03·5 or 125 05	II	4 55 18·8	.....	4 55 02·1	215		91	Near west coast of Vancouver Island or North west of Powell River
24	Sept. 13	.....	.....	.....	.....	6 21 08·9	.....	6 20 57·7	.....			
25	Sept. 14	7 07 25·4	49	128 30	IV	7 08 18·2	7 08 21·0	7 08 06·1	388	391	278	U.S.C.G.S. location
26	Sept. 20	.....	.....	.....	.....	.....	.....	20 53 12·5	.....			
27	Sept. 21	.....	.....	.....	.....	11 23 16·8	11 23 25·6	.....	.....			
28	Sept. 21	.....	.....	.....	.....	19 36 29·3	.....	.....	.....			
29	Sept. 22	10 16 56·0	48 00·0	127 00·0	III	10 17 37·5	10 17 40·3	10 17 30·6	302	345	243	U.S.C.G.S. location
30	Sept. 26	.....	.....	.....	.....	.....	.....	15 35 45·0	.....			
31	Sept. 27	19 24 12·4	49	129	VI	19 25 08·8	19 25 10·8	19 24 57·0	410	426	312	U.S.C.G.S. location

32	Sept.	27	.....	.....	.....	.....	.....	.....	19 31 35·0	.....	Same as No. 31
33	Sept.	27	.....	.....	.....	.....	.....	.....	19 44 08·1	.....	Same as No. 31
34	Sept.	28	.....	.....	.....	.....	.....	.....	15 19 20·0	.....	
35	Sept.	30	.....	.....	.....	.....	8 32 24·5	.....	.....	45	
36	Sept.	30	.....	.....	.....	.....	13 31 39·1	.....	13 31 39·6	.....	Off coast of Oregon (?)
37	Sept.	30	.....	.....	.....	.....	14 50 16·7	.....	14 49 57·6	.....	
38	Oct.	1	.....	.....	.....	.....	14 06 21·8	.....	.....	.....	
39	Oct.	4	23 27 19·4	.....	.....	II	23 27 38·8	23 27 49·2	23 27 53·1	116 204 216	Off coast of Oregon
40	Oct.	5	.....	.....	.....	II	16 13 43·3	.....	16 13 16·9	416	Off west coast of Vancouver Island
41	Oct.	7	11 59 31·3	47 40	123 30	III	11 59 39·0	11 59 53·4	11 59 55·2	82 180 194	South of Port Angeles, Wash.
42	Oct.	8	.....	.....	.....	.....	5 12 37·4	.....	.....	.....	
43	Oct.	9	22 59 27·7	48 10·8	122 46·2	IV	22 59 38·0	22 59 50·5	22 59 57·6	62 140 195	North of Port Townsend, Wash.
44	Oct.	13	.....	43 30	121·7	.....	19 46 29·5	.....	.....	.....	U.S.C.G.S. location
45	Oct.	19	.....	.....	.....	.....	.....	.....	00 18 58·7	.....	Very near Alberni
46	Oct.	26	23 41 26·3	49 01	122 08	II	23 41 44·1	23 41 41·6	23 42 05·5	.....	Near foot of Mount Baker, Wash.
47	Oct.	27	.....	.....	.....	.....	15 24 04·6	.....	15 23 55·9	.....	
48	Oct.	28	.....	.....	.....	.....	14 52 23·5	.....	14 52 18·7	.....	
49	Nov.	2	.....	.....	.....	.....	.....	.....	23 02 08·2	.....	Very near Alberni
50	Nov.	4	3 36 11·2	48	124	III	3 36 23·2	3 36 36·6	.....	73 156	South of Victoria
51	Nov.	7	9 16 43·8	49 00·0	123 44·9	II	9 16 53·7	9 16 52·9	.....	59 55	North west of Ladysmith, B.C.
52	Nov.	9	.....	.....	.....	.....	14 55 37·7	.....	.....	.....	
53	Nov.	14	8 23 30·4	49 02·4	123 41·1	I	8 23 45·7	8 23 43·6	.....	62 48	North east of Ladysmith, B.C.
54	Nov.	14	.....	.....	.....	.....	19 27 55·0	.....	.....	.....	
55	Nov.	14	.....	.....	.....	.....	22 56 17·2	.....	.....	.....	
56	Nov.	20	.....	.....	.....	.....	.....	15 06 45·0	.....	.....	
57	Nov.	24	14 40 45·7	47 52·6	124 21·8	I	14 41 02·3	14 41 14·9	14 41 11·5	102 190 160	Washington state
58	Nov.	29	0 24 35·3	48 54·6	122 27·9	II	0 24 48·7	0 24 48·4	.....	81 79	Foothills of Mount Baker, Wash.
59	Dec.	7	20 20 19·1	48 37·4	123 16·5	II	20 20 22·2	20 20 32·8	20 20 40·8	19 83 134	North west of Sidney Island
60	Dec.	11	18 50 25·8			II	18 50 38·9	18 50 33·8	18 50 37·5	79 49 71	
61	Dec.	11				I	.....	18 51 40·6	18 51 44·5	.....	Gabriola Island
62	Dec.	11	19 44 59·2	49 10±	123 50·5±	II	19 45 11·9	19 45 06·9	19 45 11·3	78 47 74	(See Fig. 2)
63	Dec.	11	19 59 43·2			II	19 59 56·3	19 59 51·4	19 59 54·6	70 50 81	
64	Dec.	12	3 06 25·3	48 36·1	123 45·8	I	3 06 30·8	3 06 40·6	3 06 42·9	27 95 107	North east of Survey Mountain
65	Dec.	13	.....	.....	.....	.....	1 08 08·6	.....	.....	.....	
66	Dec.	14	.....	.....	.....	.....	19 26 41·8	19 26 49·7	.....	.....	
67	Dec.	14	.....	.....	.....	.....	20 02 52·1	20 02 54·2	.....	.....	
68	Dec.	15	.....	.....	.....	I	7 01 08·1	7 01 12·9	7 01 31·4	.....	
69	Dec.	15	.....	.....	.....	.....	.....	.....	23 14 50·5	.....	
70	Dec.	18	10 46 55·6	49 10·1	125 01·2	II	10 47 17·3	10 47 16·8	10 46 58·7	139 129 21	South west of Alberni felt
71	Dec.	18	.....	.....	.....	.....	18 56 38·8	.....	.....	.....	
72	Dec.	19	.....	.....	.....	.....	8 18 20·3	8 18 17·7	.....	.....	
73	Dec.	21	.....	.....	.....	.....	.....	8 13 18·0	18 13 39·5	.....	Blast near Horseshoe Bay (?)
74	Dec.	23	.....	.....	.....	.....	.....	1 12 53·3	.....	.....	Blast near Horseshoe Bay (?)

Preliminary determination of epicentres is made on the basis of the difference of first P-arrivals at the three stations. Assuming the velocities of P_1 and P_n to be, respectively, 6.246 and 8.203 km/sec. as found in the Canadian Shield it is possible to construct a series of loci for any pair of stations corresponding to differences of -4, -2, 0, 2, 4, etc., seconds in P-arrivals. By measuring the difference in arrival time the earthquake is placed on one of these lines. Similarly a second set of curves, for a different pair of stations, locate the epicentre with respect to that pair. The epicentre must lie in the zone of intersection of these sets of curves. A third set of curves, corresponding to the third pair of stations, is necessary to remove the ambiguity in the two positions obtained using two stations only. This preliminary epicentre is then adjusted to make all three stations fit as well as possible an assumed origin time. As a final check the S-phases are read where possible and are used to confirm the location found above.

Where the earthquake is recorded on two stations only, two positions are obtained for an epicentre, such as numbers 5 and 23 in Table 2. One of these can occasionally be eliminated by careful study. Those seismic disturbances, which are recorded at one station only, are listed to make this history complete.

Table 2 also gives, where possible, an estimate of the intensity of each earthquake on the modified Mercalli scale. There is no great accuracy claimed for this rating, rather it is meant to give the order of relative intensities of the disturbances. For those earthquakes which are given a magnitude by the United States Coast and Geodetic Survey, an intensity rating is obtained from conversion tables (Gutenberg and Richter, 1942)[1]. Well recorded disturbances, which are known to be blasts, are listed and labelled accordingly.

DISCUSSION

If the 74 earthquakes recorded in the five-month interval August to December can be taken as an average number, one could expect to record approximately 180 earthquakes a year. This is a few more than past recording with the Victoria Benioff alone would indicate, but not unreasonably so. The more sensitive Willmore-type seismometers probably account for all the extra and this suggests 1951 was not a sub-normal year. There were no major earthquakes in 1951.

Located epicentres in Table 2 are shown in the maps of Figures 1 and 2. A preliminary study of the map suggests that no definite pattern has yet been established. However, it must be admitted that there are certain areas somewhat more active than others.

Probably that region at 128 to 129 degrees west longitude where one would expect to find the edge of the continental shelf has been most active. These earthquakes cannot be precisely located, but in general they form a line parallel to the edge of Vancouver Island. These are the strongest of any recorded. Between this "shelf" and the Island there appear to be no earthquakes until a few kilometres off land. Here only two are found and one of these (23) only a probable location.

South in the State of Washington there are several locations, not quite where one expects to find epicentres. The earthquake felt in Victoria (No. 43) is from this general area towards Puget Sound.

[1] Gutenberg, B., and Richter, C. F., "Earthquake Magnitude, Intensity, Energy and Accceleration", Bulletin, Seismological Society of America, Vol. 32, 163-191, 1942.

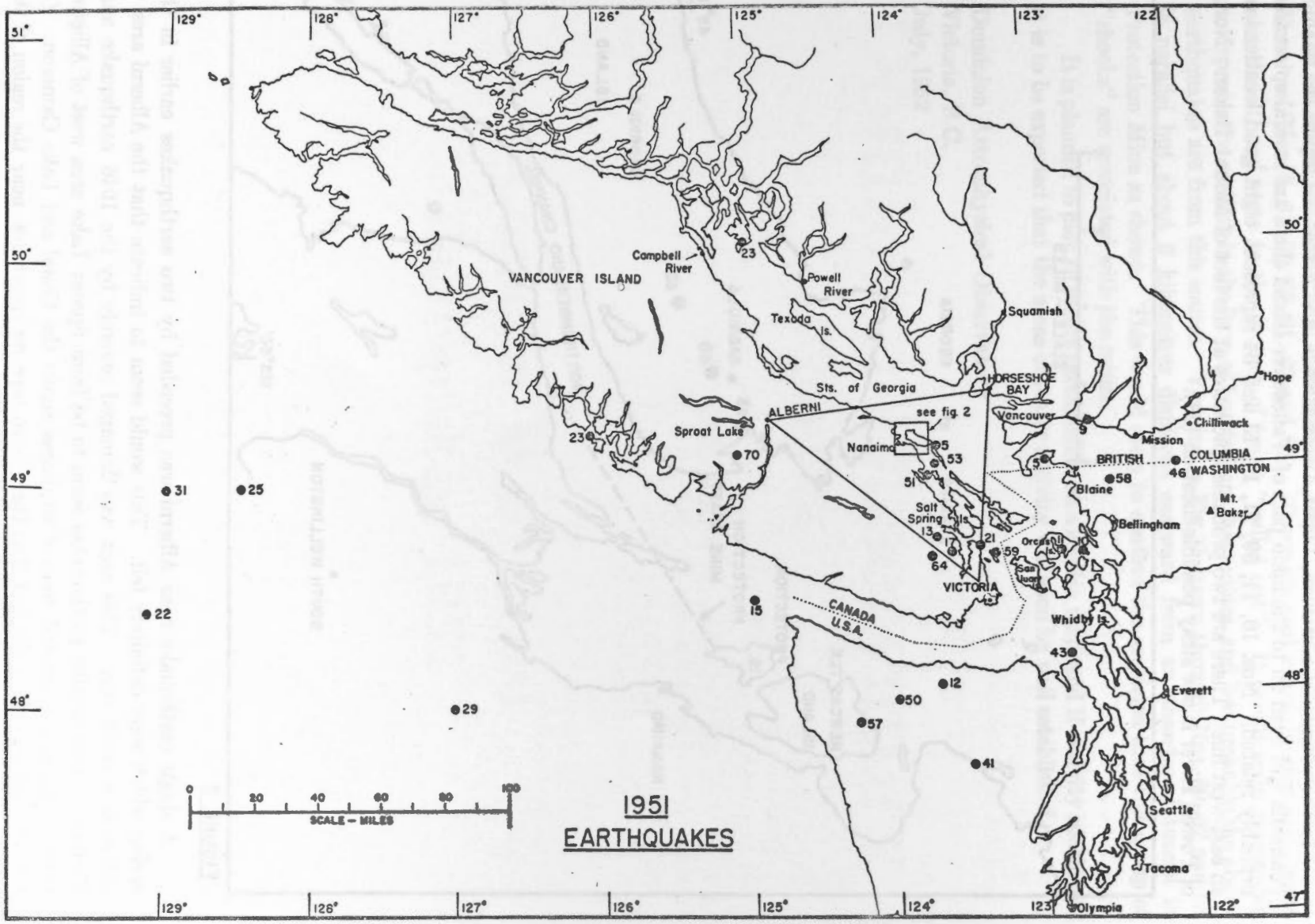
129°
128°
127°
126°
125°
124°
123°
122°
51°
50°
49°
48°
47°
VANCOUVER ISLAND
Campbell River
Powell River
Texada Is.
Sts. of Georgia
Squamish
HORSESHOE BAY
Vancouver
Hope
Chilliwack
Mission
ALBERNI
see fig. 2
Sproat Lake
Nanaimo
BRITISH COLUMBIA
WASHINGTON
Blaine
Mt. Baker
Bellingham
Salt Spring Is.
Orcas Is.
San Juan Is.
VICTORIA
CANADA
U.S.A.
Whidby Is.
Everett
Seattle
Tacoma
Olympia
23
70
31
25
53
51
58
46
13
21
59
64
15
22
43
12
50
57
29
41
0 20 40 60 80 100
SCALE – MILES
1951
EARTHQUAKES

FIGURE 1

In the vicinity of San Juan, Lopez, Orcas Islands, and across the top of the Saanich Peninsula and even on to the main part of Vancouver Island there are several epicentres, probably related. Nos. 10, 11, 59, 21, 17, 13 and 64 represent eight good locations on an east-west line. There are two probable epicentres at the foot of Mount Baker. North of Powell River is one stray possible location (23).

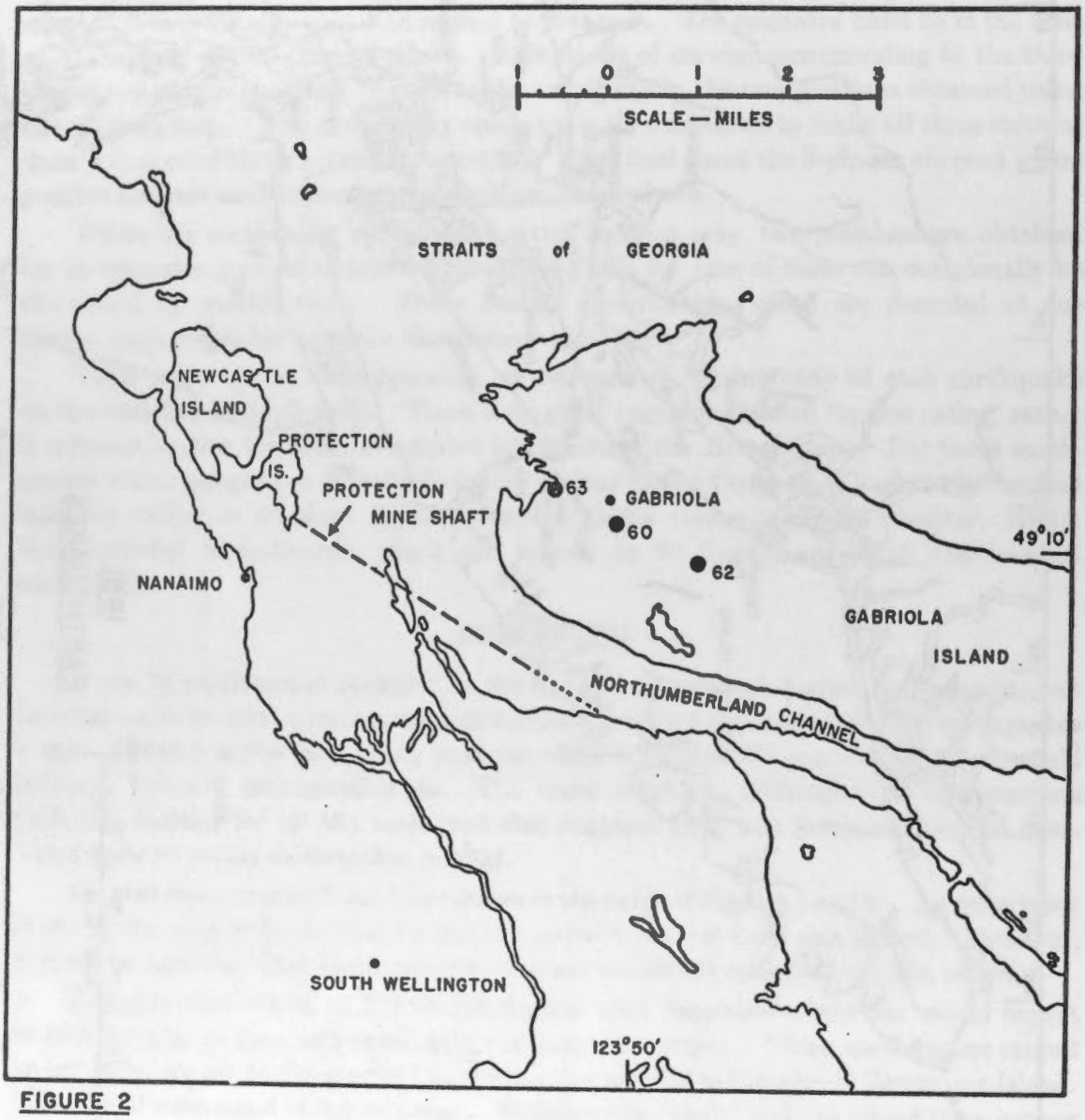

FIGURE 2

A single earthquake near Alberni was preceded by two earthquakes earlier in the spring which were definitely felt. This would seem to indicate that the Alberni area is active in a small way. This area was damaged severely by the 1946 earthquake near Comox. These smaller earthquakes seem to be from Sproat Lake area west of Alberni, rather than in a suspected zone of weakness across the Canal and Lake Cameron. (A notable feature here is the fact that there have been no epicentres near the region of the 1946 major earthquake in the northern Strait of Georgia.)

A group of earthquakes, or disturbances, have been recorded from south east of Nanaimo (Nos. 5, 51, 53, 60, 61, 62 and 63). There are coal mines in this area, some abandoned, and some in the process of being "pulled out". It would seem reasonable to expect some settling in the form of bursts from these mines, and it is probable the above earthquakes are from this source. The line in Fig. 2 drawn through Nos. 60, 62 and 63 is parallel but about 5 kilometres displaced eastward from an abandoned tunnel in Protection Mine as shown. This would seem to confirm the suspicion that this group of "shocks" are associated with the mines.

It is planned to plot all future earthquakes on a similar map, and if activity continues, it is to be expected that the areas of major activity will soon be well established.

Dominion Astrophysical Observatory
Victoria, B.C.
July, 1952

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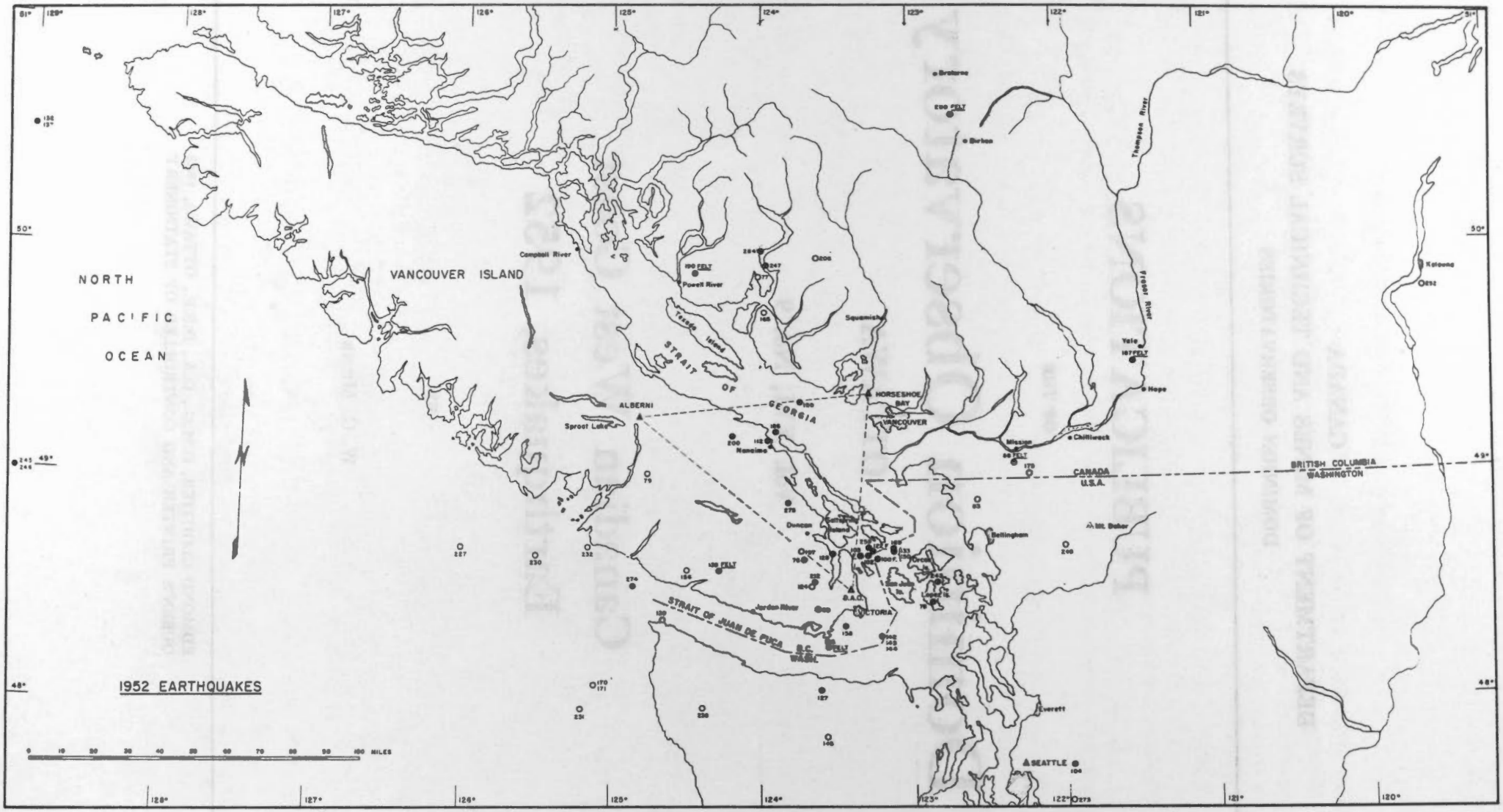
NORTH
PACIFIC
OCEAN
VANCOUVER ISLAND
Campbell River
Powell River
Texada Island
STRAIT OF GEORGIA
ALBERNI
Sproat Lake
Nanaimo
Squamish
Ocean Falls
Bralorne
Lytton
Thompson River
Fraser River
Yale
Hope
Chilliwack
Mission
HORSESHOE BAY
VANCOUVER
Kelowna
CANADA
U.S.A.
BRITISH COLUMBIA
WASHINGTON
Mt. Baker
Bellingham
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Jordan River
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STRAIT OF JUAN DE FUCA
Everett
SEATTLE
1952 EARTHQUAKES
MILES

Canadian West Coast Earthquakes, 1952

BY

W. G. Milne

ABSTRACT

Local earthquakes recorded on the seismographs at Victoria, Alberni and Horseshoe Bay, British Columbia are tabulated, continuing a listing begun in 1951. Those twelve earthquakes which were felt are discussed separately. Epicentres are plotted on two maps, the first showing 1952 epicentres on a map of southern British Columbia, the second showing epicentres for both 1951 and 1952 shocks on a map of southern Vancouver Island. While it is yet too early to draw definite conclusions there appears to be a tendency for the epicentres to lie along definite lines, some of which coincide with known faults.

INTRODUCTION

An enlarged program for the study of West Coast earthquakes was begun in August, 1951. New stations were installed at Alberni and Horseshoe Bay. These stations, with the existing station at Victoria, provided the three station network necessary for the location of epicentres in the coastal regions of southern British Columbia. A paper[1] has already been published listing the epicentres determined during the latter part of 1951. The present paper continues this listing for the year 1952.

DESCRIPTION OF STATIONS

As during 1951 the Victoria station had as its equipment for the registering of local earthquakes a short-period vertical component Benioff seismometer. At Alberni the Willmore-Sharpe seismometers continued to operate for the whole year. No changes in the installation were made from 1951. At Horseshoe Bay the vertical and east-west components are of the Willmore-Sharpe design. A Sprengnether short-period horizontal seismograph ($T_g = T_s = 1 \cdot 9^s$) was substituted for the north-south component from February to October inclusive. At all other times the north-south too was a Wilmore-Sharpe. The recorders at all three stations operate at a paper speed of 60 mm/min.

The time control at Alberni and Horseshoe Bay was obtained from CBU Vancouver radio time signals, recorded on the instruments at 10 a.m. each day. During November and December the Alberni station recorded Mare Island (NPG San Francisco) and WWV (Washington) time signals whenever possible. At Victoria, CBU time signals were recorded until October, when a complete change was made to NPG signals at 3^h, 15^h, and 20^h GMT. If these signals continue to be satisfactory, a complete change-over of the network is contemplated to recording NPG signals for five minutes three times daily instead of CBU for twenty seconds once a day.

The station co-ordinates are listed below in Table 1.

METHOD OF LOCATING EPICENTRES

The method of locating epicentres has not been changed from the method used in 1951. That is, the differences of arrival times of the P waves at pairs of stations is used with the aid of a previously constructed map to obtain an approximate epicentre. This

[1] W. G. Milne and F. Lombardo, "Canadian West Coast Earthquakes, 1951", *Publications of the Dominion Observatory*, Vol. XVI, No. 3, 1952.

approximate epicentre and the origin time are adjusted to obtain the best fit for all three stations. The adjusted epicentre is then checked with the S-P times for each station. All of these earthquakes would appear to be from a very shallow depth. The few tremors near Victoria have an S-P time of the order of 3 seconds.

TABLE I

Station	Latitude	Longitude
	° ′ ″ N	° ′ ″ W
Victoria	48 31 14	123 24 56
Alberni	49 16 14	124 49 18
Horseshoe Bay	49 22 39	123 16 33

Some indication of the possible error of location of an epicentre might be useful. To begin with let us assume the travel-time curves used are correct. The time error can amount to $\pm 0 \cdot 5$ sec. for any one station. This would mean an error of approximately 3 km. for one direction. The epicentre would thus lie in a circle of 3 km. radius. In addition, the travel-time curves used were developed for use in the Canadian Shield where sedimentary rocks are not present. Their use in British Columbia, where there are considerable thicknesses of sedimentary rock, must lead to additional errors in location. Until crustal studies now under way in British Columbia have been completed it is impossible to estimate the effects of these sedimentary layers.

EPICENTRE LOCATION

Table 2 lists the earthquakes recorded on the network stations during the year 1952. They are numbered consecutively with those of the earlier paper. All the epicentres for which satisfactory locations have been made are plotted on the attached map of south-western British Columbia. Those epicentres which are considered to be accurately located are indicated by solid circles. For those shocks where a reading is obtained at only two stations some doubt usually exists as to which of two locations is the true epicentre. Such locations are marked on the map with open circles. Open circles are also used where an epicentre is so far from the triangle of stations that it cannot be well located. Epicentres from the United States Coast and Geodetic Survey epicentre program are included to make a total of 56 earthquakes plotted on the map.

DETAILS OF PARTICULAR EARTHQUAKES

Mission

An earthquake (No. 88) was felt in the general area of Mission and Abbotsford about 40 miles east of Vancouver on February 6th at 14:04 hours GMT. It was investigated in the field about four days after its occurrence to try to obtain an accurate epicentre. Table 3 shows the intensities felt in the area according to the Modified Mercalli Scale.

The area in question is heavily drift covered, and is bounded on the north, east, and south by mountains. Mission, Abbotsford, and Huntington and Sumas on the United States border all felt the earthquake with about the same intensity. For this reason no single point can be chosen for an epicentre, and the record data permit a wide range of

TABLE 2—1952 EARTHQUAKES

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′					kms			
75	Jan. 2	.....	.....	.....	.....	22 52 28·4	.....	.....	.....			
76	Jan. 4	2 14 10·0	48 39	123 44	II	2 14 16·4	2 14 26·4	2 14 29·5	27·1	88·1	105·6	Dilation to Victoria. Near Koksilah River.
77	Jan. 22	11 21 19·7	49 54	124 02	II	11 21 45·5	11 21 32·6	11 21 33·6	159	79	88	Powell River area.
78	Jan. 25	15 50 53·8	48 28	122 54	I	15 51 00·0	15 51 10·6	15 51 20·7	38·6	105	167	Lopez Island.
79	Jan. 25	17 43 06·3	49 02	124 45	II	17 43 25·0	17 43 25·5	17 43 11·2	114·5	117·0	28·5	South of Alberni.
80	Jan. 28	.....	.....	.....	I	2 01 34·1	2 01 41·6	.....	.....			Probably in Washington State.
81	Jan. 29	23 45 45	43 30	127	.....	23 47 11·0	23 47 24·8	.....	.....			U.S.C.G.S. epicentre.
82	Jan. 31	.....	.....	.....	.....	.....	.....	19 20 02·7	.....			Near Alberni.
83	Jan. 31	22 43 12·3	48 54	122 36	II	22 43 23·8	22 43 23·7	22 43 39·6	72·1	72·0	166	In Washington State.
84	Feb. 1	.....	.....	.....	.....	1 23 46·1	1 24 02·5	.....	.....			
85	Feb. 1	.....	.....	.....	.....	17 08 05·5	.....	.....	.....			
86	Feb. 5	.....	.....	.....	.....	0 48 20·1	.....	.....	.....			
87	Feb. 6	.....	.....	.....	.....	12 04 57·5	12 05 09·7	.....	.....			South of Victoria.
88	Feb. 6	14 04 07·0	49 04·0	122 19·0	IV	14 04 23·6	14 04 19·9	14 04 35·7	101·4	78·0	186·1	Felt at Mission, B.C.
89	Feb. 6	20 25 39·1	48 26	123 38	II	20 25 42·1	20 25 56·9	20 26 00·1	17·5	101·8	127·6	West of Victoria.
90	Feb. 6	.....	49 04	122 19	I	21 49 12·9	21 49 17·1	.....	.....			Probably aftershock of No. 88.
91	Feb. 7	.....	.....	.....	.....	.....	.....	0 35 37·8	.....			Near Alberni.
92	Feb. 7	.....	49 04	122 19	I	4 36 41·8	4 36 46·5	.....	.....			Probably aftershock of No. 88.
93	Feb. 7	22 03 46·8	49 04	122 19	I	22 03 03·3	22 03 00·1	22 03 16·1	101·0	80·8	185·5	South of No. 88. Felt at Sumas.
94	Feb. 9	.....	.....	.....	I	5 29 08·5	5 29 09·6	.....	86	96		West of Bellingham, Wash. (?)
95	Feb. 13	.....	.....	.....	.....	.....	.....	20 21 03·2	.....			Near Alberni.
96	Feb. 14	.....	.....	.....	.....	.....	.....	17 13 54·0	.....			Near Alberni.
97	Feb. 15	.....	.....	.....	.....	8 39 57·8	.....	8 39 52·1	.....			On west coast of Vancouver Island. (?)
98	Feb. 16	.....	.....	.....	.....	22 31 37·4	.....	22 31 54·4	.....			Possibly near No. 94.
99	Feb. 18	.....	.....	.....	.....	.....	.....	22 54 01·2	.....			
100	Feb. 20	19 07 11	48 39	123 15	III	19 07 13·4	19 07 22·8	19 07 31·4	17	67	118	Felt in Victoria.
101	Feb. 21	.....	.....	.....	.....	7 53 15·1	.....	.....	.....			
102	Feb. 21	23 35 47	48 40	123 18	II	23 35 51·5	23 36 00·9	23 36 09·1	19	80	130	Felt in Victoria. See notes.
103	Feb. 22	9 39 32·0	48 40	123 21	III	9 39 36·7	9 39 46·7	9 39 54·4	23	81	132	Felt in Victoria. See notes.
104	Feb. 23	9 06 42	47 45	121 58	II	9 07 05·2	9 07 16·6	9 07 24·4	140			These four minor tremors were felt near Duval in the state of Washington.
105	Feb. 23	9 17 04	47 45	121 58	I	9 17 27·4	9 17 36·0	.....	140			
106	Feb. 23	9 28 02	47 45	121 58	II	9 28 25·5	9 28 36·8	9 28 45·1	140			
107	Feb. 23	9 54 29	47 45	121 58	II	9 54 52·3	9 55 06·5	9 55 14·4	140			

TABLE 2—1952 EARTHQUAKES—*Continued*

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′					kms			
108	Feb. 24	.....	.....	.....	.....	.....	5 57 17	.....	.....			
109	Feb. 26	.....	.....	.....	.....	11 42 36	11 42 42·8	11 42 47·6	.....			Teleseism.
110	Feb. 27	.....	.....	.....	.....	.....	22 54 08·7	.....	.....			
111	Feb. 29	.....	.....	.....	I	12 40 51·5	12 40 48·0	.....	.....			Probably near No. 88.
112	Mar. 2	0 11 53·6	49 10·0	123 58	III	0 12 07·4	0 12 02·9	0 12 04·0	84	57	63	Near Nanaimo.
113	Mar. 3	.....	.....	.....	.....	.....	.....	9 58 56·8			32	
114	Mar. 3	.....	.....	.....	.....	.....	.....	14 39 02·5			37	
115	Mar. 6	.....	.....	.....	.....	.....	.....	21 01 52·1	.....			Probably a blast.
116	Mar. 7	.....	.....	.....	.....	.....	.....	20 39 00·6			87	
117	Mar. 7	.....	.....	.....	.....	20 53 52·9	.....	.....	.....			
118	Mar. 8	.....	.....	.....	.....	.....	.....	15 30 35·4	.....			Probably a blast.
119	Mar. 10	.....	.....	.....	.....	.....	.....	19 30 12·6	.....			
120	Mar. 11	.....	.....	.....	.....	.....	.....	23 54 26·3	.....			
121	Mar. 12	.....	.....	.....	.....	.....	.....	0 23 30·8	.....			
122	Mar. 14	14 59 37·0	48 41	123 16	IV	14 59 42·6	14 59 51·5	15 00 00·1	33	70	140	Felt in Victoria.
123	Mar. 14	.....	.....	.....	.....	.....	.....	15 03 51·5	.....			
124	Mar. 16	5 50 20·9	48 32	123 41	II	5 50 24·5	5 50 37·5	5 50 45·8	22	101	117	South Vancouver Island.
125	Mar. 16	.....	.....	.....	II	17 20 30·4	17 20 43·5	17 20 53·5	.....			Aftershock of No. 124. (?)
126	Mar. 20	.....	.....	.....	I	10 11 42·2	.....	10 11 58·6	31			Aftershock of No. 124. (?)
127	Mar. 20	21 36 18·5	48 05	123 37	II	21 36 27·2	21 36 42·9	21 36 43·9	54	149	158	Northern Olympic mountains.
128	Mar. 21	4 41 43·5	48 41	123 32	III	4 41 47·1	4 41 57·7	4 42 02·5	22	85	116	South Vancouver Island.
129	Mar. 22	2 01 35	.....	.....	III	2 01 58·7	2 02 08·9	2 02 15·9	142	215	292	South of Seattle.
130	Mar. 27	.....	.....	.....	.....	19 30 12·7	.....	.....	120			
131	April 1	00 37 41·5	48·0	113·8	VII	0 39 17·8	0 39 17·6	0 39 27·1	.....			Felt in northwestern Montana and in British Columbia.
132	April 3	2 13 15	50·5	129	III	2 14 23	2 14 22·4	2 14 06·1	.....			U.S.C.G.S.—off coast.
133	April 4	20 51 06·0	48 41	123 08	III	20 51 10·5	20 51 19·4	20 51 28·9	26	81	140	North of San Juan Island.
134	April 5	.....	.....	.....	.....	1 14 05·8	.....	.....	26			
135	April 8	.....	.....	.....	.....	3 56 45·9	.....	.....	.....			
136	April 8	.....	.....	.....	I	.....	.....	13 52 38·0			114	
137	April 8	.....	50·5	129	II	15 28 39·0	.....	15 28 21·4			146	Off coast of northern Vancouver Island.
138	April 11	9 48 37·5	48 36	124 17	IV	9 48 48·6	9 48 56·5	9 48 51·3	67	116	84	Felt in Victoria and south west Vancouver Island.
139	April 12	.....	48 23	124 40	II	11 04 33·9	11 04 44·7	11 04 35·5	.....			Possibly off Cape Flattery.

140	April	15	.....	.....	.....	.....	0 02 06·7	.....	.....	.....		
141	April	16	.....	.....	.....	.....	17 56 18·1	.....	.....	.....		Seattle 17:56:02.
142	April	16	.....	48 19	123 13	III	22 25 41·1	22 25(12·2)*	22 25 58·8	27	118	158	Probably south east of Victoria.
143	April	16	.....	48 19	123 13	II	23 31 15·6	23 31(33·2)*	23 31 35·0	27	118	158	Same as No. 142.
144	April	16	.....	48 19	123 13	I	23 35 45·6	.....	23 36 04·9	27		158	Same as No. 142.
145	April	17	.....	47 53	123 35	II	00 27 45·6	00 27(37·6)*	00 28 02·2	76	155	178	Olympic mountain region.
146	April	17	.....	.....	.....	.....	18 57 39·3	.....	.....	83			
147	April	17	.....	.....	.....	.....	20 06 27·5	.....	.....	.....			Very near Victoria.
148	April	17	.....	.....	.....	.....	22 45 03·8	.....	.....	.....			Very near Victoria.
149	April	19	.....	.....	.....	.....	1 30 55·6	.....	.....	.....			
150	April	19	.....	48 41	123 08	II	19 05 54·5	19 05(21·0)*	19 06 12·4	26	80	139	Gulf Islands.
151	April	19	.....	.....	.....	.....	22 14 01·2	.....	.....	.....			Very near Victoria.
152	April	20	.....	.....	.....	.....	0 07 13·5	.....	.....	38			
153	April	22	.....	.....	.....	.....	16 56 48·2	.....	.....	116			Seattle 16:57:00 ($\Delta = 200$).
154	April	24	.....	.....	.....	.....	11 04 36·9	.....	.....	75			
155	April	25	.....	49 04	122 19	II	23 16 18·1	23 16 08·2	23 16 27·5	100			Possibly near No. 88.
156	April	27	.....	48 36	124 30	II	5 27 32·8	N.O.†	5 27 32·2	83		82	Probably south west Vancouver Island.
157	May	1	.....	.....	.....	II	13 09 07·6	13 09 20	13 09 23·1	211			Off Oregon coast.
158	May	1	20 12 36·8	48 21	123 28	III	20 12 40·7	20 12 56·1	20 13 00·1	24	117	141	Strait of Juna de Fuca, east.
159	May	3	.....	.....	.....	I	00 10 00·6	.....	00 10 05·6	44	64		
160	May	6	.....	.....	.....	.....	.....	.....	15 11 31·6	.....			
161	May	7	16 14 36	51	131	.....	.....	16 15 50·2	16 15 36·2	.....			Seattle 16:16:14. U.S.C.G.S. epicentre.
162	May	12	.....	.....	.....	II	5 42 29·0	5 42 48·4	5 42 48·5	256	332		South of Victoria.
163	May	12	.....	.....	.....	.....	18 06 12·7	.....	.....	.....			Very close to Victoria.
164	May	15	.....	.....	.....	.....	.....	.....	18 50 23·3	.....			
165	May	17	7 36 07·5	49 44	123 59	II	.....	7 36 18·1	7 36 20·8		67	79	Seechelt Peninsula area.
166	May	19	18 36 11·8	48 16	123 35	IV	18 36 16·7	18 36 32·3	18 36 35·2	30	125	142	Felt in Victoria. South west of city in Strait of Juan de Fuca.
167	May	30	.....	.....	.....	.....	23 31 12·2	.....	.....	191			
168	May	31	.....	.....	.....	.....	12 03 53·3	.....	.....	265			
169	June	2	8 59 34·0	48 42	123 08	II	8 59 38·8	8 59 46·6	8 59 56·4	28	76	138	Gulf Islands.
170	June	5	.....	48·1	125·1	I	18 44 27·3	.....	18 44 26·8	137			Probably off Washington coast.
171	June	5	.....	48·1	125·1	I	19 05 55·6	.....	19 05 55·2	.....			Probably off Washington coast.
172	June	5	.....	.....	.....	I	20 26 36·2	.....	.....	87			
173	June	5	.....	.....	.....	.....	21 14 50·2	.....	.....	147			
174	June	5	.....	48·1	125·1	I	21 36 55·3	.....	21 36 53·7	.....			Probably off Washington coast.
175	June	5	.....	49·01	122 13	I	23 52 28·7	23 52 26·8	.....	105			Probably near No. 88, Mission, B.C.
176	June	6	.....	.....	.....	.....	.....	.....	15 00 31·9	.....			

*Chronometer sticking, absolute time in doubt.
†Station not operating.

TABLE 2—1952 EARTHQUAKES—*Continued*

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′					kms			
177	June 7	.....	.....	.....	.....	16 51 41·7	.....	.....	.....			
178	June 7	.....	.....	.....	.....	18 49 35	.....	.....	.....			
179	June 12	.....	.....	.....	I	13 28 59·6	13 29 13·2	13 29 32	.....			Washington State. (?)
180	June 12	.....	.....	.....	I	19 00 31·5	19 00 33·7	.....	.....			West of Bellingham. (?)
181	June 17	.....	.....	.....	II	20 36 03·8	20 36 12·3	20 36 00·2	56	105		Entrance to Juan de Fuca Strait. (?)
182	June 18	.....	.....	.....	.....	.....	.....	5 11 45·2			66	
183	June 18	.....	.....	.....	.....	.....	.....	7 25 05·0			74	
184	June 18	.....	.....	.....	.....	10 58 57·0	.....	.....	106			
185	June 23	.....	.....	.....	II	17 38 01·0	17 38 15·5	17 38 20·5	.....			Probably south of Victoria.
186	June 23	23 52 42·6	49 12	123 54	III	23 52 56·5	23 52 51·3	23 52 53·2	85	51	66	North east of Nanaimo.
187	July 4	.....	49 30	121 30	IV	22 54 57·6	22 54 50·4	22 55 07·1	148	119	256	Felt at Hope B.C. Seattle 22:55:09.
188	July 4	.....	.....	.....	I	.....	23 00 34·8	.....		119		Aftershock of No. 187.
189	July 12	.....	.....	.....	I	19 16 33·9	19 16 27·6	N.O.†		69		
190	July 15	.....	49 54	124 27	III	10 08 36·8	10 08 29·8	N.O.†	180	93		Felt in Powell River.
191	July 16	.....	.....	.....	.....	18 59 03·7	.....	.....	69			
192	July 18	.....	.....	.....	.....	.....	.....	11 54 29·4	.....			
193	July 18	.....	.....	.....	.....	.....	.....	11 55 21·1	.....			
194	July 19	.....	48·3	123·2	I	11 54 22·1	.....	.....	26			Felt in south east of Victoria, location approximately 11 kms. from city.
195	July 19	.....	48·3	123·2	I	11 55 14·0	.....	.....	28			
196	July 23	.....	.....	.....	.....	6 50 11·1	.....	.....	62			
197	July 23	.....	48 41	123 45	I	10 42 01·7	.....	10 42 13·4	28		99	Lower Vancouver Island.
198	July 26	.....	.....	.....	.....	5 12 03·4	.....	.....			70	
199	July 26	14 13 51·5	49 20	123 45	III	14 14 07·1	14 13 58·1	14 14 03·4	96	37	76	East of Nanaimo.
200	July 26	21 03 11·1	49 11	124 12	II	21 03 26·7	21 03 23·2	21 03 18·3	95	73	44	West of Nanaimo.
201	July 27	19 52 14	47·5	122·4	IV	19 52 37·3	19 52 45·9	19 52 56·1	140	212	292	Seattle 19:52:24.
202	July 27	20 13 49	47·5	122·4	IV	20 14 12·8	20 14 21·0	20 14 31·5	140	212	292	Seattle 20:13:59. Seattle epicentre and origin time used.
203	July 28	.....	.....	.....	.....	.....	.....	8 25 04·2			103	
204	July 28	.....	.....	.....	.....	19 01 49·4	.....	.....	110			
205	July 29	.....	.....	.....	.....	.....	.....	23 50 31·0			76	
206	July 30	.....	49 58	123 38	II	.....	7 47 10·0	7 47 19·4		112	88	North east of Powell River, east of Jervis Inlet.
207	July 30	.....	.....	.....	I	.....	9 41 12·1	9 41 30	.....			East of Vancouver, approximately 100 kms.
208	July 30	.....	.....	.....	.....	.....	.....	23 34 21·9			26	

209	Aug.	2	.....	47·5	122·4	.....	15 50 00·8	15 50 08·8	.....	.....			Seattle 15:49:43.
210	Aug.	6	.....	47·5	122·4	.....	17 32 17·6	17 32 31·6	.....	.....			Seattle 17:32:01.
211	Aug.	6	.....	.....	.....	.....	.....	.....	21 43 17·7			25	
212	Aug.	7	3 48 33·1	48 33	123 41	II	3 48 35·2	3 48 49·2	3 48 52·0	20	97	116	North west of Victoria.
213	Aug.	7	.....	.....	.....	.....	.....	14 35 46·6	.....	.....			
214	Aug.	9	.....	.....	.....	.....	.....	3 42 31·5	.....	.....			
215	Aug.	9	.....	.....	.....	.....	.....	7 48 25	7 48 06·3	.....			Off west coast of Vancouver Island.
216	Aug.	9	.....	.....	.....	.....	.....	.....	13 16 58·6			56	
217	Aug.	10	.....	.....	.....	.....	.....	.....	14 58 03·8			150	
218	Aug.	11	.....	.....	.....	.....	22 52 12·5	.....	.....	20			Felt in Victoria.
219	Aug.	11	.....	.....	.....	.....	22 59 31·3	.....	.....	.....			Very near Victoria.
220	Aug.	11	.....	.....	.....	.....	23 01 09·1	.....	.....	.....			Very near Victoria.
221	Aug.	18	.....	.....	.....	.....	.....	.....	6 39 23·0	.....			
222	Aug.	19	.....	.....	.....	.....	.....	3 07 08·9	.....	.....			
223	Aug.	20	15 24 59	43	127	IX	15 26 32·3	N.O.†	15 26 38·9	.....			Off coast of Oregon. U.S.C.G.S. epicentre. M = 7-7½.
224	Aug.	21	.....	.....	.....	.....	5 00 58·2	.....	.....	.....			Very near Victoria.
225	Aug.	21	.....	.....	.....	.....	.....	.....	12 53 56·2	.....			
226	Aug.	21	.....	.....	.....	.....	19 09 56	.....	.....	.....			Aftershock of No. 223.
227	Aug.	25	.....	48·7	126·0	.....	2 16 19	2 16 21·2	2 16 01·6	.....			Off Barkley Sound, poor location.
228	Aug.	26	.....	.....	.....	.....	9 51 50·4	.....	.....	110			
229	Aug.	26	.....	.....	.....	.....	.....	20 05 07·0	.....	.....			
230	Aug.	30	.....	48 40	125·5	II	19 47 34·5	.....	19 47 24·2			93	Off Barkley Sound.
231	Aug.	30	.....	48·0	125·2	II	21 29 08·0	.....	21 29 08·5	143			Off Washington coast.
232	Aug.	31	.....	48 42	125 08	.....	10 05 59·2	10 06 03·5	10 05 48·4	129	158	68	Off Barkley Sound.
233	Sept.	1	.....	.....	.....	.....	8 03 13·4	.....	.....	.....			Seattle 8:03:08.
234	Sept.	2	.....	.....	.....	.....	3 51 20·0	.....	.....	.....			Seattle 3:51:04.
235	Sept.	2	.....	.....	.....	.....	7 36 47	.....	.....	.....			
236	Sept.	3	.....	.....	.....	.....	22 09 28·0	.....	.....	.....			
237	Sept.	4	.....	.....	.....	.....	.....	.....	18 51 05·8	.....			
238	Sept.	6	.....	48·0	124·4	.....	.....	10 41 28·7	10 41 42·5	.....			Olympic Peninsula.
239	Sept.	9	.....	.....	.....	.....	.....	.....	8 17 57·1	.....			
240	Sept.	13	.....	48·7	122·0	.....	22 58 57·6	22 58 59·8	22 59 14·6	110	130	230	East of Bellingham.
241	Sept.	18	.....	.....	.....	.....	.....	.....	8 52 55·3	.....			
242	Sept.	22	.....	.....	.....	.....	.....	.....	2 40 44·4	.....			
243	Sept.	22	7 21 46·1	48 33	122 51	III	7 21 52·7	7 22 02·0	7 22 12·5	42	98	165	Near Lopez Island.
244	Sept.	30	.....	.....	.....	.....	0 54 18	0 54 33·2	0 54 36·6		200		South in Washington State.
245	Oct.	1	1 47 03	49	129	IV	1 48 01	.....	1 47 51·2	410		340	Butte 1:49:55 } U.S.C.G.S.
246	Oct.	1	1 53 33	49	129	V	1 54 31	1 54 33·5	1 54 20·7	410	440	340	Butte 1:56:21 } epicentres.
247	Oct.	4	12 18 17	49 56	123 58	III	12 18 44	12 18 30·2	12 18 32·9	166	81	97	North of Seechelt Peninsula.
248	Oct.	4	.....	.....	.....	.....	.....	.....	12 47 15·0			80	

†Station not operating.

TABLE 2—1952 EARTHQUAKES—*Concluded*

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′					kms			
249	Oct. 7	.....	.....	.....	.....	14 20 39	.....	.....	.....			
250	Oct. 9	.....	.....	.....	.....	.....	.....	9 24 36·1	.....			
251	Oct. 11	.....	.....	.....	.....	.....	.....	9 03 45·1	.....			
252	Oct. 11	.....	49·8	119·5	IV	10 06 12	10 06 12·5	.....	.....			Felt at Kelowna, B.C.
253	Oct. 12	.....	47·2	123·3	.....	17 06 24·2	17 06 38·3	17 06 41·7	78	173	199	Seattle 17:06:10. Washington State.
254	Oct. 14	.....	.....	.....	.....	21 51 26·0	21 51 34·8	.....	.....			East of Victoria in Washington.
255	Oct. 18	.....	.....	.....	.....	.....	.....	14 00 48·5	.....			
256	Oct. 19	.....	.....	.....	.....	.....	.....	12 21 11·6	.....			
257	Oct. 20	.....	.....	.....	.....	3 20 31	3 20 01·7	.....	.....			
258	Oct. 21	.....	.....	.....	.....	.....	.....	15 36 36·8	.....			
259	Oct. 21	21 10 33·2	48 42	123 17	III	21 10 37·3	21 10 45·7	21 10 54·2	23	76	129	Gulf Island area.
260	Oct. 28	15 55 27	48 42	123 18	III	15 55 31	15 55 39·5	15 55 47·7	23	76	128	Gulf Island area.
261	Oct. 29	.....	.....	.....	.....	3 42 58	.....	.....	.....			
262	Oct. 29	.....	.....	.....	.....	4 39 31	.....	.....	.....			
263	Oct. 29	.....	.....	.....	.....	6 57 56	6 58 09	6 57 57	.....			Off coast.
264	Oct. 29	.....	.....	.....	.....	7 10 10	.....	.....	.....			
265	Oct. 29	.....	.....	.....	.....	9 35 21	9 35 31	9 35 21	.....			Off coast.
266	Oct. 29	.....	.....	.....	.....	20 04 06	.....	20 04 07	.....			Probably near Nos. 263 and 265.
267	Oct. 31	.....	.....	.....	.....	19 12 11·6	19 12 28·3	19 12 29·9	.....			Not seismic.
268	Oct. 31	.....	.....	.....	.....	19 12 54·2	19 13 11·0	19 13 12·4	.....			
269	Oct. 31	.....	.....	.....	.....	19 14 09·0	19 14 25·6	19 14 26·8	.....			
270	Oct. 31	.....	.....	.....	.....	19 20 50·0	19 21 05·6	19 21 07·4	.....			
271	Oct. 31	.....	.....	.....	.....	19 21 49·5	19 22 05·0	19 22 06·5	.....			
272	Oct. 31	.....	.....	.....	.....	19 22 56·5	19 23 12·6	19 23 14·5	.....			
273	Nov. 10	.....	47·6	121·9	IV	22 54 30·7	22 54 40·4	22 54 48·8	.....			Seattle 22:54:14. Felt near North Bend, Washington.
274	Nov. 19	.....	48 32	124 49	III	12 28 03·2	12 28 10·4	12 28 00·9	97	165	81	Entrance to Juan de Fuca Strait.
275	Nov. 20	.....	48 54	123 56	III	21 31 42·8	21 31 45·2	21 31 45·7	57	74	73	East of Lake Cowichan.
276	Nov. 21	.....	.....	.....	.....	19 53 34·7	19 53 15·7	.....	.....			
277	Nov. 21	.....	.....	.....	.....	21 34 29·2	21 34 44·1	21 34 46·6	.....			Not seismic.
278	Nov. 21	.....	.....	.....	.....	21 35 56·2	21 36 10·6	21 36 13·1	.....			
279	Nov. 21	.....	.....	.....	.....	21 36 31·8	21 36 45·9	21 36 48·6	.....			
280	Nov. 21	.....	.....	.....	.....	21 37 20·5	21 37 35·1	21 37 37·6	.....			
281	Nov. 21	.....	.....	.....	.....	21 37 35·1	.....	.....	.....			

282	Nov.	23	.....	.....	.....	.....	0 16 50·7	.....	00 16 51·1	.....	
283	Nov.	24	.....	.....	.....	I	23 17 46	23 17 24	23 17 38	.....	Readings doubtful.
284	Nov.	26	.....	50·0	124·0	II	6 30 21·2	6 31 03·3	6 31 09·1	.....	Jervis Inlet.
285	Dec.	8	.....	.....	.....	.....	16 41 17·8	.....	.....	.....	
286	Dec.	9	.....	.....	.....	.....	.....	.....	9 20 28·7	.....	
287	Dec.	9	.....	.....	.....	.....	19 37 59·5	19 38 12·0	19 38 07·5	.....	Not earthquake.
288	Dec.	10	.....	50·6	122·7	IV	13 55 19·0	13 55 07·8	13 55 16·2	281 145 212	Felt at Pioneer Mine, B.C.
289	Dec.	10	.....	.....	.....	.....	17 07 42·0	17 07 58·3	17 08 02·6	.....	Not earthquake.
290	Dec.	12	.....	.....	.....	.....	.....	.....	17 36 13·1	.....	
291	Dec.	16	.....	.....	.....	.....	5 43 40·9	.....	.....	.....	
292	Dec.	26	.....	.....	.....	.....	21 35 47·6	21 35 56·9	.....	.....	South of Victoria.

choices along the line of the valley since the epicentre lay to the east of all the stations. The felt region extends about one mile east and one mile west of the valley.

At Mission some woodpiles were reported to have been toppled, but on the field survey none could be found. No other damage was reported. Throughout the area it was reported that a noise like a rumbling truck accompanied the earthquake, and in Mission itself (rock at this point) one person thought a truck had struck the house. People were awakened by this noise along the valley. The noise and the tremor were not noticed north of Mission beyond the first plateau.

At Sumas an aftershock was reported on the following afternoon by one person, and this coincided with a small trace on the Horseshoe Bay record at 22:44 on February 7th.

TABLE 3

Intensity III

Mission, Matsqui, Abbotsford, Huntington, Sumas.

Intensity II

Hatzig, Hatzig Lake.

Not Felt

Haney, Steelhead, Ruskin.

Victoria

During 1952 several earthquakes were felt in the vicinity of Victoria. Contrary to some reports, none of these earthquakes did any damage.

There were three tremors in as many days on the 20th, 21st, and 22nd of February. The first (No. 100) was felt in Victoria and Sidney, B.C., at 19:07 GMT. The intensity was scarcely more than II on the scale. It was felt at the Observatory as the rumble of a truck. The smaller tremor (No. 102) on the next afternoon at 23:36 was felt generally, and again at the Observatory. At 9:39 on February 22nd many people in Victoria were awakened by the third and strongest tremor of this series (No. 103). It was felt at Sidney, Saltspring Island, San Juan Island, but not at Duncan, Nanaimo, or Vancouver. This earthquake and the next at 14:59 GMT on March 14th (No. 122) were felt in Alberni, and in fact alarmed many residents. That of March 14th was felt in Victoria as well as Jordan River, Port Angeles, Vancouver, and Saltspring Island but not Duncan or Nanaimo. These four tremors were located instrumentally under Haro Strait between Sidney and the International Border.

Tremors on April 11th at 9:49 (No. 138) and on May 19th at 18:36 (No. 166) were located on south-west Vancouver Island and south of Victoria in the Strait of Juan de Fuca respectively. Apparently in both cases the area around Jordan River felt the tremors more strongly than in the previous earthquakes for there was a request for information on the epicentre from the British Columbia Electric Company's office in order that they might decide on the wisdom of patrolling their power lines in that region. Although farther from Vancouver than the four previous shocks, the tremors were well pronounced in various parts of that city.

After the California earthquake in July, the Victoria local newspapers published a paragraph to the effect that the seismologist at the Observatory would welcome any

reports on local tremors. In a few days there were many telephone enquiries about rumblings that various residents thought were earthquakes. To date only one of these reports has led to the discovery of an earthquake, a very weak tremor on the Victoria records. That is No. 218 at 22:52 hours on August 11th. The tremor apparently was located just off the south end of the city. Similar disturbances (Nos. 194 and 195) were felt in Victoria on July 19th. Again the epicentre must be very close to the south-east coast of the island for the felt region is limited to a few streets.

South-East British Columbia

An earthquake (No. 131) whose epicentre has been placed by the United States Coast and Geodetic Survey on the east side of Flathead Lake in northwestern Montana, was felt in Canada. Questionnaires sent out after the tremor yielded the knowledge that the earthquake was felt at Fernie and Newgate in British Columbia. For this reason the earthquake is listed in the 1952 earthquakes. It occurred on April 1st at 00:38 hours GMT. Maximum intensity at the epicentre is given as VII on the Modified Mercalli Scale.

Hope

Along the Fraser River Canyon in the region of Hope and Yale a sharp tremor (No. 187) was felt at 22:55 hours on July 4th. The list of centres where this earthquake was felt is given in Table 4. Province of British Columbia highway construction crews felt the tremor between Hope and Spuzzum and noticed some boulders set into motion by the vibrations. A flour sack was reported overturned at Hope.

It appears that the earthquake was not felt east of the Fraser River, nor south of Hope. The instrumental epicentre is in the mountain region west of Yale, so the two facts put together seem to fix the epicentre between Harrison Lake and the Fraser River. There is one isolated centre, Abbotsford, where two people felt the tremor whereas communities closer to the epicentre felt nothing. This would seem to indicate that the Mission tremor was actually at the north end of the valley near Mission, and Abbotsford, reporting a strong intensity, did so because of local conditions.

A second tremor six minutes later was felt generally around Hope, Yale, and Spuzzum.

TABLE 4

Place	Intensity	Place	Intensity
Yale	IV	Chilliwack	0
Hope	IV	Princeton	0
Spuzzum	III	Abbotsford	II
North Bend	III	Mission	0
Lytton	0	Agassiz	0

Powell River

An earthquake (No. 190) was reported by a few persons at Powell River on July 15th at 10:09 hours GMT. No other centre appears to have felt the tremor, although a good record was obtained on the seismograms.

Kelowna

Questionnaire forms, distributed in the area after an earthquake reported from Kelowna on October 11th (No. 252) show that two isolated centres felt the tremor quite strongly. However, places between or near Kelowna and Grand Forks reported no disturbance at all. It is quite possible that the epicentre was nearer Kelowna for the Horseshoe Bay and Victoria records indicated that source. The intensity rating for either of these centres was less than III. Alberni did not record the earthquake.

Pioneer Mine

A tremor (No. 288) which registered slightly at Butte, Montana, awakened persons in Pioneer Mine and Birken, B.C. at 13:55 GMT, December 10. No damage has been reported. Records were strong at all three stations in the network. The felt area would appear to be elliptical in shape with the major axis in a north-west direction, as neither Pemberton nor Seton Lake reported a tremor.

DISCUSSION OF EPICENTRES

While it is still too early to draw any final conclusions from the location of epicentres, it is interesting to combine the data obtained to date on a single map. This has been done for the southern part of Vancouver Island on the map of Figure 2. The map also shows the location of some known faults. These have been taken from a paper by Clapp.[2]

Examination of the figure seems to give some indications of correlation between epicentres 15, 274, 156, 138 and 64 and a known fault. A second well-defined line seems to pass northwestward from epicentres 166 to 197; it might possibly be extended still farther north through epicentres 275 and 200. These patterns may of course have no significance whatever, but they at least suggest that regularities in the arrangement of epicentres may eventually emerge.

An outstanding feature about epicentres in the southern part of the island is that they are usually felt strongly in Alberni, although Duncan and Nanaimo, which are frequently closer to the epicentres, report no notice of the earthquakes. Residents of Alberni continue to be disturbed by each event. Alberni is in a valley almost totally surrounded by sedimentary rocks forming mountains. In the valley itself are one or more outcropings of volcanic rocks. During the 1946 earthquake considerable damage was reported from Alberni although the epicentre was on the other coast of the island.

The epicentres at Mission, at Hope, at Kelowna, and at Pioneer Mine appear to be isolated events to date. Perhaps such can be expected in the mountainous interior of British Columbia. It would not be surprising if there were minor tremors in that area of British Columbia along the continental divide north of Montana. The Montana seismologists report epicentres up to the border, and it seems reasonable to expect that similar disturbances would be detected farther north. In fact, although no record was obtained, it seems certain that the Banff area was shaken by a tremor on March 3rd.

Again as in the past there were several tremors, apparently along the continental shelf as far west as 129°. These are well recorded on the instruments but because more

[2] Charles H. Clapp, "Geology of the Victoria and Saanich Map Areas, Vancouver Island, B.C.", *Geological Survey of Canada*, Memoir No. 36, 1913.

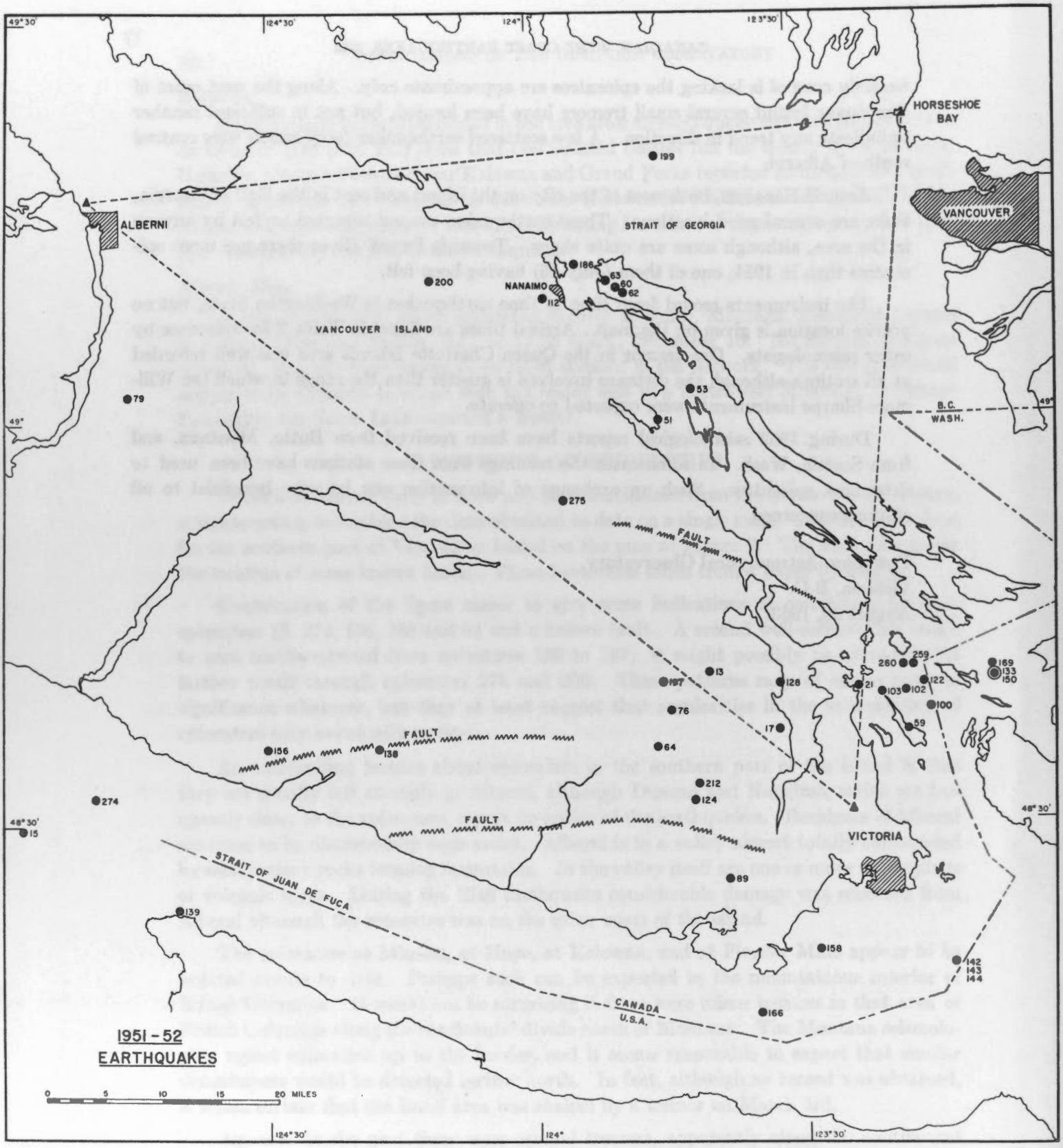
westerly control is lacking the epicentres are approximate only. Along the west coast of Vancouver Island several small tremors have been located, but not in sufficient number to indicate any trend in direction. A few scattered earthquakes (very small) were centred south of Alberni.

Around Nanaimo, both west of the city on the island and east in the Gulf of Georgia, there are several good locations. These earthquakes are not reported as felt by anyone in the area, although some are quite sharp. Towards Powell River there are more epicentres than in 1951, one of them (July 15) having been felt.

The instruments record from time to time earthquakes in Washington State, but no precise location is given on the map. Arrival times are listed in Table 2 for reference by other seismologists. One tremor in the Queen Charlotte Islands area was well recorded at all stations although the distance involved is greater than the range in which the Willmore-Sharpe instruments were expected to operate.

During 1952 seismological reports have been received from Butte, Montana, and from Seattle, Wash. In some cases the readings from these stations have been used to determine epicentres. Such an exchange of information can be very beneficial to all stations concerned.

Dominion Astrophysical Observatory,
Victoria, B.C.
August 20, 1953.


49°30'
124°30'
124°
123°30'
HORSESHOE BAY
199
ALBERNI
STRAIT OF GEORGIA
VANCOUVER
186
63
60
62
200
NANAIMO
112
VANCOUVER ISLAND
79
53
51
49°
B.C.
WASH.
49°
275
FAULT
13
197
128
21
259
280
169
133
150
122
103
102
100
59
76
17
FAULT
156
138
64
212
124
274
48°30'
15
FAULT
VICTORIA
48°30'
STRAIT OF JUAN DE FUCA
89
139
158
142
143
144
CANADA
U.S.A.
166
1951 - 52
EARTHQUAKES
0 5 10 15 20 MILES
124°30'
124°
123°30'

CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS
DOMINION OBSERVATORIES

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

Vol. XVI, No. 13

Canadian West Coast Earthquakes, 1953

BY

W. G. Milne

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.,
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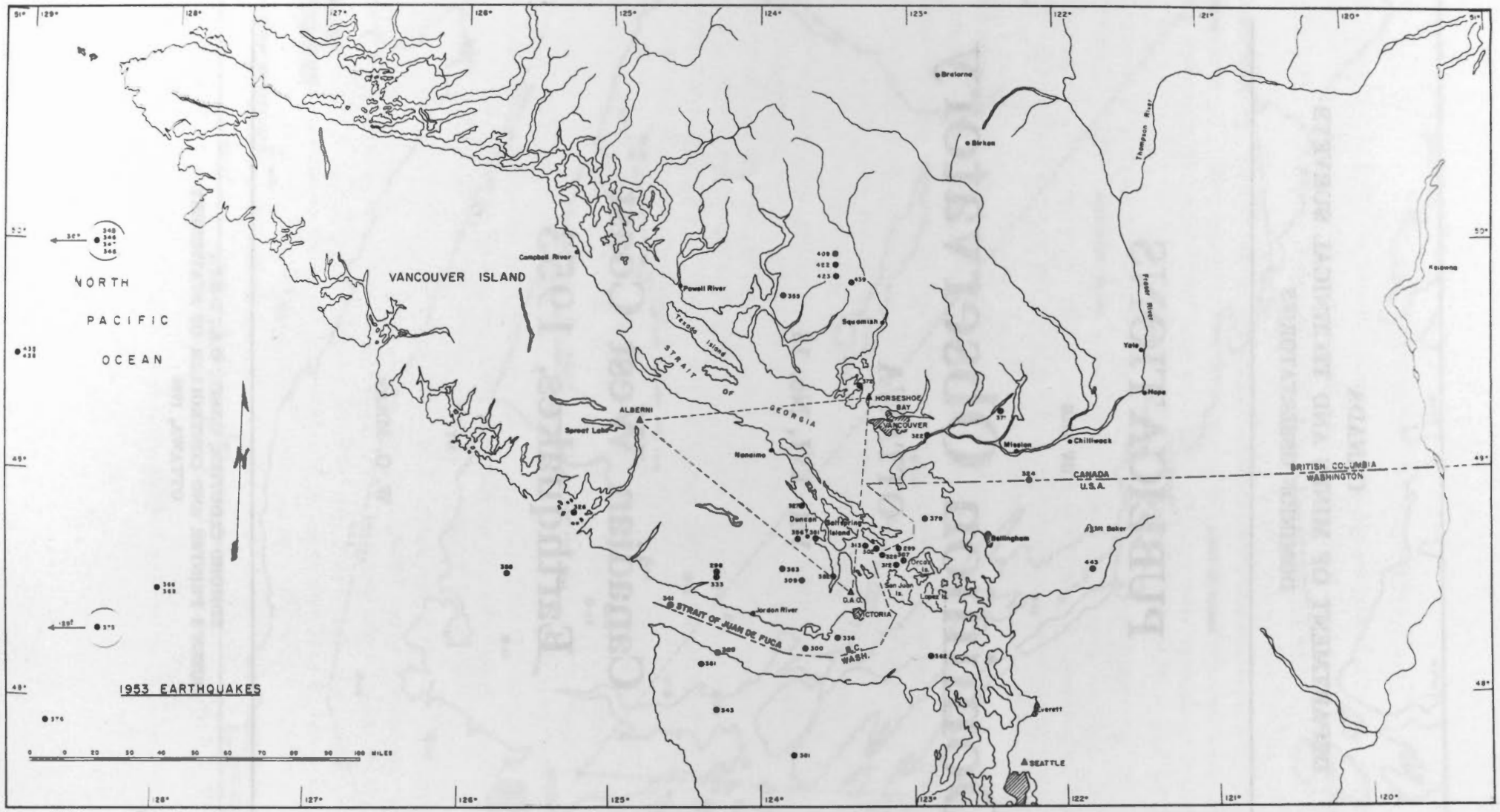
OTTAWA, 1955

600—1955


NORTH
PACIFIC
OCEAN
VANCOUVER ISLAND
Campbell River
Powell River
Texada Island
STRAIT OF GEORGIA
ALBERNI
Sproat Lake
Nanaimo
Duncan
Galiano Island
Jordan River
STRAIT OF JUAN DE FUCA
VICTORIA
D.A.O.
H.C.
WASH.
HORSESHOE BAY
VANCOUVER
Squamish
Brelorne
Birken
Thompson River
Fraser River
Yale
Hope
Chilliwack
Mission
CANADA
U.S.A.
BRITISH COLUMBIA
WASHINGTON
Bellingham
Mt. Baker
Orcas Is.
San Juan Is.
Lopez Is.
Everett
SEATTLE
Kelowna
1953 EARTHQUAKES
0 0 20 30 40 50 60 70 80 90 100 MILES

Canadian West Coast Earthquakes, 1953

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W. G. Milne

ABSTRACT

In 1951 the Dominion Observatory began a program of studying the earthquakes of southwestern British Columbia. The present paper lists 150 earthquakes recorded during 1953; this brings to 443 the number of tremors recorded since the inception of the program in August, 1951. The new epicentres are tabulated and plotted on a map of southwestern British Columbia. A detailed map of south Vancouver Island shows all the epicentres recorded in this area throughout the program.

The paper also gives the details of the newly built and newly equipped Victoria station.

INTRODUCTION

This report is a continuation of the investigation of local earthquakes in western sections of Canada. The first report was made for the latter half of 1951[1], and a subsequent list of tremors was published for 1952[2]. Data for locating the epicentres are obtained from the Victoria, Alberni, and Horseshoe Bay seismograph stations, and quite often from neighbouring United States installations.

DESCRIPTION OF STATIONS

A new office building for the Dominion Astrophysical Observatory was completed in June, 1953. This building provides office space and dark-room facilities for the seismological section, as well as much larger vaults than had previously been available. Three component Benioff variable reluctance seismographs were ordered for these new vaults and it was planned to take the existing Benioff vertical to Seven Falls. As it turned out it was necessary to make the transfer to Seven Falls before the new Benioff recorder had been received, so that for some time the Victoria station was without short-period instruments.

The schedule of the move from the old to the new vaults was as follows:

January 1 to July 3	Milne-Shaw horizontal seismographs and original Benioff vertical seismograph operating in old vault.
July 3 to September 6	Milne-Shaw horizontals and new Benioff vertical in new vault.
September 6 to October 23	Milne-Shaw horizontals only recording in new vaults.
October 23 to December 4	Milne-Shaw horizontals in new vault. Benioff vertical seismometer (T_s = 1 sec.) recording through Leeds and Northrup galvanometer (T_g = 1·9 sec.) in new vault. Magnification unknown, microseisms very large.
December 4 to December 31	All new seismometers (3 component Benioff short-period only) and Milne-Shaw horizontals recording in new vault.

[1] W. G. Milne and F. Lombardo, "Canadian West Coast Earthquakes, 1951", *Publications of the Dominion Observatory*, Vol. XVI, No. 3, 1952.

[2] W. G. Milne, "Canadian West Coast Earthquakes, 1952", *Publications of the Dominion Observatory*, Vol. XVI, No. 9, 1953.

The operation from December 4th on has been as intended for the permanent installation. The Milne-Shaw seismographs, being long-period instruments, are of use primarily in recording teleseisms, not the local tremors reported here. The short-period Benioff seismographs are operated conventionally, ($T_s = 1$ sec., $T_g = 0{\cdot}2$ sec.). Damping during the period covered by this paper was slightly less than critical, and the gain is set at about $\frac{1}{3}$ scale, which is the limit allowable because of microseismic amplitudes. It is estimated that this represents magnification of 10,000 to 15,000.

There has been no change in the timing arrangements at Victoria. Time marks are placed on the records by a pendulum clock. Time signals from NPG (San Francisco) are recorded, when they can be received, at 0^h, 6^h, 12^h, and 18^h G. M. T.

The new vault is some distance removed from the previous one. This has necessitated the redetermination of the station co-ordinates. The two sets of co-ordinates, as well as those of Alberni and Horseshoe Bay, are given in Table I.

TABLE I

Station		Latitude	Longitude
		° ′ ″ N	° ′ ″ W
Victoria	1 Jan. to 3 July	48 31 14	123 24 56
Victoria	4 July to 31 December	48 31 09·9	123 24 55·1
Alberni		49 16 14	124 49 18
Horseshoe Bay		49 22 39	123 16 33

At Alberni the instrumentation is the same as that installed in 1951. Willmore-Sharpe seismometers record through Turner galvanometers on a Sprengnether three-component recorder. Canadian Broadcasting Corporation time signals from the Dominion Observatory, Ottawa, are placed on the records automatically at 18^h G. M. T. WWV signals are usually put on, in addition, at 3^h. At Horseshoe Bay the instrumentation is now the same as at Alberni. At both stations T_s is approximately $\frac{1}{3}$ sec. and T_g is about $\frac{1}{10}$ sec. In both locations the instruments are very sensitive to traffic noise.

The time signals broadcast over CBU, Vancouver, by the Canadian Broadcasting Corporation, and recorded at Alberni and Horseshoe Bay, are carried from Ottawa to Vancouver by wire. The NPG signals recorded at Victoria are received directly from San Francisco by short-wave receiver. The fact that these two signals travel to the seismic network by two different media raised the question whether there might be a small difference between the two time standards used.

An opportunity arose of recording both CBU and NPG signals on a single record. Within the limits imposed by the slow paper speed of 60mm/min. no difference in the two sets of signals could be detected. Since this is the paper speed normally used within the network there can be no error in the epicentre locations due to the difference in timing standards.

EPICENTRE LOCATION

The system of epicentral location described in the 1951 paper is still in use. The charts used are still based on velocities determined in the Canadian Shield. Current investigations suggest that these velocities are appropriate.

The earthquakes recorded at each of the three stations (Alberni, Horseshoe Bay and Victoria) during 1953 are listed in Table II. The earthquakes are numbered consecutively with those of the two earlier papers. Epicentres have been given where possible. Epicentres of earthquakes off the coast located by the United States Coast and Geodetic Survey have been included in the table even though the data from the Canadian stations were not sufficient to allow a location.

All the epicentres regarded as dependable have been plotted on the attached map of southern British Columbia.

DETAILS OF PARTICULAR EARTHQUAKES

Yukon Tremors

Table II lists three earthquakes originating in the Yukon. It seems desirable that these should be included in the report, but it must be stressed that the Yukon is so far from the existing network of stations that only the very largest shocks from that area can be included.

The strongest of these Yukon earthquakes, with a magnitude of $6\frac{1}{2}$, occurred on January 11. The United States Coast and Geodetic Survey places the epicentre at 65°N, 133°W. We have had a report that at Mayo, some 130 miles southwest of this epicentre, buildings and telephone poles swayed, but without damage to any installations. Mayo appears to be the nearest settled point to the epicentre.

Kitimat Landslide

The seismographs did not record a series of events which occurred in the Kitimat project at about 6:30 a.m., P.S.T., on September 1. A report in the Prince Rupert newspaper is the source of the following information.

The event began with a slight tremor, sufficient to shake quite heavy objects. However, the felt area seemed to be not larger than the camp itself. An operator of a tractor working along the road, noticed the earth moving like a wave, and cracks opening in the ground. He had difficulty making his way to safety as the whole road was crumbling underfoot. There was a long crack in the earth striking from west to east, and some piling was moved 100 feet across a clearing. Further mention is made of a small tremor being felt about 6 hours before the slide.

The main damage of this event seems to be confined to a very small area, and to be connected with a landslide or subsidence. However, evidence does indicate that a slight tremor may have been the trigger to start the earth movement. It would not be surprising if, when instrumental coverage permits a study of this whole coastal area, it is found that many such small tremors exist at the heads of inlets similar to this and quite like those already being recorded from Jervis Inlet, farther south.

Ferguson

One person in the area of Ferguson reported that an earthquake was felt there on February 3rd at about 3 a.m. P.S.T. This area is in eastern British Columbia just east of Upper Arrow Lake, in the Columbia River drainage basin.

DISCUSSION OF EPICENTRES

There are several points worth noting in the distribution of the 1953 epicentres. The first concerns the concentration of epicentres in the vicinity of Jervis Inlet (Nos. 409, 422, 423, 439 and 440). None of these earthquakes were large, but a trend first noted in the 1952 earthquakes is being continued. Epicentres 77, 206, 247, and 284, listed in the 1952 report, were in the same area.

Another outstanding feature of this year's activity is the number of moderately heavy tremors off the west coast of Vancouver Island. The tables show a total of 26 earthquakes in this area. Of these, 345 and 435 are the major events, the latter being of intensity at least VI. It is clear that there is a well marked area of seismic activity at some distance west of Vancouver Island, and that the intensity of events in this area is currently greater than that nearer the continent.

The majority of the earthquakes located seem to occur towards the southern end of Vancouver Island. The attached map shows all the epicentres located in this area since the inception of the program. The concentration of epicentres in this area may be partly due to the location of the stations but it must be largely real. The Victoria area is no more favoured by the location of the stations than the other points of the triangle.

In earlier reports it was noted that the epicentres in this area seemed to define rough lines, which might be considered to correspond to active faults. This tendency seems to be continuing, but until more evidence has accumulated no final conclusions can be drawn.

ACKNOWLEDGMENTS

Once again, thanks are due to those United States seismograph stations who have co-operated in the location of many of the epicentres listed here. Readings from Butte, Hungry Horse and Seattle have often been used, and the kindness of their seismologists in supplying them is greatly appreciated.

Dominion Astrophysical Observatory,
Victoria, B.C.,
March 7, 1955.

TABLE 2—1953 EARTHQUAKES

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′					kms			
293	Jan. 7	.....	.....	.....	I	13 07 19·6	13 07 32·8	.....			96	Probably west of Bowen Island in Howe Sound.
294	Jan. 8	05 26 04	47·5	124·5	III	05 26 19·9	05 26 30·9	05 26 29·0	95	197	182	In western Washington State.
295	Jan. 11	.....	65	133	.....	22 57 38	.....	.....	1850			U.S.C.G.S. epicentre in Yukon, Mag 6½—6.
296	Jan. 13	.....	.....	.....	II	04 19 52·6	.....	04 19 28·5			430	Possibly northwest of Alberni.
297	Jan. 13	.....	.....	.....	II	15 29 38·1	15 29 49·6	.....	.....			Probably near Seattle, Washington.
298	Jan. 15	.....	48 37	124 18	II	07 00 51·3	07 00 59·2	07 00 53·7	84			Near No. 138 (1952) southwestern Vancouver Island.
299	Jan. 20	06 54 05	48 42	123 06	III	06 54 11·2	06 54 18·5	06 54 29·1	34	78	143	Waldron Island.
300	Jan. 30	18 43 47	48 16	123 43	II	18 43 52·9	15 44 07·7	18 44 09·2	38	130	140	Strait of Juan de Fuca.
301	Jan. 30	.....	.....	.....	I	.....	22 24 33·4	.....	38			Strait of Juan de Fuca.
302	Feb. 2	.....	48 42	123 15	II	17 41 30·4	17 41 38·6	17 41 47·4	23	77	131	Gulf Islands—Victoria P/S amplitude approx. 2/1.
303	Feb. 3	11 18 33	50 18	116 55	III	11 19 44·7	11 19 37·3	11 19 54·0	536	496	608	Felt at Ferguson, B.C. Epicentre near Duncan Lake.
304	Feb. 12	.....	.....	.....	.....	01 31 29	.....	.....	.....			Yukon.
305	Feb. 12	.....	.....	.....	.....	04 35 25	.....	.....	.....			Yukon.
306	Feb. 20	.....	.....	.....	I	00 52 27·0	.....	00 52 16·4	113			Probably south of Alberni near canal.
307	Feb. 20	.....	48 39	123 04	II	05 16 38·7	05 16 46·8	05 16 57·0	31	81	146	Gulf Islands.
308	Feb. 20	.....	.....	.....	.....	.....	.....	08 40 44·4			83	Off west coast of Island.
309	Feb. 21	.....	48 34	123 44	III	11 26 39·0	11 26 50·6	11 26 52·7	25	98	111	South Vancouver Island.
310	Feb. 24	.....	.....	.....	IV	19 40 30·7	19 40 42·1	19 40 52·8	128	243	293	Felt in Seattle, Washington.
311	Feb. 25	.....	.....	.....	II	01 59 04·8	01 59 16·9	.....	.....			May be near No. 310.
312	Feb. 25	.....	48 38	123 07	III	09 29 23·9	09 29 33·3	09 29 42·9	26	86	144	Gulf Islands.
313	Feb. 27	.....	48 43	123 19	II	20 44 37·7	20 44 45·8	20 44 53·9	22	76	126	Gulf Islands.
314	Mar. 4	.....	.....	.....	I	.....	.....	09 34 15·8			72	
315	Mar. 4	.....	.....	.....	I	18 32 53·5	.....	.....	11			Felt in Victoria.
316	Mar. 7	.....	.....	.....	I	.....	.....	17 02 31·4			58	
317	Mar. 7	.....	.....	.....	I	21 56 08·4	.....	.....	17			
318	Mar. 8	.....	.....	.....	II−	06 31 41·1	06 31 51·7	.....	148			Near Seattle?
319	Mar. 8	.....	.....	.....	II+	21 54 25·9	21 54 38·6	21 54 40·6	120	226	248	In western Washington State.
320	Mar. 10	.....	47·5	123·5	II+	00 02 04·7	00 02 19·9	00 02 16·9	.....			In western Washington State.
321	Mar. 12	.....	.....	.....	II−	.....	.....	00 45 34·4			79	

TABLE 2—1953 EARTHQUAKES—*Continued*

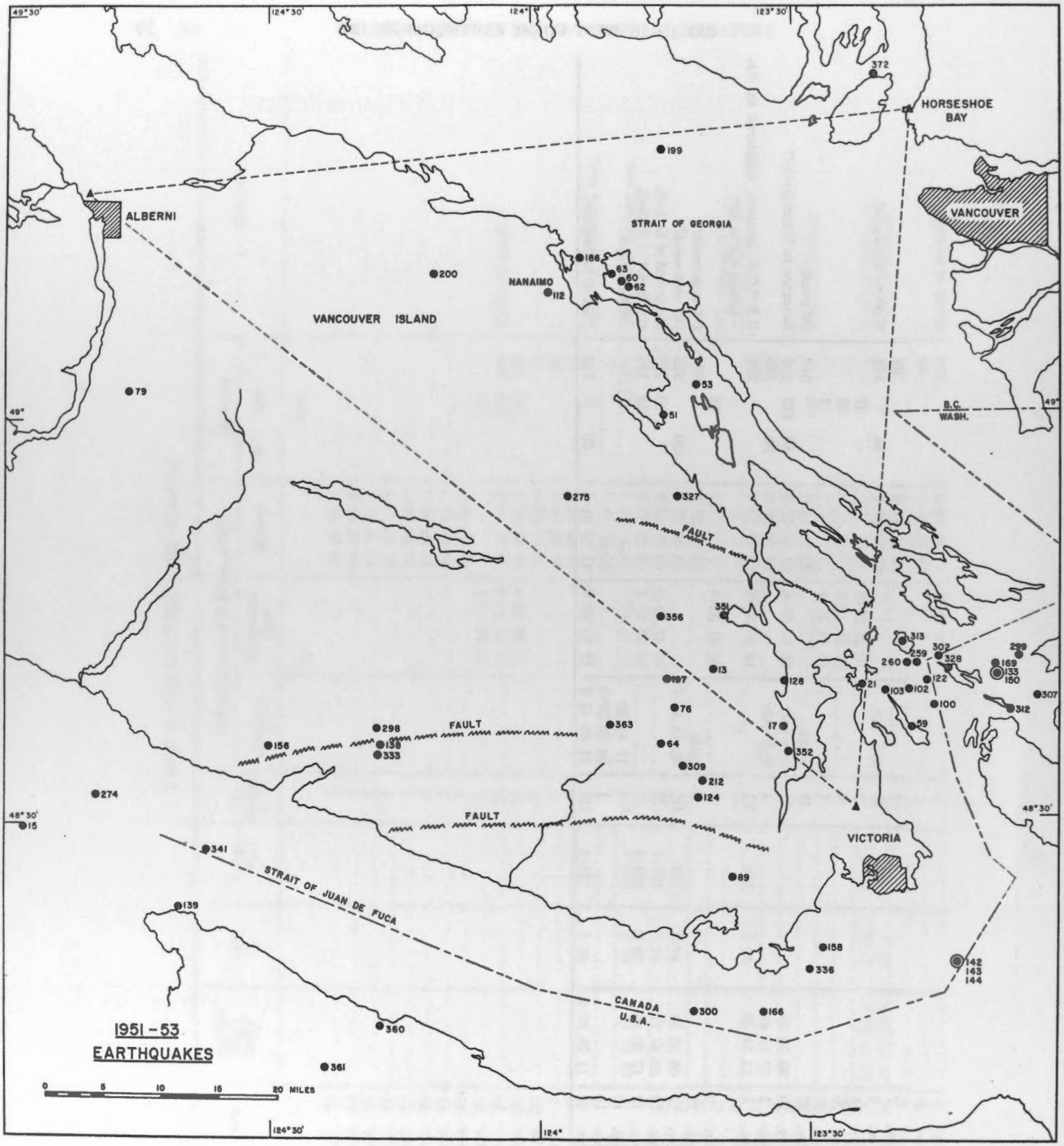
No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′					kms			
322	Mar. 12	19 04 11	49 12	122 54	III−	19 04 24·9	19 04 16·8	19 04 33·2	83	31	142	In Fraser River south of New Westminster, probably blasting.
323	Mar. 13	.....	.....	.....	I	01 30 36·2	.....	.....	14			
324	Mar. 14	00 58 23	49 00	122 12	II	00 58 40·6	00 58 38·6	00 58 53·8	103	91	193	Sumas Mountain, B.C.
325	Mar. 17	.....	.....	.....	I	.....	.....	06 01 00·1			10	
326	Mar. 22	20 15 57	48 52	125 15	III	20 16 19·3	20 16 22·0	20 16 06·3	140	156	57	Entrance to Barkley Sound.
327	Mar. 23	07 03 08	48 54	123 44	II	07 03 26·8	07 03 38·9	07 03 43·4	46	62	91	Near Chemainus, Vancouver Island.
328	Mar. 25	16 52 00	48 41	123 14	III−	16 52 04·6	16 52 13·0	16 52 22·0	22	77	134	Gulf Islands.
329	Mar. 27	.....	.....	.....	I	.....	.....	22 37 51·8			14	
330	Mar. 28	.....	.....	.....	I	.....	22 13 14·3	.....		48		
331	Mar. 31	.....	.....	.....	I	.....	20 46 33·2	.....		12		
332	April 2	.....	.....	.....	I	.....	.....	00 27 41·1			72	
333	April 2	07 58 33·5	48 35	124 18	II+	07 58 46·2	07 58 53·9	07 58 47·4	73	120	81	Southwest Vancouver Island.
334	April 8	.....	.....	.....	I	.....	.....	04 56 26·9			72	
335	April 8	.....	.....	.....	I	21 18 34·8	.....	.....	8			
336	April 8	22 44 09·7	48 19	123 30	II	22 44 14·8	22 44 28·9	22 44 33·1	24	115	150	South of Victoria in Strait of Juan de Fuca.
337	April 9	.....	.....	.....	II−	00 27 31·7	.....	00 27 23·6	213		79	Off west coast of Vancouver Island.
338	April 10	11 06 27·8	.....	.....	III	11 16 52·7	11 07 05·3	11 07 04·1	168	272	242	South in Washington State.
339	April 15	.....	.....	.....	I	04 55 33·5	.....	.....	104			
340	April 15	.....	.....	.....	I	14 32 35·4	.....	.....	118			
341	April 15	21 35 33·5	48 28	124 37	II+	21 35 48·7	.....	21 35 49·4	89		94	Entrance to Strait of Juan de Fuca.
342	April 19	.....	.....	.....	II	09 36 01·6	.....	09 36 19·6	137		290	Probably in Puget Sound area.
343	May 4	.....	48·0	124·3	II+	00 44 38·6	00 44 51·3	00 44 49·4	92	174	145	Western Washington State.
344	May 14	.....	.....	.....	I	01 46 47	.....	.....	.....			Same general area as No. 345.
345	May 14	07 41 44	50	130	IV	07 42 52	.....	07 42 36·3	500		371	Off west coast of Vancouver Island, U.S.C.G.S. location.
346	May 14	18 27 41	50	130	IV	18 28 52	.....	18 28 37·2	518		405	Off west coast of Vancouver Island.
347	May 20	23 14 23	50	130	IV	23 15 33·0	.....	23 15 22·4	495		340	Off west coast of Vancouver Island.
348	May 21	12 29 51	50	130	IV	12 31 00·0	.....	12 30 47·1	490		375	Off west coast of Vancouver Island.
349	May 23	.....	.....	.....	I	.....	.....	10 04 32·8			89	
350	May 24	.....	.....	.....	I	.....	.....	04 38 13·9			76	
351	June 2	22 07 58	48 45	123 39	II−	22 07 03·5	22 07 10·6	22 07 15·4	28	75	105	South Vancouver Island.
352	June 4	00 11 03	48 35	123 32	II+	00 11 06·4	00 11 18·5	00 11 23·3	11	91	122	South Vancouver Island.

353	June	9	.....	.....	.....	II	18 48 25	.....	18 48 13·0	.....			Probably off west coast.
354	June	9	.....	.....	.....	II	23 30 03·5	.....	23 29 43·5	.....			Northern Vancouver Island.
355	June	11	23 37 32	49 49	123 52	III	23 37 55·5	23 37 42·5	23 37 46·8	148	63	90	Sechelt Peninsula area.
356	June	16	17 53 20	48 45	123 46	III−	17 53 27·0	17 53 33·8	17 53 36·9	34	78	98	South Vancouver Island.
357	June	19	.....	.....	.....	II	22 52 23·8	.....	22 52 23·6	.....			Off west coast.
358	June	27	07 09 17	48·6	125·7	II+	No Time	07 09 48·5	.....	176	202	99	Off west coast—Victoria S–P readable.
359	July	4	.....	.....	.....	.....	No Time	.....	10 00 12·9	.....			Off west coast.
360	July	5	13 55 07	48 15	124·3	III	No Time	13 55 32·4	13 55 26·1	63	139	115	Western Strait of Juan de Fuca.
361	July	6	09 48 34	48·2	124·4	II	No Time	09 48 58·4	09 48 52·5	80	149	114	Northwest Washington State.
362	July	11	08 13 30	48 14	122 52	III+	08 13 37·7	08 13 50·6	08 13 58·3	52	130	184	Entrance to Puget Sound.
363	July	17	08 57 45	48 37	123 52	II+	08 57 51·6	08 58 00·6	08 58 01·7	35	94	100	Southern Vancouver Island.
364	July	18	.....	.....	.....	I	22 29 44·7	.....	.....	.....			
365	July	21	.....	.....	.....	III	08 54 00·6	.....	.....	.....			
366	July	22	10 17 39	48·5	128	IV+	10 18 32·4	.....	10 18 22·4	425		326	U.S.C.G.S. location.
367	July	22	.....	.....	.....	III	10 37 05·0	.....	10 36 55·8	.....			Probably off west coast.
368	July	22	10 37 20	48·5	128	IV+	10 38 13·0	.....	10 38 03·3	415		330	U.S.C.G.S. location.
369	July	26	.....	.....	.....	II	17 47 50	.....	17 47 28·3	.....			Off west coast.
370	July	28	.....	.....	.....	II	18 49 08	.....	18 48 50·1	.....			Off west coast.
371	July	29	06 00 48	49·3	122·4	II	.....	06 00 58·4	06 01 15·2		59	173	Due east of Horseshoe Bay between Pitt and Stave Lakes.
372	Aug.	1	05 33 10	49 25	123 21	II	05 33 27·7	05 33 12·7	05 33 28·7	102	8	108	Between Gambier and Bowen Islands, Howe Sound.
373	Aug.	4	10 26 22	48·3	129·1	IV+	10 27 17·3	10 27 20·5	10 27 06·5	420	437	325	Off west coast.
374	Aug.	4	.....	.....	.....	II	.....	.....	10 54 13·4	.....			Same as No. 373.
375	Aug.	4	.....	.....	.....	II	.....	.....	11 08 31·3	.....			Same as No. 373.
376	Aug.	4	11 35 27	47·9	128·7	IV	11 36 25	11 36 25·2	11 36 11·0	400	427	320	Off west coast.
377	Aug.	6	.....	.....	.....	I	23 29 26·7	.....	.....	.....			
378	Aug.	9	.....	.....	.....	I	.....	05 50 43·9	.....	.....			Very close to Horseshoe Bay.
379	Aug.	10	11 22 25	48 50	122 55	III	No Time	11 22 34·5	11 22 49·2	49	60	146	Strait of Georgia.
380	Aug.	16	.....	.....	.....	II	06 15 45·1	.....	06 15 56·9	.....			Probably off west coast.
381	Aug.	20	18 32 41	47·8	123·8	III	18 32 52·9	.....	18 33 08·9	79		173	In Olympic Mountains.
382	Aug.	20	.....	.....	.....	I	.....	.....	20 37 24·5	.....			
383	Aug.	21	.....	.....	.....	I	.....	.....	23 51 12·0	.....			
384	Aug.	26	.....	.....	.....	I	.....	.....	23 23 03·1	.....			Nos. 382, 383, 384 are alike in appearance.
385	Aug.	29	.....	.....	.....	I	04 30 43·0	.....	.....	.....			
386	Aug.	31	.....	.....	.....	I	04 46 24·7	.....	.....	.....			
387	Sept.	4	.....	.....	.....	II	18 44 46·7	.....	18 44 24·2	.....			Probably in Washington.
388	Sept.	7	.....	.....	.....	I	23 29 32·8	.....	.....	.....			
389	Sept.	8	.....	.....	.....	I	00 12 38·6	.....	.....	.....			
390	Sept.	8	.....	.....	.....	I	11 42 25·5	.....	.....	.....			
391	Sept.	8	.....	.....	.....	I	11 54 04·9	.....	.....	.....			
392	Sept.	10	.....	.....	.....	I	.....	.....	14 36 43·8	.....			

TABLE 2—1953 EARTHQUAKES—*Concluded*

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′					kms.			
393	Sept. 12	.....	.....	.....	I	.....	.....	19 09 25·4	.....			
394	Sept. 13	.....	.....	.....	I	.....	.....	00 12 05·3	.....			
395	Sept. 15	.....	.....	.....	I	.....	.....	19 10 00·3	.....			
396	Sept. 19	.....	.....	.....	I	.....	.....	23 30 40·1	.....			
397	Sept. 23	.....	.....	.....	I	.....	.....	21 30 09·3	.....			
398	Sept. 23	.....	.....	.....	I	.....	.....	21 58 49·3	.....			
399	Sept. 23	.....	.....	.....	I	.....	.....	21 59 37·9	.....			
400	Sept. 25	.....	.....	.....	I	.....	.....	21 10 02·9	.....			
401	Sept. 29	.....	.....	.....	I	.....	15 59 12·8	.....		123		
402	Sept. 29	.....	.....	.....	II	.....	16 31 15·1	16 31 15·3		210	211	Probably south.
403	Sept. 30	.....	.....	.....	II	.....	19 36 28·9	19 36 31·1		114	132	
404	Sept. 30	.....	.....	.....	I	.....	.....	22 22 54·5			66	
405	Oct. 1	.....	.....	.....	I	.....	.....	09 00 26·3			50	
406	Oct. 2	.....	.....	.....	I	.....	.....	00 27 17·0			80	
407	Oct. 2	.....	.....	.....	I	.....	06 11 00·9	.....		74		Probably in Sechelt area.
408	Oct. 4	.....	.....	.....	I	.....	.....	07 43 30·9			34	
409	Oct. 4	19 41 14	50·0	123·5	III	.....	19 41 28·9	19 41 32·4		76	116	Probably in Sechelt area.
410	Oct. 8	.....	.....	.....	I	.....	.....	18 59 49·9			72	
411	Oct. 10	.....	.....	.....	I	.....	.....	23 59 56·4			54	
412	Oct. 11	.....	.....	.....	I	.....	.....	11 44 41·0			94	
413	Oct. 12	.....	.....	.....	I	.....	.....	17 54 17·9			52	
414	Oct. 13	.....	.....	.....	I	.....	.....	08 28 08·0	.....			Off west coast?
415	Oct. 13	.....	.....	.....	II	.....	.....	08 56 30·9	.....			Off west coast?
416	Oct. 13	.....	.....	.....	I	.....	.....	15 26 58·6			460	
417	Oct. 13	.....	.....	.....	I	.....	.....	17 13 28·8			325	
418	Oct. 13	.....	.....	.....	I	.....	.....	21 30 57·7			74	
419	Oct. 21	.....	.....	.....	I	.....	S–P only	06 57 37·4		100	130	North of Sechelt?
420	Oct. 27	.....	.....	.....	I	.....	.....	15 44 50·4			48	
421	Oct. 29	.....	.....	.....	I	.....	.....	04 20 02·8			76	
422	Oct. 31	00 10 58·6	49·9	123·5	II	.....	00 11 11·6	00 11 17·3		68	111	North of Sechelt?
423	Oct. 31	16 29 43·5	49·9	123·5	II	.....	16 29 54·8	16 30 01·9		64	109	North of Sechelt?
424	Nov. 2	.....	.....	.....	II	.....	.....	01 59 32·3			108	
425	Nov. 3	.....	.....	.....	I	.....	.....	08 13 58·1			66	
426	Nov. 4	.....	.....	.....	I	.....	11 26 10·8	11 26 18·9			110	North of Sechelt?

427	Nov.	7	.....	.....	.....	I	.....	.....	22 53 23·6			58	
428	Nov.	9	.....	.....	.....	II	S–P only	.....	22 09 31·9	84		110	Western Olympics?
429	Nov.	18	.....	.....	.....	I	.....	10 25 50·7	.....		37		
430	Nov.	20	.....	.....	.....	I	.....	06 31 42·6	.....		20		
431	Nov.	23	.....	.....	.....	I	.....	10 45 27·0	.....		13		
432	Nov.	27	.....	.....	.....	II	trace	.....	22 53 18·3			310	Off coast.
433	Nov.	29	23 50 39	.....	.....	II	S–P only	23 51 07·8	23 51 07·8	86	172	196	Entrance to Puget Sound?
434	Dec.	1	20 15 44	.....	.....	I	S–P only	.....	20 16 05·6	25		135	
435	Dec.	4	14 54 46	49·5	129	VI	.....	14 54 51·5	14 54 34·4			375	U.S.C.G.S. location, registered at distances out to 80°.
436	Dec.	6	.....	.....	.....	I	.....	06 01 55·6	.....		58		
437	Dec.	12	.....	.....	.....	I	trace	.....	08 05 33·7			370	Off west coast?
438	Dec.	12	08 28 36	49·5	129	III	08 29 44·9	.....	08 29 28·7	430		375	Off west coast?
439	Dec.	12	09 47 27	49·7	123·4	II	.....	09 47 36·5	09 47 46·5		50	116	Northeast of Sechelt.
440	Dec.	12	12 20 18	49·7	123·4	II	.....	12 20 27·7	12 20 37·8		52	114	Northeast of Sechelt.
441	Dec.	12	.....	.....	.....	I	17 41 00	.....	trace	.....			Off west coast.
442	Dec.	16	.....	.....	.....	I	04 32 39·8	.....	trace	.....			
443	Dec.	20	11 35 33·2	48·6	121·8	III	11 35 45·8	11 35 48·8	11 36 01·3	70		190	East of Bellingham.


49°30'
124°30'
124°
123°30'
372
HORSESHOE BAY
199
ALBERNI
STRAIT OF GEORGIA
VANCOUVER
186
63
60
62
200
NANAIMO
112
VANCOUVER ISLAND
79
53
51
49°
B.C.
WASH.
49°
275
327
FAULT
356
351
313
302
259
260
328
169
133
150
13
197
128
21
103
102
122
100
307
312
76
363
17
59
298
FAULT
156
136
333
64
352
309
212
124
274
48°30'
15
48°30'
FAULT
VICTORIA
341
STRAIT OF JUAN DE FUCA
89
139
158
336
142
143
144
CANADA
U.S.A.
300
166
360
361
1951-53
EARTHQUAKES
0
5
10
15
20 MILES
124°30'
124°
123°30'

CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS
DOMINION OBSERVATORIES

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

Vol. XVIII, No. 3

Canadian West Coast Earthquakes, 1954

BY

W. G. MILNE

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.,
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1955

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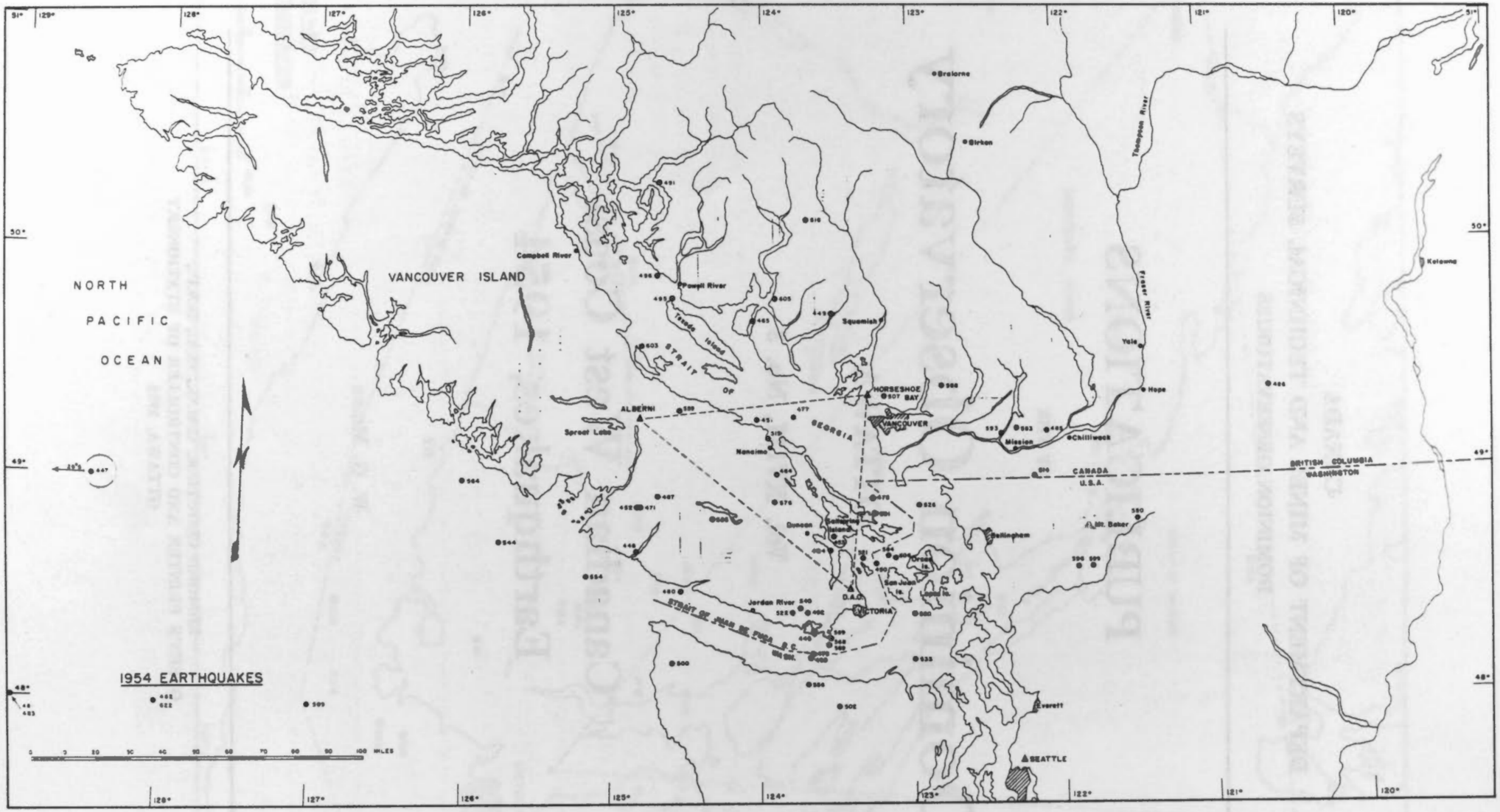
NORTH
PACIFIC
OCEAN
VANCOUVER ISLAND
STRAIT OF GEORGIA
Campbell River
Powell River
Tzuzuk Island
Squamish
Sproat Lake
Nanaimo
Duncan
Jordan River
Galiano Island
Saltspring Island
Orcas Is.
San Juan Is.
Lopez Is.
D.A.O.
VICTORIA
HORSESHOE BAY
VANCOUVER
ALBERNI
Bellingham
Mt. Baker
Everett
SEATTLE
Mission
Chilliwack
Hope
Yale
Fraser River
Thompson River
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Sicamous
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CANADA
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WASHINGTON
1954 EARTHQUAKES
MILES

Canadian West Coast Earthquakes, 1954

BY

W. G. Milne

ABSTRACT

This report continues a series, already published, dealing with earthquakes on the west coast of Canada. During 1954 there were 178 earthquakes recorded on the network of seismograph stations in southwestern British Columbia, and of these epicentral determinations were possible for 67. The earthquakes located are plotted on an accompanying map of the area. A list of the few earthquakes recorded on the Crowsnest Pass seismographs is included.

Instrumental changes at the Horseshoe Bay station late in 1954 are described.

INTRODUCTION

The seismological network set up in southwestern British Columbia in 1951 has continued to operate during 1954. The Victoria station, which dates back to 1899, is the central station. The records of the Alberni and Horseshoe Bay stations are combined with those of Victoria for the purpose of locating many of the small local earthquakes occurring in the immediate area. Three temporary units in the southeastern Rocky Mountain region were added at Fernie, Coleman, and Turner Valley. A discussion of the seismograph records obtained during 1954 at the six stations, is presented in this paper as a continuation of the series of reports on seismic activity in British Columbia given for 1951[1], 1952[2], and 1953[3].

DESCRIPTION OF STATIONS

At the Dominion Astrophysical Observatory near Victoria, the new seismological station continues to be the centre of the network. The three-component short-period Benioff seismographs, of variable reluctance type, record the local earthquakes. In addition the Victoria station is equipped with Milne-Shaw seismographs for recording teleseisms. A standard chronometer is used to place time marks on the record, and accurate time control is obtained from automatically recorded NPG (San Francisco) time signals whenever available. A more detailed description of this station is given in the report for 1953.

The Alberni station, which is serviced by a local operator, is equipped with short-period Willmore-Sharpe seismometers. These drive Turner galvanometers, which in turn record on a Sprengnether microseismic recorder at the paper speed of 60 mm/min. Time control is supplied once a day by automatically recorded Dominion Observatory time signals.

Until December 1st, 1954, the Horseshoe Bay seismographs were identical with those at Alberni. During 1953 a new ferry service was inaugurated between Horseshoe Bay and Nanaimo to add to the two services already operating from the dock, a few hundred yards from the seismograph. Because of the very short-period design of the Willmore-Sharpe seismometers, the record was disturbed for a period of two to five minutes when

[1] W. G. Milne and F. Lombardo, "Canadian West Coast Earthquakes, 1951", *Publications of the Dominion Observatory*, Vol. XVI, No. 3, 1952.

[2] W. G. Milne, "Canadian West Coast Earthquakes, 1952", *Publications of the Dominion Observatory*, Vol. XVI, No. 9, 1953.

[3] W. G. Milne, "Canadian West Coast Earthquakes, 1953", *Publications of the Dominion Observatory*, Vol. XVI, No. 13, 1955.

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the ferry docked and departed. The Willmore-Watt seismometers, with periods of the order of one second, were substituted for the Willmore-Sharpe units. One galvanometer was installed with a period of 0·25 sec., and the other galvanometers with periods approximately 0·03 sec. The longer period unit eliminates most of the ferry and traffic noise, but brings the system into the frequency range of microseisms. Many teleseisms as well as all the local tremors appear on the records from the 0·25 sec. galvanometer. On the system with the 0·03 sec. galvanometers, traffic noise still persists, but the record is much less disturbed by microseisms and the earthquakes are more clearly seen. The new galvanometers have a very short focal length so the Sprengnether method of placing time marks on the records was changed. Instead of using chronometer contacts to move a prism in the light path and so shift the light spot, the contacts now close a circuit which supplies a small voltage directly to the galvanometer. The spot is thus moved with a minimum of relay stages in the system. As in the past, time corrections are obtained daily from automatically recorded Dominion Observatory time signals.

Seismograph stations established late in 1953 in the Rocky Mountain area along the southern British Columbia-Alberta border, have been used to investigate the rockburst activity in the coal mines of the Crowsnest Pass. These stations have recorded a few local tremors although their sensitivity is not high. At Fernie and Coleman the recorders are in the mine offices. Willmore-Watt seismometers and recorders are used. T_s is approximately 1 sec. and T_g is 0·25 sec. Standard chronometers are used and CBC radio time signals are recorded when available. The Turner Valley station in Alberta is equipped with similar seismographs.

The co-ordinates of the stations are given in Table I.

TABLE I

Station	Latitude			Longitude		
	°	′	″N	°	′	″W
Victoria	48	31	09·9	123	24	55·1
Alberni	49	16	14	124	49	18
Horseshoe Bay	49	22	39	123	16	33
Fernie	49	29·0		114	58·6	
Coleman	49	38·1		114	31·2	
Turner Valley	50	39	52	114	16	44

METHOD OF LOCATING EPICENTRES

When an earthquake is of sufficient strength to record on three seismographs, an epicentre can be determined. Preliminary co-ordinates are obtained by using differences in arrival times of P waves at pairs of stations. This position is adjusted to obtain the best possible fit for the three stations, again using only the P phase. The distance to each station, scaled from a map, is checked against the S-P distance to eliminate any major error in the position of the epicentre. For all this work the travel-time curves for the Canadian Shield[4] are used; curves more appropriate to the area have not yet been determined. Epicentres a considerable distance out of the triangle, and epicentres out of the

[4] John H. Hodgson, "A Seismic Survey in the Canadian Shield", *Publications of the Dominion Observatory*, Vol. XVI, No. 5, 1953.

TABLE II—1954 EARTHQUAKES

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′			h m	h m s		kms		
444	Jan. 14	.....	.....	.....	I	.....	05 43 50·5	.....	.....			Very close to Horseshoe Bay.
445	Jan. 15	06 33 26	48 20	123 40	II	S-P = 3ˢ5	.....	06 33 48·2	28		135	Probable location southwest of Victoria.
446	Jan. 15	23 39 20	.....	.....	III	No record	23 39 27·0	23 39 44·5	15		155	Northeast of Horseshoe Bay, approx. 15 kms.
447	Jan. 16	.....	49	129·5	IV	S-P = 37ˢ	22 46 18·4	22 43 00·1	.....			Off west coast of Vancouver Island.
448	Jan. 20	08 28 24	48 41	124 51	II	S-P = 9ˢ5	08 28 44·9	08 28 33·0			65	On west coast of Vancouver Island.
449	Jan. 20	11 57 35	49 44	123 32	II	.....	11 57 29·0	11 57 52·2			107	Northeast of Horseshoe Bay.
450	Jan. 24	17 49 20	48 38	123 15	II	S-P = ˢ·1	17 49 35·4	17 49 43·5		91	137	Gulf Islands.
451	Jan. 26	23 10 55	49 16	123 02	III	23 11 11	23 11 05	23 11 05·0		49	60	North of Nanaimo.
452	Fef. 3	16 17 26	48 53	124 50	II	16 17 44·0	(16 17 47·5)	16 17 33·0	120		43	South of Alberni.
453	Feb. 7	10 40 39	48 45	123 32	III	10 40 43·5	10 40 51·5	10 40 57·8	27	75	112	West of Saltspring Island.
454	Feb. 20	23 42 19	48 41	123 33	II+	23 42 22·5	23 42 33·1	23 42 38·0	21	85	116	Southern Vancouver Island.
455	Feb. 22	.....	.....	.....	I	.....	.....	18 22 05	.....			
456	Feb. 23	.....	.....	.....	I	.....	.....	22 35 51·1	.....			
457	Feb. 23	.....	.....	.....	II	23 16 18	.....	.....	.....			Off west coast of Vancouver Island.
458	Feb. 24	.....	.....	.....	I	.....	.....	19 12 49·0	.....			
459	Feb. 24	.....	.....	.....	I	.....	.....	21 29 06·2	.....			
460	Feb. 25	.....	.....	.....	I	.....	.....	01 08 35·3	.....			
461	Mar. 2	.....	.....	.....	I	.....	.....	19 15 02·2	.....			Very close to Alberni.
462	Mar. 3	.....	.....	.....	I	.....	.....	16 14 22·7	.....			Very close to Alberni.
463	Mar. 4	.....	.....	.....	I	.....	.....	18 34 54·6	.....			
464	Mar. 7	.....	49 02	123 54	II	S-P = 7ˢ9	23 28 44·9	23 28 47·1	62	65	72	Southern Vancouver Island.
465	Mar. 8	.....	49 42	124 04	II	.....	13 09 40·6	13 09 41·5		71	71	Sechelt Peninsula.
466	Mar. 10	.....	.....	.....	II	00 35 07·0	00 35 21	.....	95			Horseshoe Bay is likely an S reading. Direction is southeast of Victoria.
467	Mar. 11	.....	.....	.....	I	.....	.....	19 42 56·6	.....			
468	Mar. 12	.....	.....	.....	I	04 17 19·4	.....	.....	70			
469	Mar. 12	.....	.....	.....	II	14 35 48·4	.....	.....	.....			(Seattle 14:35:47), probably off Coast of Washington.
470	Mar. 12	.....	.....	.....	II	20 38 45·8	20 38 43·7	.....	120			Probably in Mission area.
471	Mar. 13	00 04 50	48 53	124 49	II+	00 05 08·8	00 05 11·0	00 04 57·3	112	126	43	South of Alberni.
472	Mar. 16	.....	.....	.....	IV	15 56 44·0	15 56 55·8	15 57 04	.....			South of Seattle (Seattle 15:56:29).
473	Mar. 18	.....	.....	.....	I	21 36 04·7	.....	.....	.....			

TABLE II—1954 EARTHQUAKES—*Continued*

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′			h m s	h m s		kms		
474	Mar. 22	.....	.....	.....	II	22 46 06·5	.....	.....	.....			Probably off west coast.
475	Mar. 25	.....	.....	.....	.....	17 40 04·0	17 40 07·5	.....	131			Probably east of Bellingham.
476	Mar. 25	21 16 35	48 14	123 40	III	21 16 40·9	21 16 56·4	21 16 58·2	36	131	140	Southwest of Victoria.
477	Mar. 25	21 31 00	49 17	123 45	III	21 31 15·1	21 31 06·8	21 31 13·2	90	37	78	Gulf of Georgia.
478	Mar. 30	05 29 18	48 55	123 16	III	05 29 25·3	05 29 27·1	05 29 37·5	46	51	120	Gulf Islands.
479	April 3	.....	.....	.....	I	.....	15 54 47	.....	.....			
480	April 4	12 42 29	48 31	124 32	III	12 42 42·8	12 42 51·0	12 42 43·6	84	133	87	Entrance to Juan de Fuca Strait.
481	April 5	.....	48	129	VI	19 26 55	.....	19 26 46	.....			U.S.C.G.S. epicentre.
482	April 5	.....	48	128	V	19 35 53	.....	19 35 45	.....			U.S.C.G.S. epicentre.
483	April 5	.....	48	129 (?)	IV	19 48 37	.....	19 48 29	.....			Off west coast.
484	April 9	.....	.....	.....	I	00 58 03·2	.....	.....	20			Southwest of Victoria.
485	April 12	.....	49·2	122·1	III	23 32 10·6	23 32 05·2	23 32 21·5	125	91	199	East of Vancouver, epicentre only approximate.
486	April 15	.....	49 22	120 35	IV	19 20 10·2	19 20 08·8	19 20 24·4	222	197	320	South of Princeton, B.C. (using S-P values). Seattle readings fit well and this tremor was recorded at Butte.
487	April 15	.....	48 56	124 42	II	23 30 47·5	.....	23 30 36·3	107		38	South of Alberni.
488	April 22	.....	48 13	123 41	II	19 28 49·6	19 29 04·9	19 29 06·4	27	131	143	Strait of Juan de Fuca.
489	May 5	.....	.....	.....	IV	01 43 53·7	.....	.....	150			Felt in Tacoma, Wash. (Seattle P=01:42:40·0).
490	May 6	.....	.....	.....	I	record fogged	.....	15 15 23·5	.....			
491	May 10	.....	50·3	124·7	III	.....	05 11 19·4	05 11 15·0		142	116	North of Powell River.
492	May 14	.....	48 25	123 42	II	19 06 19·9	.....	19 06 37·8	20	130	115	South Vancouver Island.
493	May 15	.....	47·4	122·5	VI	13 02 32·9	13 02 45·2	13 02 52·1	.....			Puget Sound epicentre computed by Professor Neumann.
494	May 15	.....	.....	.....	II	17 39 29·0	.....	.....	127			
495	May 19	.....	49·8	124·6	II	.....	18 39 55·2	18 39 47·8		108	63	Texada Island.
496	May 19	.....	49·9	124·7	II	.....	23 02 46·0	23 02 39·0			76	North Strait of Georgia.
497	May 20	.....	.....	.....	I	22 56 21·7	.....	.....	.....			Very near Victoria.
498	May 21	.....	.....	.....	I	14 00 44·3	.....	14 00 17·9	.....			These seem to be the same event, but their arrival times do not permit an epicentral determination.
499	May 21	.....	.....	.....	II	17 04 31·5	.....	.....	.....			

500	May	22	.....	48·2	124·6	III	12 47 29·7	12 47 40·2	12 47 33·8	97	160	116	In Olympic Mountains.
501	May	26	.....	.....	.....	I	22 34 22·6	.....	.....	.....			Very near Victoria.
502	June	3	.....	48·0	123·5	III	07 58 48·4	07 59 00·3	07 59 03·8	49	155	175	South of Port Angeles.
503	June	10	.....	.....	.....	II	.....	.....	21 19 34·0	.....		60	
504	June	18	.....	.....	.....	III	15 10 01·7	15 10 13·6	15 10 20·2		195		Felt in Seattle (Seattle 15:09:51).
505	June	20	.....	.....	.....	III	19 20 49·0	19 20 59·1	19 21 07·2	145	250	300	(Seattle 19:20:34). Epicentre near Seattle?
506	June	22	.....	.....	.....	I	.....	.....	01 43 25·5			205	
507	June	22	20 08 58	49 22	123 11	II	20 09 13·4	20 09 00·2	20 09 18·6	97	12	119	Very close to Horseshoe Bay; perhaps a blast along the Capilano River.
508	June	23	.....	.....	.....	II	.....	.....	23 17 25·6			62	
509	July	5	.....	48	127	III	01 13 07·5	.....	01 13 00·7	.....			Off west coast.
510	July	11	.....	.....	.....	IV	04 56 36·1	.....	04 56 19·2	.....			Off west coast (Seattle 04:56:47).
511	July	12	.....	.....	.....	II	.....	.....	16 38 43·9			95	
512	July	13	.....	.....	.....	II	.....	.....	06 01 49·1			182	
513	July	15	13 24 35	54	138	IV	13 26 32	.....	.....	.....			Queen Charlotte Islands (U.S.C. G.S.).
514	July	15	.....	49·0	122·2	III	21 43 14·1	21 43 12·3	21 43 27·9	110	95	225	Abbotsford area.
515	July	16	19 40 37	49 11	123 58	III	19 40 51·4	19 40 46·6	19 40 47·6	86	56	62	Near Nanaimo.
516	July	21	02 17 35	50 09	123 42	III	02 18 03·9	02 17 49·7	02 17 55·7	200	93	127	North of Sechelt Peninsula.
517	July	28	.....	.....	.....	I	.....	.....	19 59 27·2			80	
518	July	29	.....	.....	.....	I	.....	.....	21 05 34·4			55	
519	July	29	.....	.....	.....	I	.....	.....	22 09 14·4			95	
520	July	30	.....	.....	.....	I	.....	.....	13 28 45·5			26	
521	Aug.	1	17 21 59	48 39	123 20	III	17 22 02·8	17 22 12·8	17 22 20·6	15	83	129	Gulf Islands.
522	Aug.	2	07 23 53	48 25	123 48	III	07 23 58·2	07 24 11·5	07 24 12·3	31	112	118	South Vancouver Island.
523	Aug.	2	.....	.....	.....	II	.....	.....	16 03 40·1			85	
524	Aug.	3	.....	.....	.....	I	03 25 32·7	.....	.....	.....			Very close to Victoria.
525	Aug.	3	.....	.....	.....	II	05 13 13	.....	05 12 54·3			150	Northwest of Alberni.
526	Aug.	5	10 26 56	48 53	122 57	III	10 27 05·5	10 27 06·0	10 27 19·6	55	58	143	South Gulf of Georgia.
527	Aug.	11	.....	.....	.....	I	.....	.....	18 37 52·4			78	
528	Aug.	19	.....	.....	.....	I	.....	05 04 33·2	.....		32		Very near Horseshoe Bay.
529	Aug.	20	.....	.....	.....	I	12 16 14·4	12 16 20·7	.....	50			Probably in the Gulf Islands area.
530	Aug.	25	.....	.....	.....	II	14 25 33·7	S-P = 11^{s}7	14 25 51·0	20	90		Probably in Gulf Islands area, very weak records.
531	Aug.	27	.....	.....	.....	II	04 56 11	.....	04 55 50·8	.....			Northwest of Alberni.
532	Aug.	31	.....	.....	.....	I	05 58 18·6	.....	.....	65			
533	Sept.	1	.....	48·2	123·0	III	12 42 24·1	12 42 38·7	12 41 45·7	55			Seattle 12:42:27, epicentre under Strait of Juan de Fuca between Victoria and Port Townsend.
534	Sept.	1	.....	.....	.....	I	22 28 25·0	.....	.....	72			
535	Sept.	2	.....	.....	.....	I	13 50 18·5	.....	.....	76			

TABLE II—1954 EARTHQUAKES—*Continued*

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′			h m s	h m s		kms		
536	Sept. 3	.....	.....	.....	I	17 58 22·8	.....	.....	15			
537	Sept. 3	.....	.....	.....	II	20 39 41·7	.....	.....	75			
538	Sept. 3	.....	.....	.....	II	20 40 52·5	.....	.....	.....			
539	Sept. 3	.....	.....	.....	II	23 00 50·5	.....	23 01 11·5	65		220	Southeast of Victoria.
540	Sept. 4	.....	48 26	123 45	II	01 16 24·4	.....	01 16 39·0	27		122	South Vancouver Island.
541	Sept. 4	.....	.....	.....	II	07 13 34·0	.....	07 13 53·3	65		220	Southeast of Victoria.
542	Sept. 4	.....	.....	.....	I	07 15 36·0	.....	.....	.....			
543	Sept. 4	.....	.....	.....	I	20 15 42·0	20 15 55·7	.....	33	105		Gulf Islands area.
544	Sept. 4	.....	48 44	125 45	III	21 49 23·3	.....	21 49 11·1	175		92	Off Barkley Sound.
545	Sept. 5	.....	.....	.....	I	16 17 08·2	.....	.....	35			Probably two earthquakes.
546	Sept. 7	.....	.....	.....	I	08 52 28·4	.....	.....	65			
547	Sept. 11	.....	.....	.....	I	05 41 55·2	.....	.....	75			
548	Sept. 11	.....	.....	.....	I	.....	.....	08 27 50·2			52	
549	Sept. 13	.....	.....	.....	II	20 53 50·7	.....	20 54 06·7	63		170	Probably south of Port Angeles, in Washington.
550	Sept. 15	.....	48·8	121·5	III	03 37 34·0	03 37 34·9	.....	148	152		East of Mount Baker.
551	Sept. 16	.....	.....	.....	I	06 53 26·8	.....	06 53 46·7	65			Probably south in Washington.
552	Sept. 17	.....	.....	.....	I	.....	.....	20 38 14·7			33	
553	Sept. 17	.....	.....	.....	II	.....	.....	21 53 29·6			55	
554	Sept. 20	.....	48 35	125 11	II	03 23 40·3	.....	03 23 32·2	130		82	Off Barkley Sound.
555	Sept. 20	.....	48 50	124 20	II	07 07 10·7	.....	07 07 06·9	75		62	South central Vancouver Island.
556	Sept. 21	.....	48·1	123·7	II	22 32 27·2	.....	22 32 43·6	55		135	There seem to be at least three and perhaps four local shocks within the space of a minute. The first only is located.
557	Sept. 24	.....	.....	.....	I	.....	.....	17 28 45·4	.....			
558	Sept. 24	.....	.....	.....	III	.....	20 50 13·3	20 50 06·9		120	93	Victoria recorder stopped; No epicentre location is possible.
559	Sept. 25	.....	49 19	124 32	III	08 18 16·2	08 18 11·5	08 17 59·5	123	95	35	Northeast of Alberni.
560	Sept. 25	.....	.....	.....	II	.....	.....	22 02 10·5	.....			Felt in Alberni.
561	Sept. 30	.....	.....	.....	I	18 06 26·0	.....	.....	85			
562	Oct. 2	.....	.....	.....	I	.....	.....	19 30 25·8	.....			
563	Oct. 4	.....	.....	.....	I	.....	.....	23 21 51·4	.....			

564	Oct.	5	.....	49·0	126·0	III	13 01 07·1	.....	13 00 49·2			100	Horseshoe Bay record very weak. Epicentre probably off Barkley Sound.
565	Oct.	6	.....	.....	.....	I	.....	.....	11 37 41·9	.....			
566	Oct.	7	.....	.....	.....	II	.....	.....	14 14 19·7			165	
567	Oct.	11	.....	.....	.....	I	.....	.....	02 52 29·8			55	
568	Oct.	13	.....	48 17	123 34	II	19 33 23·8	(19 33 43·6)	19 33 41·3	32	125	145	Strait of Juan de Fuca.
569	Oct.	13	.....	48 17	123 34	II	21 49 09·7	(21 49 28·9)	21 49 27·2	32	125	145	Same as No. 568.
570	Oct.	15	.....	.....	.....	II	.....	.....	18 15 05·2	.....			
571	Oct.	16	.....	.....	.....	III	02 26 03·3	.....	02 25 44·2			155	Probably off west coast.
572	Oct.	19	.....	.....	.....	II	.....	.....	21 03 53·1			80	
573	Oct.	24	.....	.....	.....	II	.....	.....	06 50 30·8			65	Very sharp on Alberni record.
574	Oct.	27	.....	.....	.....	II	19 55 30·3	.....	.....	120			
575	Oct.	28	.....	.....	.....	I	.....	.....	23 14 50·4	.....			
576	Nov.	1	06 33 53	48 54	123 55	II	06 34 02·0	06 34 04·5	06 34 05·3	57	73	77	South central Vancouver Island.
577	Nov.	2	.....	.....	.....	II	01 52 00·9	.....	.....	102			
578	Nov.	2	.....	.....	.....	II	07 44 05·5	07 43 54·1	07 43 40·1			155	Victoria P very weak. Probably off west coast.
579	Nov.	2	.....	.....	.....	II	.....	.....	23 54 29·7			80	
580	Nov.	3	.....	48·4	123·0	III	05 35 26·0	05 35 38·5	05 35 46·2	40	115	200	South of Gulf Islands.
581	Nov.	4	.....	.....	.....	II	10 54 40·0	10 54 53·2	.....	70	162		Probably in Puget Sound area.
582	Nov.	6	.....	.....	.....	I	01 29 17·3	.....	.....	15			
583	Nov.	6	.....	49·3	122·3	II	16 39 48·7	16 39 39·2	.....	115	60		Victoria record weak. Epicentre probably between Pitt Lake and Stave Lake.
584	Nov.	8	02 52 29	48 40	123 11	III	02 52 31·7	02 52 40·6	02 52 49·8	16	87	135	Gulf Islands area.
585	Nov.	9	.....	.....	.....	II	00 20 52·4	00 21 10·8	00 21 13·4	92			Records are weak, except for Victoria.
586	Nov.	9	.....	.....	.....	I	23 56 36·1	.....	.....	19			
587	Nov.	11	.....	.....	.....	III+	22 15 31·2	.....	22 15 44·0	174		270	Seattle 22:15:43. Felt at Raymond, Wash. Seattle reading probably S.
588	Nov.	12	.....	49·4	122·8	II+	21 59 54·6	21 59 42·4	22 00 00·7	114	39	152	Directly east of Horseshoe Bay.
589	Nov.	12	.....	48 18	123 33	III	23 31 17·4	23 31 32·3	23 31 35·7	30	125	144	Southwest of Victoria.
590	Nov.	13	.....	.....	.....	II	08 25 42·9	08 26 10·2	.....	.....			
591	Nov.	20	.....	48 51	123 15	III	10 13 08·5	10 13 07·2	10 13 21·0	41	58	124	Gulf Islands area.
592	Nov.	26	.....	.....	.....	I	20 30 49·1	.....	.....	35			Very close to Victoria.
593	Nov.	29	.....	49·2	122·4	II	14 48 24·6	14 48 18·8	.....	94	71		Probably south of Stave Lake.
594	Nov.	30	.....	.....	.....	II	02 23 17·7	.....	.....	107			
595	Nov.	30	.....	.....	.....	II	03 38 22·3	.....	.....	38			
596	Dec.	1	.....	48·6	121·9	II	22 54 47·7	22 54 50·6	.....	125			East of Bellingham.
597	Dec.	2	.....	.....	.....	I	08 24 03·8	.....	.....	80			
598	Dec.	2	.....	43·5	125	III	09 06 12·1	09 06 23·8	.....	.....			Off coast of Oregon.

TABLE II—1954 EARTHQUAKES—*Concluded*

No.	Date	Origin Time GMT	Lat. N.	Long. W.	Intensity	Arrival Times of P-Phase, GMT			Distance			Remarks
						Victoria	Horseshoe Bay	Alberni	V	HB	A	
			° ′	° ′			h m s	h m s		kms		
599	Dec. 2	.....	48·6	121·8	II	22 50 54·1	22 50 56·0	.....	.....			East of Bellingham.
600	Dec. 3	.....	.....	.....	III	02 18 16·5	02 18 26·1	.....	.....			Probably same area as No. 601 below.
601	Dec. 3	08 46 02	44	127	IV+	08 47 26·0	08 47 35·9	08 47 31·7	.....			Off coast of Oregon.
602	Dec. 3	19 09 02	67·5	136	.....	.....	.....	.....	.....			Yukon (not recorded).
603	Dec. 5	.....	49·6	124·8	I	.....	00 01 43·8	00 01 23·8		116	55	Not very reliable epicentre.
604	Dec. 5	.....	.....	.....	I	.....	01 49 33·3	01 49 30·9		67	33	Probably northwest of Nanaimo.
605	Dec. 7	.....	49·8	123·9	I	.....	22 08 04·2	22 08 09·6		62		Jervis Inlet area.
606	Dec. 8	.....	48 39	123 07	II	18 39 58·4	18 40 07·1	18 40 16·8	27	84	105	Gulf Islands area.
607	Dec. 11	.....	.....	.....	I	10 37 52·7	10 38 00·8	.....	.....			
608	Dec. 11	.....	.....	.....	I	10 58 47·7	10 59 02·3	.....	.....			
609	Dec. 11	.....	.....	.....	I	11 00 53·2	11 01 09·9	.....	.....			
610	Dec. 11	.....	.....	.....	I	11 11 04·5	.....	.....	.....			
611	Dec. 11	.....	.....	.....	I	11 42 01·9	.....	.....	.....			
612	Dec. 11	.....	.....	.....	I	12 01 21·3	12 02 28·5	.....	.....			
613	Dec. 11	.....	.....	.....	I	12 15 02·7	12 15 11·0	.....	.....			
614	Dec. 11	.....	.....	.....	I	12 27 43·5	12 27 51·1	.....	.....			
615	Dec. 11	.....	.....	.....	I	13 06 36·4	13 06 30·8	.....	.....			
616	Dec. 11	.....	.....	.....	I	13 08 10·9	13 08 17·3	.....	.....			
617	Dec. 11	.....	.....	.....	II	16 05 13·8	16 06 21·7	.....	.....			
618	Dec. 13	.....	.....	.....	II	00 31 08·0	00 31 17·5	.....	40			
619	Dec. 17	.....	.....	.....	II	12 03 46·7	12 04 02·9	12 04 00·4	.....			Probably south in Washington, very weak.
620	Dec. 20	.....	.....	.....	I	12 36 52·8	12 37 08·5	.....	.....			Very small.
621	Dec. 21	.....	.....	.....	.....	.....	18 00 52·5	18 01 08·9		62	172	
622	Dec. 25	.....	48	128	III	01 32 30·1	S-P = 43s.6	01 32 16·4	372	438	310	Off west coast.

triangle but close to any one station are not precisely located, and in these cases the epicentral co-ordinates are given only to 0·1 minute of arc. Epicentres termed "off the west coast" fall into this category as well.

In a few cases, co-ordinates have been given for epicentres where only two stations have recorded the disturbance and no trace of the earthquake can be found on the record of the third station. From the records of two seismograph stations only, there are two possible epicentres for one event. Of the two, that epicentre more distant from the third station, at which no disturbance was recorded, is listed as the true origin.

Seattle readings, supplied by Professor Neumann in his regular bulletin, are often combined with data from the stations of the southwest British Columbia network to obtain an epicentre. Hungry Horse readings, supplied directly through the co-operation of the United States Coast and Geodetic Survey and the Bureau of Reclamation, are used to supplement the readings of the Crowsnest Pass stations. Dr. Nile at Butte frequently contributes his readings for stronger tremors. Provision of these data, which make epicentral determinations possible, is greatly appreciated.

Table II lists all the earthquakes recorded on the southwestern British Columbia network during 1954. The co-ordinates of the epicentres that have been located are shown in detail on a map of the area. Table III lists those few tremors recorded at the Crowsnest Pass stations. In no instance were the stations well enough placed with respect to the tremors to permit epicentral determinations.

The values of intensity given in Table II are only approximate. They are intended to follow as closely as possible the Modified Mercalli Intensity Scale of 1931, given here as Table III. For the earthquakes that are felt, the value of intensity given is reliable. For those earthquakes that have a magnitude listed on the epicentre card, the intensity at the origin can be determined. For all other earthquakes, the intensities are estimated by comparing the amplitudes recorded on the Benioff seismograms with those recorded for earthquakes that have been felt. Personal observation indicates that such estimated intensities tend to be too low.

TABLE III

MODIFIED MERCALLI INTENSITY SCALE[5]

(Abridged)

I Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel Scale)

II Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale)

III Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing truck. Duration estimated. (III Rossi-Forel Scale)

IV During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. (IV to V Rossi-Forel Scale)

V Felt by nearly everyone; many awakened. Some dishes, windows, etc. broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale)

VI Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale)

VII Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars. (VIII Rossi-Forel Scale)

VIII Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbs persons driving motor cars. (VIII+ to IX Rossi-Forel Scale)

IX Damage considerable in specially designed structures; well designed frame structures thrown out of plumb: great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale)

X Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale)

XI Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

DETAILS OF PARTICULAR EARTHQUAKES

Princeton, April 15, 1954

An earthquake, strong enough to have been recorded as far distant as Butte, Montana, was centred south of Princeton, British Columbia, on April 15. There were no reports that the earthquake was felt, probably because the area is sparsely settled. The epicentre reported in Table II has been computed from the Butte, Hungry Horse, and Seattle readings together with those of the Canadian stations. Its intensity is listed as IV.

Victoria, May 15, 1954

A few residents of Victoria and surrounding municipalities felt an earthquake at 5:02 a.m. PST on May 15th. The maximum intensity felt at Victoria was estimated at II. No damage was reported. There is no indication that the tremor was felt on the mainland

[5] H. O. Wood and F. Neumann, "Modified Mercalli Intensity Scale of 1931", *Bull. Seism. Soc. Am.*, 21, 277-283.

south of Vancouver. Professor Frank Neumann, of the University of Washington, in a letter places the epicentre in the Vashon Island area southwest of Seattle. His estimate of the focal depth is 50 to 60 km.

Victoria, September 24, 1954

One person in Victoria felt a very slight earthquake in the city at 12:50 p.m. PST on September 24th. It is likely that this corresponds to earthquake number 588 of Table II. The epicentre is probably under the Strait of Juan de Fuca, southwest of Victoria. On the following day, one very slight shock was felt at Alberni at 14:02 p.m. PST.

Crowsnest

The local earthquakes recorded at Coleman and Fernie for the last few months of 1954 are listed in Table IV. Prior to September the instruments were running at a reduced sensitivity, and part of the time they were not operating due to mechanical difficulties. The few earthquakes that occurred during the period are all very small, probably of the order of II or III on the intensity scale. The epicentres lie a few miles either northwest or southeast of Coleman; quite close to the high ridge of the Rocky Mountain range. A few were strong enough to have been recorded on the Benioff seismographs at Hungry Horse.

TABLE IV

CROWSNEST EARTHQUAKES

Date	Time (GMT)			Station	Distance	Remarks
	h	m	s		kms	
Sept. 9	18	07		Coleman	220	Possibly northwest of Coleman
Sept. 10	20	28·8		Coleman	40	
Sept. 24	07	30	35	Coleman	27	Hungry Horse 07:30:54; epicentre north of Coleman
Sept. 24	23	02	13	Coleman	15	Hungry Horse 23:02:40; epicentre south of Coleman
Sept. 28	20	19	49	Coleman	31	Epicentre near Fernie?
Oct. 20	13	41	16	Coleman	9	
Oct. 21	00	16	54	Coleman	8	
Oct. 29	05	22	52	Coleman	31	Hungry Horse 05:23:16; epicentre north of Coleman
Nov. 4	21	38	34	Coleman	31	Fernie, distance 40 km; epicentre northwest of Coleman
Nov. 20	22	19	17	Coleman	19	Hungry Horse, distance 106 km.

Off the West Coast

In reports on earthquakes in British Columbia many of the epicentres are placed "off the west coast". Some of these epicentres are just a few kilometers west of Vancouver Island at approximately 126°W and 49°N. There are also many more, and apparently stronger tremors around the area at 130°W and 49°N. Many of these are reported on the United States Coast and Geodetic Survey epicentre cards. For the years these reports have been published the general trend of such epicentres is along a line striking some 40°

west of north. It appears that this line of epicentres is in itself a zone of activity quite separate from those epicentres near Vancouver Island. Projected to the south this line passes near the many epicentres off the coast of northern California, and projected to the north it passes through the origin of many of the strong tremors associated with the Queen Charlotte Islands.

DISCUSSION OF EPICENTRES

The earthquake epicentres for 1954 seem to fall within the regions where activity has been reported for the previous three years. One of the most striking features appears on the map on which the epicentres for the four years have been plotted. A line of origins extends from Nanaimo slightly southeast to the Strait of Juan de Fuca. Although this line is well defined, it is not in agreement with the direction of faulting in the area, as indicated on the diagram.

Again the Gulf Islands area is very active, but for small shocks only, during 1954. A few of the epicentres are scattered into the Gulf of Georgia whereas in the past they were all very near the Islands. These two regions make up the area into which the majority of epicentres listed in this report fall.

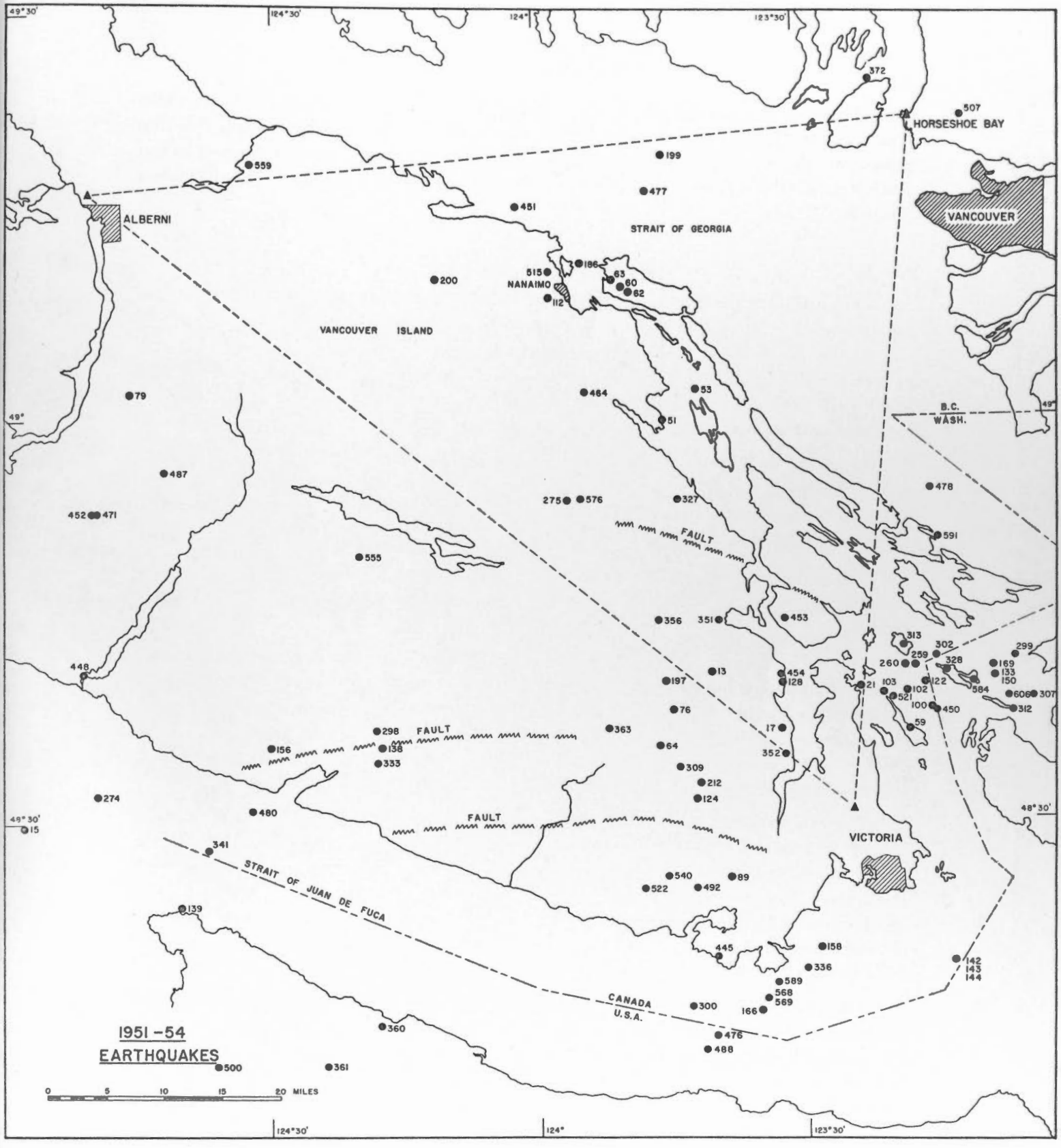
The three seismographs have recorded several shocks whose origins are under the Olympic Mountain range, an area of very rugged peaks some 40 miles south of the Victoria station.

Off the west coast of Vancouver Island, two lines of epicentres seem well marked. Three tremors were recorded off Barkley Sound, in an area which was the epicentre of a strong tremor in 1918. Two epicentres lie in the general area of the June 23, 1946 tremor in the north Gulf of Georgia, the first to be recorded in that area since that date. The absence of shocks for the years 1951-1953 is surprising for the 1946 tremor was very strong and its aftershocks could be expected to continue for many years.

The Powell River-Jervis Inlet area again has been the origin of a number of small tremors. Several small earthquakes have origins in the mountains lying north of the Fraser River and extending from the coast to the Fraser Canyon. The Abbotsford-Huntington area was active in 1954, but the tremors are smaller than in the past. One shock south of Princeton, although the first recorded from that region since this network of seismographs was installed in 1951, is in an area which was believed to have been active early in the century.

The number of earthquakes recorded during 1954 is consistent with the results of the previous three years. The intensities seem to be less for those tremors based within the populated area of the province. Again, the strongest earthquakes are those some distance off the west coast. No tremors were felt generally over any considerable area, although the one earthquake of May 15th was reported as being felt by many persons in Victoria.

Dominion Astrophysical Observatory,
Victoria, B.C.,
May 26, 1955.


49°30'
124°30'
124°
123°30'
372
307
HORSESHOE BAY
199
559
477
451
ALBERNI
STRAIT OF GEORGIA
VANCOUVER
186
515
NANAIMO
63
60
62
200
112
VANCOUVER ISLAND
79
464
53
49°
51
B.C.
WASH.
49°
487
478
275
576
327
452
471
FAULT
591
555
356
351
453
313
302
299
448
259
328
260
169
133
150
13
454
128
197
21
103
102
122
584
606
307
521
100
450
312
76
59
298
FAULT
363
17
156
138
64
352
333
309
212
124
274
480
49°30'
15
FAULT
48°30'
VICTORIA
341
STRAIT OF JUAN DE FUCA
540
89
522
492
139
445
158
336
142
143
144
589
568
569
CANADA
U.S.A.
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166
360
476
488
1951 - 54
EARTHQUAKES
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0 5 10 15 20 MILES
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124°
123°30'


1867 Centennial of Canadian Confederation 1967
Le Centenaire de la Confédération Canadienne