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## OTTAWA

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# Canadian West Coast Earthquakes, 1951

BY

W. G. Milne and F. Lombardo

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## 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: (V) | August 1st to December 31st inclusive<br>$\varphi$ = 48° 31′ 14″ N.<br>$\lambda$ = 123° 24′ 56″ W.<br>Benioff short-period vertical seismograph. |
| Horseshoe Bay: (HB) | August 6th to December 31st inclusive<br>$\varphi$ = 49° 22′ 39″ N.<br>$\lambda$ = 123° 16′ 33″ W.<br>Willmore-Sharpe north-south, east-west, and vertical component short-period seismographs. |
| Alberni: (A) | August 11th to December 31st inclusive<br>$\varphi$ = 49° 16′ 14″ N.<br>$\lambda$ = 124° 49′ 18″ W.<br>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)[2]. 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.

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

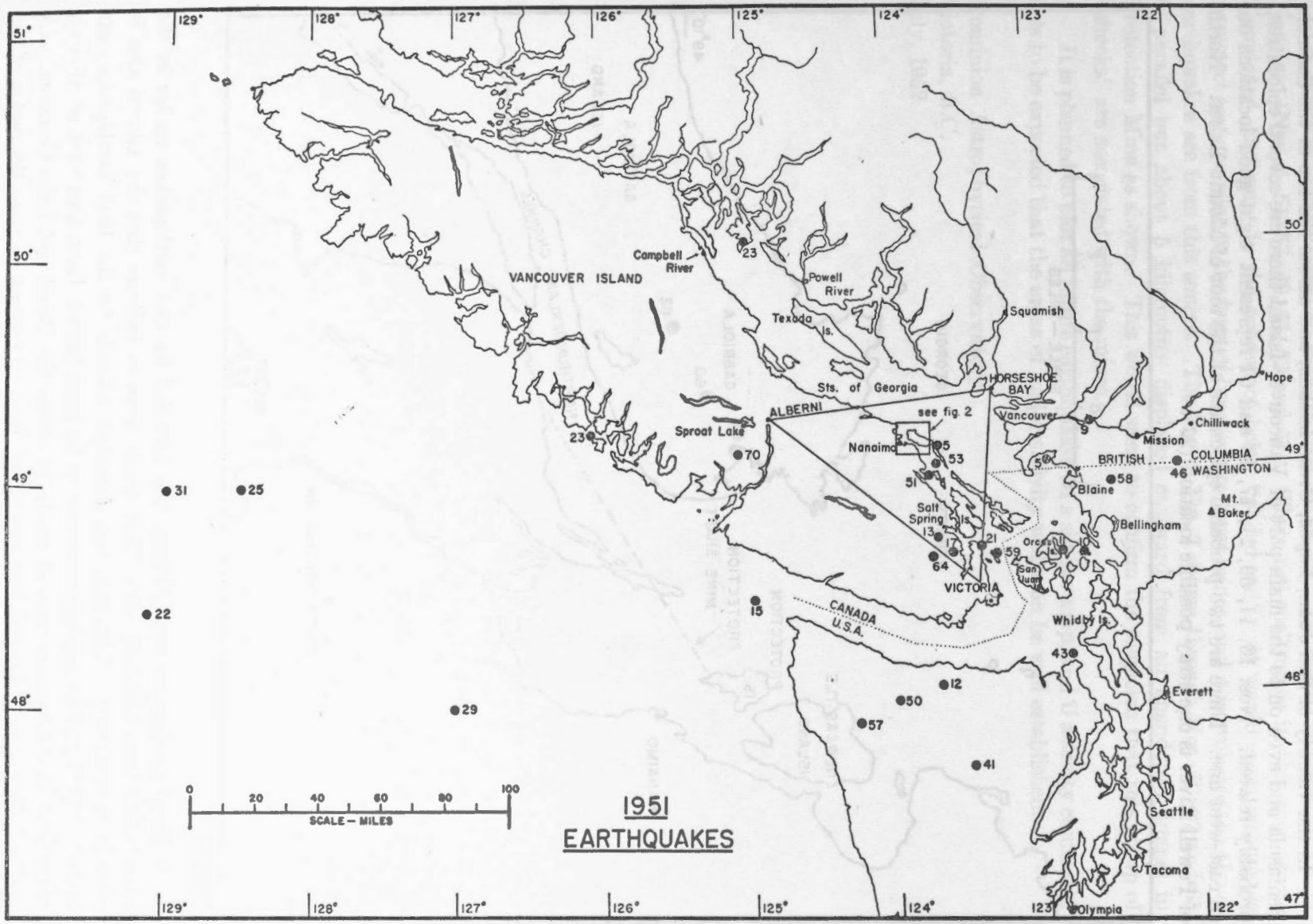
1951
EARTHQUAKES
SCALE – MILES
0 20 40 60 80 100
VANCOUVER ISLAND
Campbell River
Powell River
Texada Is.
Sts. of Georgia
ALBERNI
Sproat Lake
see fig. 2
Nanaimo
Squamish
HORSESHOE BAY
Vancouver
Hope
Chilliwack
Mission
BRITISH COLUMBIA
WASHINGTON
Blaine
Mt. Baker
Bellingham
Salt Spring Is.
Orcas Is.
San Juan
VICTORIA
CANADA
U.S.A.
Whidbey Is.
Everett
Seattle
Tacoma
Olympia
129°
128°
127°
126°
125°
124°
123°
122°
51°
50°
49°
48°
47°

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).

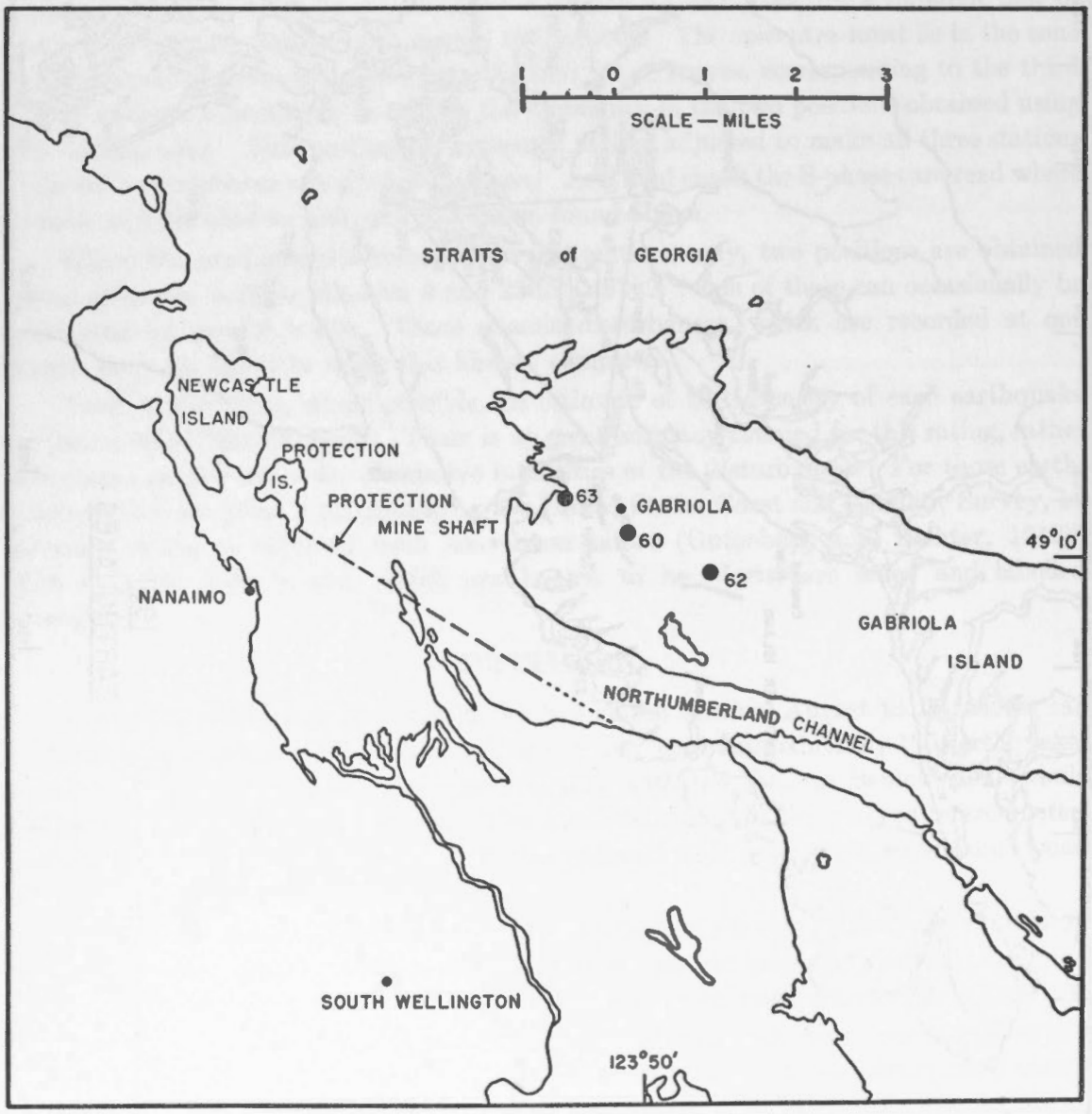


FIGURE 2

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