

OCCURRENCE OF MICROEARTHQUAKES

by

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The U.S. Geological Survey has operated a network of short-period seismograph stations within and around the Hanford Reservation of the Atomic Energy Commission since March 23, 1969. The data from 7 vertical seismometers (6 before August 9, 1969) are telemetered to Menlo Park, California, where they are recorded on film. Earthquake epicenters are determined by computer.

The network was established to determine the level of micro-earthquake activity in the vicinity of the Hanford Reservation. Within the network, microearthquakes with magnitudes as low as 0 can be located when the background noise level is low. At 200 km, the practical limit at which epicenters can be determined by the network, microearthquakes of magnitude 2 or greater can usually be located. The accuracy of epicenter determination is greatest for microearthquakes occurring within the network and decreases rapidly as the distance of the microearthquake from the network increases.

Epicenters for 166 seismic events were located for the period from March 23 to December 31, 1969 (figure 25 and table 2). Approximately

Figure 25 is at the end of the report.

one-fourth of these are thought to be explosions rather than microearthquakes. Most of the explosions occurred 80 km west, 200 km north, and between 80 and 150 km east of the center of the network. Approximately 105 microearthquakes were located within 75 km of the center of the network, as were some explosions (table 2 and fig. 4).

Table 2 belongs near here.

Most of the microearthquakes in the immediate vicinity of the Hanford Reservation occurred in two separate zones. One very restricted zone, near the center of the triangle formed by stations B, E, and G, produced over 230 detectable events, 36 of which have been located. These micro-earthquakes generally have the most precisely determined epicenters of any in the region because of the advantageous distribution of stations. Activity in this zone began in May, increased to a peak in August, and continued at a reduced level until the end of 1969. The second active zone near the Hanford Reservation extends from a point between stations O and E in a northwest direction to the vicinity of station S. Approximately 500 detectable microearthquakes occurred in this area with most of them concentrated at the two ends of the zone. Seismic activity fluctuated along this zone, reaching peaks at the east end in April and November, the west end in May, and the center in October. A small amount of additional seismic activity on the Hanford Reservation occurred along a north-trending zone between stations M and G. All of the microearthquakes detected on or near the Hanford Reservation had Richter magnitudes below 2.0, which is generally below the threshold of (noninstrumental) human perception.

TABLE 2. -- Located microearthquakes and other seismic events in
south-central Washington, March 23-December 31, 1969.

Note: The numbers in this table are reproduced from the computer output where values for origin time, latitude, longitude, and magnitude are computed to two decimal places. These values have no meaning beyond one decimal place. Relative evaluation is based upon the quality of P and S arrivals, the distribution of stations, the number of stations available, and the P-arrival time residuals at the stations used to determine the epicenter. The letters indicate the following maximum probable epicentral errors: A-1 km, B-3 km, C-5 km, D-10 km, E-15 km, F-25 km. **Origin time is given in Greenwich Mean Time (GMT).**

-	Date	Origin Time(GMT)	Latitude	Longitude	Richter	Relative	Remarks	
					hr min sec	°	°	Evaluation
1	0324	2232 19.54	46.34.82	118.55.43	-0.01	D		
2	25	1911 52.25	47.41.64	120.19.18	1.29	F		
3	26	2232 7.29	47. 7.78	118.58.52	1.45	E		
4	27	4 3 1.71	48.16.81	119.16.21	1.98	F		
5	27	2240 47.42	46.36.10	119.10.08	-0.14	D		
6	31	1715 18.90	46.39.19	119. 6.29	0.89	C		
7	0401	311 17.15	47.59.51	118.50.49	1.96	F		
8	01	419 54.75	46.39.27	119. 6.64	0.83	D		
9	01	20 3 49.38	46.33.38	118.52.63	0.20	E		
10	05	15 5 50.79	47.10.42	119.43.39	1.30	F		
11	06	1515 57.94	46.59.42	119.11.41	0.75	F		
12	08	226 4.28	47. 2.85	119. 3.54	0.96	F		
13	08	649 17.29	47.10.44	119.59.07	1.15	F		
14	08	1115 54.38	47. 1.52	119.34.88	1.01	E		
15	10	112 11.87	46.42.40	117.46.80	1.83	E		
16	11	035 28.98	46.59.08	119. 1.87	0.99	E		
17	12	321 45.04	47. 8.10	119. 2.78	1.10	E		
18	12	1110 29.27	46.59.12	120.27.37	1.39	C		
19	19	546 2.18	45.47.35	119.41.54	2.10	E		
20	20	219 14.13	48.17.50	118.53.59	2.56	F		
21	21	1416 34.34	47.11.94	119.43.23	1.85	E		
22	22	2059 50.60	46.36.06	119. 8.84	1.16	D		
23	24	143 0.91	46.43.62	117.41.96	2.05	E		
24	24	12 3 56.67	47. 9.51	119.41.35	1.29	E		
25	24	12 9 34.78	47.10.92	119.41.83	1.28	E		
26	29	15. 8 0.77	46.36.13	119. 9.45	0.09	D		
27	30	2033 1.71	47. 9.90	119.36.81	1.21	F		
28	30	2143 58.23	46.39.80	119. 6.16	0.57	D		
29	0501	052 36.39	48. 7.84	118.44.84	2.06	F		
30	01	1652 3.15	46.59.10	119.49.20	1.29	E		
31	02	1836 59.79	46.35.93	119. 9.75	0.01	D		
32	04	925 3.82	47. 9.80	119.41.23	1.35	E		
33	05	1835 4.60	46.36.14	119.10.01	0.05	D		
34	05	1926 25.34	48.11.13	118.49.79	1.94	F		
35	06	034 0.83	46.38.44	117.43.94	1.83	F		

TABLE 2. -- continued

Date	Origin Time (GMT)			Latitude	Longitude	Richter Magnitude	Relative Evaluation	Remarks
	hr	min	sec					
36	07	548	37.29	46.49.53	119.20.79	0.52	E	
37	07	2036	20.22	46.25.66	119.37.51	0.21	E	
38	08	1556	21.31	46.36.23	119. 9.65	0.23	D	
39	09	19 6	8.24	47.41.00	119.47.64	2.34	E	
40	10	1441	12.55	46.41.54	117.26.11	2.00	F	
41	10	1937	21.61	46.49.83	119.35.46	1.75	C	explosion?
42	10	1955	34.92	46.49.55	119.36.83	-0.08	D	
43	11	350	11.13	48.11.04	118.58.70	2.23	F	
44	14	2321	47.53	47. 1.73	119.34.41	1.05	E	
45	0517	0 1	28.53	46.39.13	119. 7.77	0.16	D	
46	18	145	41.60	46.49.33	119.38.81	-0.10	D	
47	18	3 0	32.66	46.51.15	119.45.09	-0.14	D	
48	19	1859	24.52	47.49.60	118. 3.40	2.77	E	
49	22	148	1.94	46.44.74	117.33.67	2.09	F	
50	22	933	22.64	46.44.34	119.20.94	0.22	D	
51	23	945	42.31	46.51.57	119.46.22	0.09	D	
52	0601	1216	44.96	46.25.30	119.16.74	0.15	S	
53	03	413	3.06	46.42.79	119.35.47	-0.07	C	
54	06	926	43.24	47. 7.61	119. 5.15	1.06	E	
55	08	9 3	58.91	46.49.22	119.23.62	0.57	D	
56	08	1236	12.26	46.25.24	119.16.17	0.94	R	
57	10	1450	27.30	46.25.37	119.16.42	1.37	E	
58	15	453	36.40	46.25.28	119.16.13	0.27	E	
59	23	5 7	45.03	46.56.55	119.42.25	1.01	D	
60	27	241	20.33	46.25.49	119.16.27	0.72	E	
61	0701	622	38.18	46.25.57	119.16.75	0.54	E	
62	02	2333	21.39	46.35.95	117.55.09	1.73	F	
63	11	2340	45.09	46.35.39	117.58.54	1.76	F	
64	15	430	1.00	46.25.15	119.15.50	1.25	B	
65	15	2354	10.52	46.25.37	119.16.28	1.05	B	
66	18	431	39.68	46.47.45	120.24.95	1.86	D	
67	23	255	14.57	47. 3.01	119.14.62	1.24	E	
68	23	257	38.46	47. 2.68	119.14.71	1.16	E	
69	24	7 8	10.68	47.41.77	120.22.23	1.83	F	
70	24	1013	36.35	46.25.25	119.16.27	0.92	B	
71	28	1555	1.23	47. 3.76	119.12.91	1.23	E	
72	29	1429	24.01	46.19.28	119.32.43	0.12	E	
73	31	614	22.14	46.25.43	119.17.01	1.79	B	
74	31	21 9	45.65	46.25.46	119.16.46	1.25	B	
75	0801	1036	52.83	46.25.33	119.16.29	0.77	B	
76	01	1248	20.17	46.25.58	119.16.25	1.25	B	
77	01	1558	23.83	47.47.17	119.35.68	2.51	F	
78	02	3 4	14.71	47.11.92	117.22.54	2.80	E	
79	02	2141	39.13	46.25.38	119.16.62	1.02	B	
80	04	1531	8.44	47.47.44	119.56.95	2.60	F	
81	05	2339	24.85	46.35.55	118. 3.72	1.88	E	
82	07	1918	27.65	47. 0.65	119.22.54	0.85	E	
83	08	7 5	48.07	47.36.19	119. 8.90	2.03	F	
84	08	17 4	50.62	47.46.41	119.33.96	2.45	F	
85	08	2240	16.99	46.15.06	118. 0.57	1.62	F	
86	11	550	15.64	46.25.49	119.15.73	0.96	B	
87	11	1336	34.92	46.42.32	119.55.46	1.46	D	
88	12	1418	3.09	46.25.47	119.16.06	0.63	B	
89	14	1631	45.27	47.41.26	119.33.90	2.69	E	
90	15	1141	53.75	46.25.47	119.16.31	0.50	B	

TABLE 2. -- continued

			Origin Time (GMT)			Richter Magnitude	Relative Evaluation	Remarks
	Date		hr min sec	Latitude	Longitude			
91	15	1623	4.07	46.25.17	119.16.73	1.51	B	
92	18	1439	18.64	46.48.92	119.28.97	0.33	C	
93	18	1850	57.30	46.25.32	119.16.12	0.53	B	
94	21	148	30.04	46.25.70	119.16.95	0.56	B	
95	22	844	1.46	46.25.37	119.14.91	1.09	B	
96	31	252	28.09	46.25.58	119.16.75	0.22	B	
97	31	1118	7.74	46.25.74	119.16.87	1.59	B	
98	31	1119	31.32	46.25.44	119.17.24	1.48	B	
99	31	1627	32.91	46.16.83	120.53.29	2.14	F	
100	0901	035	47.99	46.25.41	119.16.85	0.47	B	
101	01	2027	43.19	46.25.41	119.16.85	0.20	B	
102	02	0034	10.30	46.25.19	119.16.15	1.07	B	
103	02	1241	52.47	46.25.92	119.16.81	1.21	B	
104	02	2150	30.71	46.41.42	119.35.73	1.61	A	21km deep
105	04	1817	11.31	46.25.53	119.15.53	1.09	B	
106	0906	2228	34.86	46.25.55	119.15.55	1.15	B	
107	10	1214	58.18	46.57.65	119.37.10	1.64	D	
108	12	021	52.36	46.35.40	118.22.84	1.77	E	explosion
109	13	830	46.00	47.47.89	119.23.57	2.37	E	
110	21	1021	21.06	46.25.92	119.16.78	0.47	B	
111	26	1436	6.26	46.42.65	119.34.28	0.04	C	
112	27	1 2	45.42	46.38.30	118. 1.53	2.12	E	explosion
113	1002	059	1.63	46.58.69	118.18.12	1.88	F	
114	02	214	27.50	46.26.01	119.16.35	0.99	B	
115	02	3 0	47.75	46.42.31	119.21.44	0.35	C	
116	02	637	45.20	46.25.87	119.16.35	0.22	B	
117	03	156	50.98	46.41.18	119.14.45	0.61	C	
118	06	1158	5.96	46.25.87	119.17.69	0.62	B	
119	06	12 4	1.30	46.25.59	119.17.55	0.61	B	
120	06	2230	18.09	46.52.55	120.34.59	1.87	E	explosion
121	14	724	57.71	46.40.97	119.15.94	0.79	B	
122	15	834	58.31	47.19.12	122. 5.86	3.12	F	
123	15	1952	58.35	46.49.70	119. 2.90	0.76	D	
124	15	2046	6.80	46.40.79	117.41.67	1.58	F	explosion
125	16	1530	45.90	46.48.91	120.29.83	1.62	E	
126	16	1913	43.33	46.41.47	119.14.52	1.17	B	
127	17	1810	36.40	46.48.78	120.28.62	1.68	E	explosion
128	17	20 8	0.13	46.42.45	117.50.74	1.51	F	explosion
129	19	730	22.37	46.15.55	118.17.27	1.91	D	
130	20	2329	3.17	46.41.84	117.48.46	1.28	E	
131	21	2048	16.11	47.38.51	118.14.14	1.99	F	
132	21	2235	38.72	46.31.56	118. 6.26	1.42	E	explosion
133	23	1741	10.14	46.52.52	120.32.14	1.82	E	explosion
134	23	2348	43.49	46.49.37	120.29.70	1.72	D	explosion
135	24	447	5.24	46.41.12	119.14.01	0.25	C	
136	28	039	46.44	46.50.25	120.30.00	1.90	E	explosion
137	28	416	57.28	46.44.12	119.19.33	0.21	D	
138	28	513	3.17	46.44.32	119.19.86	0.86	C	
139	29	034	36.37	46.50.06	120.31.43	2.04	E	
140	30	1616	35.83	46.48.74	120.31.75	1.89	E	explosion
141	1101	0 0	23.50	46.51.13	120.29.14	1.91	D	explosion
142	01	112	46.82	46.51.89	120.30.62	2.23	E	explosion
143	03	2246	23.52	46.43.54	119.15.68	0.40	D	
144	05	041	27.22	47. 5.92	118. 3.37	2.51	F	
145	05	1940	44.77	46.50.18	120.29.82	1.84	D	explosion

TABLE 2. -- continued

			Origin Time (GMT)		Richter Magnitude	Relative Evaluation	Remarks
	Date	hr min sec	Latitude	Longitude			
146	06	021 30.04	46.48.60	120.29.86	1.81	D	
147	08	1140 20.70	46.43.23	119. 6.28	1.22	C	
148	08	12 2 0.60	46.43.50	119. 6.82	0.53	C	
149	10	056 15.41	46.33.22	119.39.00	0.94	C	
150	10	814 16.49	46.46.20	119. 3.91	0.84	D	
151	10	852 18.52	46.43.48	119. 6.85	0.73	C	
152	10	1859 8.10	46.43.59	119. 7.08	1.34	C	
153	10	19 3 27.03	46.43.87	119. 7.02	0.93	C	
154	18	1817 38.04	46.36.70	119.38.21	0.31	D	
155	21	423 57.88	46.30.42	119.37.36	0.07	D	
156	21	1631 56.04	46.37.29	118.53.06		D	
157	23	" 5 8 31.68	46.42.44	119.22.40	1.18	C	
158	26	1216 25.96	46.37.30	119.38.69	-0.03	D	
159	26	2231 8.73	46.25.60	119.15.65	0.55	B	
160	30	240 41.85	46.38.03	118.43.18	1.22	D	
161	1201	23 1 44.75	46. 8.95	118.35.26	1.41	E	
162	03	2018 48.69	46.46.42	119.45.66	1.49	D	
163	13	1755 57.02	46.40.62	119.13.29	0.58	D	
164	18	2137 59.96	46.41.02	119.13.77	0.35	D	
165	18	2257 39.70	46.41.08	119.13.17	0.93	B	
166	30	141 57.00	46.40.58	119.12.85	0.50	C	

Most of the microearthquakes near the Hanford Reservation appear to be less than 10 km deep although it has generally not been possible to accurately determine their depths. Accurate determination of the depth of focus of an earthquake requires a distribution of stations around the epicenter with at least one station having an epicentral distance less than the depth of focus of the earthquake. These criteria generally are not met for the Hanford events. A few of the better recorded microearthquakes in the main zones of activity appear to have occurred at depths of 5 km or less. Significantly deeper events were microearthquake number 104 with a well determined depth of 21 km and microearthquake number 149 with a depth of around 11 km, both of which occurred along the north-trending zone of minor activity between stations M and G. Other microearthquakes located along this zone were too poorly recorded to make accurate depth determination possible.

A few of the seismic events on or near the Hanford Reservation are explosions rather than microearthquakes, but the great majority within or close to the network have dilatational first motion at one or more stations which precludes their being explosions. Landslides would probably not be mistaken for earthquakes because landslides have a distinctive signal on a seismogram. There is no apparent association between irrigation activity and the seismic activity of the region, and there are microearthquakes occurring on the Hanford Reservation where no irrigation takes place.

The results of the U.S. Geological Survey seismic study indicate that the Hanford Reservation is in a region of microearthquake activity which is moderate by comparison with the microearthquake activity of seismically active regions of California and Nevada where similar monitoring studies have been made. The loci of activity have fluctuated between several zones during the recording period. A longer recording period will better define the areas of microearthquake activity in the Hanford region and the fluctuations of activity with time.