SEISMOLOGY REPORT

on

**Washington, Idaho, Northern Oregon
and Western Montana**

and the

Hanford Area, Washington

to

Douglas United Nuclear, Inc.

Richland, Washington

May 3, 1966

by

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General Discussion of Seismicity of Washington State, the Hanford Area and Related Tectonics

There has been a noticeable lack of investigation of earthquakes, magnitude determination, earthquake mechanisms and related tectonics, in the state of Washington, including the development of reliable local travel time curves. Most epicenters and depth estimates of earthquakes in Washington, since 1952, have been obtained with theoretical travel-time curves. The closure from the recording seismograph stations in Washington (usually five or six stations) is quite good for epicenter location, however proper depth of these shocks are questionable.

Two exceptions must be mentioned; the April 13, 1949, and the April 29, 1965, Puget Sound earthquakes. The focal depth of the April 29, 1965, Seattle shock was approximately 60 km. The focal depth of the April 13, 1949, Olympia-Tacoma shock was of the same depth.

The shocks of lesser magnitude in Washington appear to have a focal depth between 10 and 40 km, as a general rule. It therefore suggests that the larger shocks originate deeper, giving a more moderate surface intensity than quakes of comparable magnitude in southern California (Algermissen, 1964).

One item to keep in mind is the thick section of poorly consolidated sediments in western Washington, especially in the Puget Sound area, when relating magnitude to intensity. In eastern Washington (i.e., Hanford area) there is a thinner section of unconsolidated material resting on the Columbia River Basalts, thus giving a more rigid surface layer and therefore being more comparable to southern California in relating magnitude to expected intensity. A complete list of all shocks of approximately magnitude 5 or greater or intensity 6 or greater, is shown in table I. A list of all earthquakes in the general Hanford area are listed in table II. The word intensity bound in this report has reference to the MM intensity scale, as

explained in appendix I. The earthquakes listed in table I are plotted on a map of the Northwestern States (fig. 1). This map shows the MM intensity, which is how the majority of shocks, in these states, were rated, prior to 1964. Some relatively larger shocks, prior to 1964 and almost all shocks thereafter, are rated both as to intensity and magnitude. A map of all magnitude determined earthquakes are plotted on fig. 2. The town of Richland is plotted on fig. 1 and fig. 2. The Hanford facilities are just to the north of Richland.

In the Hanford area there is a definite lack of noticeable seismic activity, except for two shocks, (1893, March 6 and 1936, July 16), both of intensity VII. It appears that the Hanford area has experienced a few small shocks, but only rarely a moderate shock, in the last one hundred years. There is no mention of a large earthquake anywhere in the area, comparable to a magnitude 6.5 - 7.1 (table II) (fig. 1), making the area appear much less seismically active than southern California, since at least 1865.

Because of the lack of detailed data on the geologic structure, below the Tertiary volcanics, related to major tectonic features at the surface, the conclusion as to seismic risk is derived from seismic evidence alone. Any information, geophysical (other than seismic) or geological, should be viewed as entirely additional information to substantiate or alter the following view.

It is therefore concluded that, pending a comprehensive, geophysical and geologic survey which may alter one's views, the area between longitude 114° W and 121° W is one of moderate seismicity in Washington, Oregon, Idaho, and Montana.

In the past there have been seismically inactive areas where devastating earthquakes have occurred. (Charleston, South Carolina, 1886; The Grand Bank in the north Atlantic, 1929; Baffin Bay, 1933; southwest Brazil, 1955). However, while the exception is always present, conclusions can only be

obtained by examining the factual data available as an entity in itself. With this procedure, the only conclusion is that since there has not been a shock of magnitude greater than 5.8 or MM intensity greater than VII in the Hanford-Richland area in the last one hundred years, there is no reason to believe there will be experienced any shocks greater than that in the next 50 to 100 years.

TABLE I

The summary of all earthquakes of magnitude 4.8 or greater, or of intensity VI or greater, having occurred in Washington, northern Oregon (north of 45° latitude), Idaho, and western Montana (west of 111° longitude), between 1865 through 1965.

Year	Day	Latitude N.	Longitude W.	Intensity	Magnitude
1865	Aug. 25	48.5	123.5	6	
1869	May 22	46.6	112.0	6	
1871	May 19	46.7	122.1	6	
1872	Dec. 11	46.4	112.5	6	
1872	Dec. 11	48.5	123.4	6	
1872	Dec. 14 or 16	47.7	123.0	6	
1877	Oct. 12	45.8	123.5	8	
1880	Dec. 12	47.5	122.5	6	
1891	Nov. 29	48.0	123.5	6	
1892	Feb. 4	45.6	122.8	6	
1892	Apr. 17	47.0	123.0	6	
1893	Mar. 6	46.0	119.0	7	
1895	Apr. 16	48.0	123.0	6	
1896	Jan. 4	48.4	123.5	6	
1896	Feb. 7	48.3	124.3	6	
1896	Apr. 2	45.3	123.3	6	
1897	Nov. 4	45.0	113.0	6	
1905	Nov. 11	42.9	114.5	7	
1908	Dec. 21	45.2	111.8	6	
1909	Jan. 11	49.0	122.7	7	
1915	Aug. 18	49.0	120.4	6	
1916	May 13	43.7	116.2	7	

<u>Year</u>	<u>Day</u>	<u>Latitude N</u>	<u>Longitude W</u>	<u>Intensity</u>	<u>Magnitude</u>
1918	Nov. 1	46.7	119.5	6	
1920	Jan. 24	49.0	122.7	7	
1925	June 28	46.0	111.2	8	
1925	July 10	46.0	111.2	6	
1926	Dec. 30 or 31	47.8	120.1	6	
1928	Feb. 3	47.8	121.7	6	
1930	Mar. 16	46.5	112.0	6	
1930	July 19	45.0	123.2	6	
1931	Apr. 18	48.7	122.2	6	
1931	Dec. 31	47.5	123.0	6	
1932	Aug. 6	47.7	122.3	6	
1935	Oct. 7	47.0	111.9	6	
1935	Oct. 12	46.6	112.0	7	
1935	Oct. 19	46.6	112.0	8	
1935	Oct. 27	46.6	112.0	6	
1935	Oct. 31	46.6	112.0	8	
1935	Nov. 22	46.6	112.0	6	
1935	Nov. 28	46.6	112.0	6	
1936	Feb. 13	46.6	112.0	6	
1936	June 12	46.6	112.0	6	
1936	July 16	46.0	118.3	7	5.8
1939	May 12	46.0	111.5	6	
1939	Nov. 13	47.2	123.0	7	5.8
1941	Apr. 7	48.3	119.6	6	
1941	Dec. 29	45.5	122.7	6	
1942	June 12	47.5	121.6	6	
1942	Nov. 1	48.0	116.7	6	

Year	Day	Latitude N	Longitude W	Intensity	Magnitude
1943	Nov. 29	48.4	122.9	6	
1944	July 12	44.7	115.2	7	
1945	Jan. 28	48.2	122.4	6	
1945	Feb. 14	44.6	115.4	6	
1945	Apr. 29	47.4	121.7	7	
1945	Apr. 30	47.4	121.7	6	
1945	Sept. 23	48.0	114.2	6	
1945	Nov. 12	48.1	121.3	6	
1946	Feb. 15	47.3	122.7	7	5.8
1946	Feb. 15	47.4	122.2	6	
1946	Feb. 23	47.5	123.0	6	
1946	Dec. 11	48.4	114.4	6	
1947	Mar. 14	47.2	113.5	6	
1947	Nov. 23	44.8	112.0	8	
1948	Jan. 13	47.8	120.3	6	
1949	Apr. 13	47.1	122.7	8	7.1
1950	Apr. 14	48.0	122.5	6	
1950	Aug. 20	47.2	113.5	6	
1951	Oct. 9	48.1	122.7	6	
1952	Apr. 1	48.0	113.8	7	
1952	Apr. 22	46.2	111.4	6	
1953	Aug. 8	46.2	111.4	6	
1953	Dec. 16	45.5	122.7	6	
1954	Mar. 16	47.4	122.1	6	
1954	May 15	47.4	122.3	6	
1955	Mar. 26	48.1	122.0	6	
1957	Jan. 26	48.2	122.5	6	

Year	Day	Latitude N	Longitude W	Intensity	Magnitude
1957	Feb. 11	47.5	121.7	6	.
1957	Nov. 17	45.3	123.8	6	— — —
1957	Dec. 18	47.4	116.0	6	
1958	Apr. 12	48.0	122.2	6	
1958	May 28	46.5	113.0	6	
1958	Oct. 7	46.6	124.0	6	
1959	Aug. 6	47.7	120.0	6	
1959	Aug. 18	44.6	111.1	8+	7.1
1959	Aug. 18	six aftershocks		7	all between 5.5-6.4
1959	Aug. 19	two aftershocks		6	5 and 6
1959	Aug. 23	two aftershocks		6 and 7	
1959	Sept. 14	aftershock		6	
1960	Jan. 7	46.7	122.7	6	
1960	Apr. 11	47.6	122.3	6	
1960	Sept. 10	47.7	123.2	6	
1961	Sept. 16	46.0	122.2	6	
1961	Sept. 17	46.0	122.2	6	
1961	Nov. 7	45.7	122.9	6	
1962	Jan. 15	47.8	120.2	6	
1962	Nov. 6	45.6	122.7	7	4.8
1962	Dec. 31	47.0	122.0	6	
1963	Jan. 24	47.4	122.6	6	
1963	Jan. 27	44.4	114.6	6	
1963	Sept. 11	44.4	114.7	6	4.9
1964	July 14	48.9	122.5	6	5.0
1964	Oct. 1	45.7	122.8	5	5.3
1964	Oct. 21	44.8	111.6	5	5.8
1965	Jan. 6	44.9	112.7	6	5.1

<u>Year</u>	<u>Day</u>	<u>Latitude N</u>	<u>Longitude W</u>	<u>Intensity</u>	<u>Magnitude</u>
1965	Apr. 29	47.4	122.3	8	7.0
1965	Oct. 8	44.8	111.0	6	5.0
1965	Oct. 23	47.5	122.4	6	4.8

Table II

A summary of all felt earthquakes recorded in the general Hanford area (between latitude 45 and 47.5 N, and longitude 117 and 121 W), between 1865 through 1965.

Year	Day	Latitude N	Longitude W	Intensity	Magnitude
1866	Nov. 30	45.5	121.1	felt	
1866	Dec. 7	45.5	121.1	felt	
1872	Jan. 4	46.0	118.3	felt	
1874	Jan. 17	46.6	120.5	felt	
1875	May 6	46.6	120.5	felt	
1893	Mar. 6	46.0	119.0	7	
1893	Mar. 10	45.9	119.3	felt	
1893	July 7	47.4	120.3	felt	
1915	Jan. 17 and 19	45.4	118.1	3 and 3	
1918	Feb. 28	46.5	120.5	5	
1918	Nov. 1	46.7	119.5	6	
1922	Oct. 16	45.8	119.4	3	
1922	Dec. 12	45.7	118.7	3	
1924	Jan. 6	46.1	118.7	5	
1924	May 27	46.1	118.7	4	
1926	Apr. 11	46.1	118.7	3	
1926	Apr. 23	46.1	118.7	4	
1927	Jan. 4	47.6	120.6	4	
1930	Sept. 3	47.3	117.8	felt	
1934	Sept. 14	47.0	120.5	four felt	
1934	through	47.0	120.5	five at 4	
1934	Dec. 2	47.0	120.5	seven at 5	
1935	Oct. 24	47.0	112.5	felt	

Year	Day	Latitude N	Longitude W	Intensity	Magnitude
1936	July 16	46.0	118.3	7	5.8
1936	July 16	aftershocks		three at 5	
1937	Sept. 20			six felt	
1938	May 9	46.0	118.3	felt	
1938	May 24	46.0	118.3	felt	
1939	Jan. 26	45.7	118.7	4	
1940	Jan. 5	47.4	119.6	felt	
1941	Jan. 3	46.7	117.3	felt	
1943	Apr. 14	46.4	117.1	felt	
1944	Jan. 9	46.6	120.5	felt	
1944	Sept. 1	46.0	118.3	4	
1945	Sept. 23	46.0	118.3	4	
1948	Aug. 28	47.8	117.5	4	
1948	Dec. 20	45.0	120.2	4	
1949	Feb. 6	46.4	120.5	3	
1949	Apr. 14	46.7	117.2	felt	
1950	June 25	47.5	117.5	4	
1951	Jan. 7	45.9	119.2	5	
1952	Mar. 4	47.7	117.4	felt	
1959	Jan. 21	46.0	118.3	4	
1959	Nov. 9	45.4	119.6	4	
1961	May 22	47.6	120.2	4	

While there have been weaker earthquakes in the area, their locations are not verified due to lack of seismic stations to record these very low magnitude events.

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MODIFIED MERCALLI INTENSITY SCALE OF 1931

(abridged)

- I. Not felt except by a very few under especially favorable circumstances.
- II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
- 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 of truck. Duration estimated.
- IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
- V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles and other tall objects sometimes noticed. Pendulum clocks may stop.
- VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
- 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. 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. Disturbed persons driving motor cars.
- 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.
- 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.
- 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.

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