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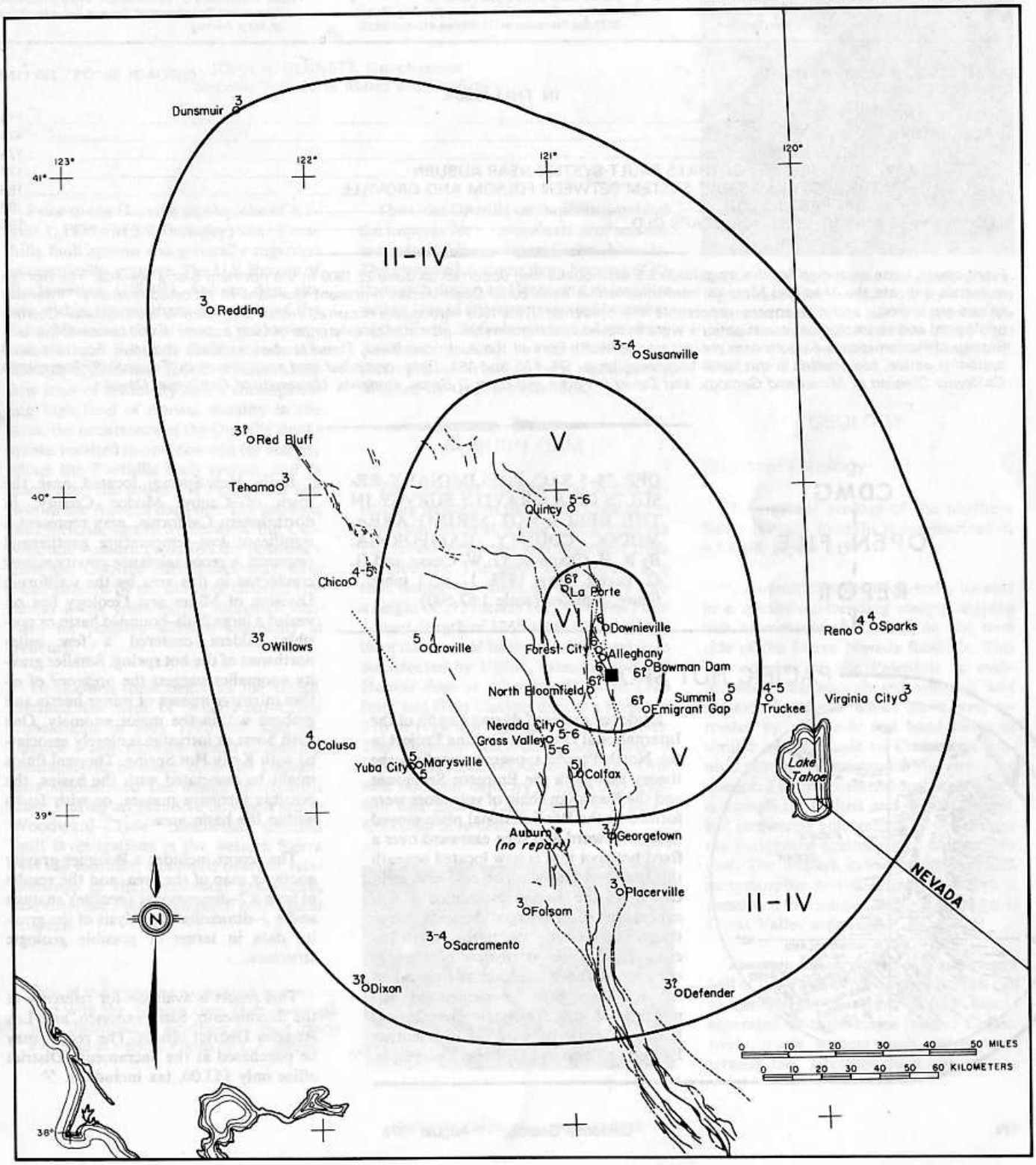
SEISMICITY AND CRUSTAL MOVEMENT — FOOTHILLS FAULT SYSTEM



SEISMICITY OF THE FOOTHILLS FAULT SYSTEM BETWEEN FOLSOM AND OROVILLE, CALIFORNIA

By

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INTRODUCTION

The Foothills fault system, between Folsom and Oroville, is bound on the east by the northward trending Melones fault zone and on the west by the northwestward trending Bear Mountain fault zone. Recent studies have revealed more extensive Late Cenozoic faulting then previously recognized within the northern Sierra Nevada, including portions of the Foothills fault system (Alt and others, 1977; Schwartz and others, 1977). Damaging earthquakes, in the magnitude range 5 to 6, have occurred within this portion of the Foothills fault system in 1975, 10 km south of Oroville, and in 1909 and 1888 about 15 km northeast of Nevada City (figure 1, front cover). This article summarizes evidence from microearthquake surveys, from historical earthquake reports, and from geodetic surveys that the Foothills fault system is active between Oroville and Folsom.

SEISMICITY BETWEEN OROVILLE AND FOLSOM

Bear Mountain Fault Zone

Following the 1975 Oroville earthquake, improved regional seismograph coverage has led to the detection of several magnitude ~ 1.0 microearthquakes along the western or Bear Mountain zone of the Foothills fault system north of Auburn. Between December 1975 and March 1977, seven such events were recorded. Marks and Lindh (1977) located two events southeast of Honcut and one event east of Marysville (figure 1). The northern two events occurred on December 19, 1975 and January 1, 1976, while the southern event occurred on May 3, 1976. Marks and Lindh (1977) also located a magnitude 2.1 earthquake 10 km east of Honcut which occurred on February 13, 1976. Cramer and Sherburne (1977) reported two events near Smartville that occurred on August 21, 1976 and September 2, 1976. Finally Eaton and others (1977) located an event east of Honcut which occurred on February 7, 1977. The hypocentral parameters for these seven events are listed in table 1.

TABLE 1. KNOWN MICROEARTHQUAKE ACTIVITY IN SIERRA FOOTHILLS BETWEEN HONCUT AND FOLSOM FOR THE PERIOD DECEMBER 1975 THROUGH JULY 1977*

Date (yr.mo.day)	*Time (UT) (hr.min.)*	*Lat N*	*Long W*	*Depth*	*Magnitude*
	Bear Mountain Zone				
75 12 19	19 14	39°17.06'	121°29.28'	~18 km	1.3
76 01 01	10 22	39°17.45'	121°29.30'	~18 km	0.7
76 02 13	23 13	39°21.97'	121°22.20'	~ 7 km	2.1
76 05 03	12 16	39°08.25'	121°23.72'	~15 km	1.1
76 08 21	01 31	39°13.82'	121°18.08'	<5 km	0.8
76 09 02	18 00	39°13.64'	121°19.46'	<5 km	1.3
77 02 07	14 49	39°19.83'	121°22.80'	~ 4 km	1.3
	Melones Zone				
76 11 19	05 11	38°54.60'	120°57.14'	~10 km	1.1
77 05 15	18 44	39°16.7'	121°05.3'	~ 9 km	1.1

*Microearthquakes that occurred in the Rocklin pluton are not listed in this table, they are listed in Cramer and others (1977).

Melones Fault Zone

Besides the three damaging earthquakes mentioned in the introduction, other earthquake activity points toward the Melones zone as being active. Cloud (1976) lists felt reports of earthquakes near Nevada City as far back as 1867. Also listed by Cloud are two magnitude ~ 3.0 events instrumentally located along and to the west of the Melones zone. The first occurred about 20 km northeast of Auburn on March 12, 1950, and the second about 15 km southwest of Nevada City on October 5, 1960 (figure 1). Eaton and others, (1977) and Eaton and Conens (1977) detected two magnitude ~ 1.0 events on the Melones zone using a recently installed regional seismograph network. The hypocentral parame-

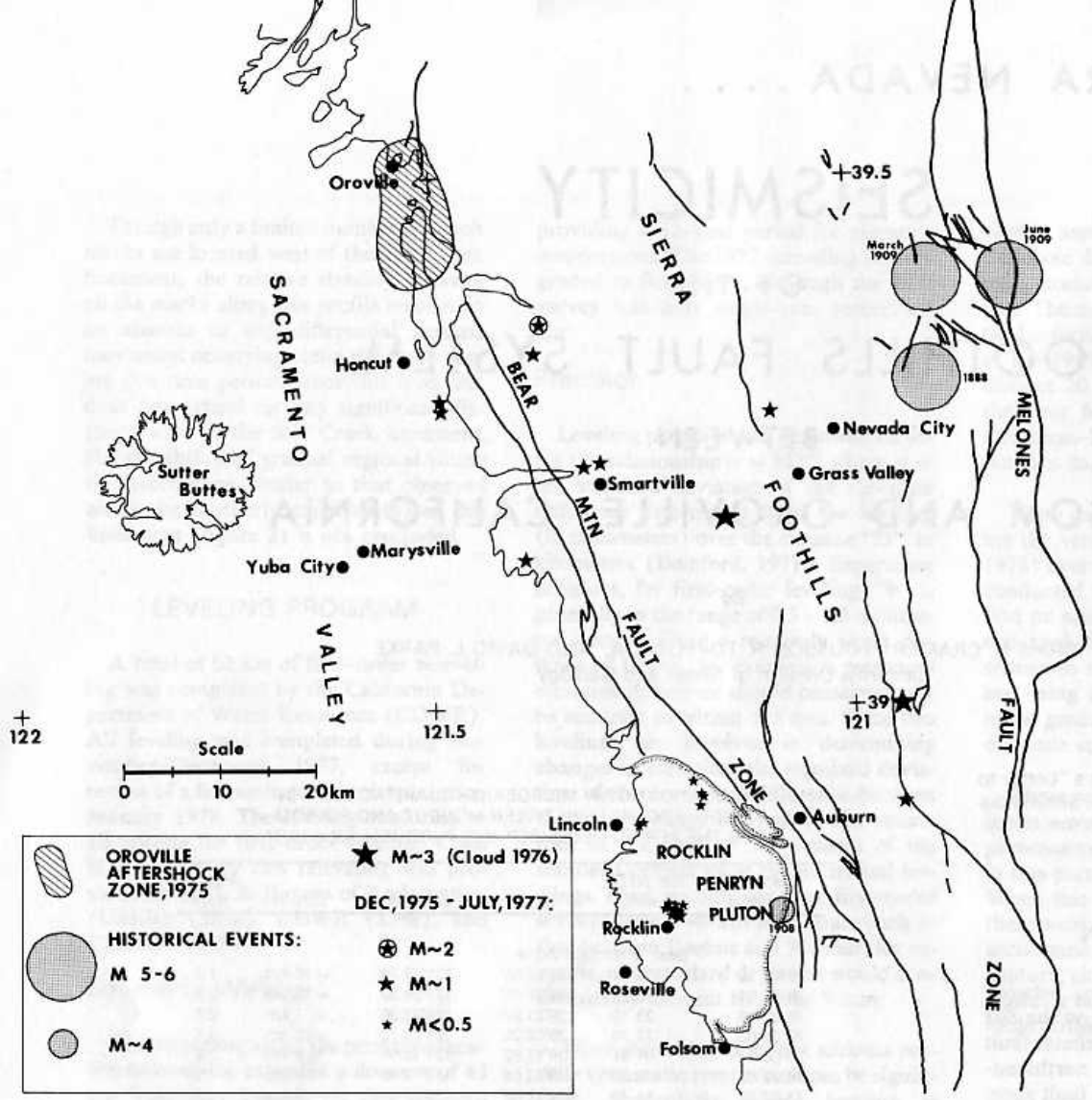

Figure 1. Map of northern part of Foothills fault system showing known earthquake activity between Oroville and Folsom. The contact to the west of the Bear Mountain fault zone is the boundary between the Sacramento Valley and the Sierra foothills. Hachured line indicates boundary between the Rocklin–Penryn pluton and metavolcanic rocks of the foothills. The 1888, 1908, and 1909 earthquakes were researched by CDMG; for the 1908 and 1909 events see Toppozada and others (1978).

ters for these two events are also listed in table 1. The first event occurred 10 km east of Auburn on February 7, 1977 and the second 7 km west of Nevada City on May 15, 1977 (figure 1).

DETAILED STUDIES NEAR ROCKLIN

Two microearthquake investigations have been conducted in the vicinity of Rocklin, California. The first by McNally and others (1978) discovered microearthquake activity within the Rocklin–Penryn pluton. During that survey, microearthquakes ($M \leqq 1$) were concentrated in a cluster of activity near the town of Rocklin with two additional events near Lincoln (figure 1). The second microearthquake survey by Cramer and Sherburne (1977) confirmed the presence of the cluster of activity near Rocklin and detected additional microearthquakes ($M < 0$) near the northern edge of the pluton (figure 1). Continued monitoring by Eaton and others (1977) and Eaton and Conens (1977) using a regional telemetered network showed ongoing activity within the cluster near Rocklin, the largest being two magnitude 1.6 events.

Composite focal mechanisms based on P–wave first motions for both the Rocklin cluster of activity and the four events near the northern edge of the Rocklin–Penryn pluton indicate normal faulting, down to the east, on fault planes trending about N10°W with dips of 55° to 70° to the east (Cramer and others, 1977; McNally and others, 1978). This trend is compatible with the regional fault trend of the Sierra foothills. P–wave first motion data from the magnitude 1.1 event east of Auburn (Eaton and others 1977) also indicates normal faulting, down to the east, and is compatible with the composite mechanisms for the Rocklin pluton activity. This sense of down to the east motion on a normal fault is also compatible with geologic observations elsewhere along the Foothills fault system (Drew Smith, CDMG Geologist, oral communication; Alt and others 1977; Schwartz and others 1977).

Reports of felt earthquakes near Rocklin are rare (Townley and Allen, 1939; Bolt and Miller, 1975). Cloud (1976), in his review of the seismicity of the area, reported only three historical events that may have occurred near Rocklin. The three events are a February 23, 1885 event, an April 21, 1892 event reported as felt in Newcastle (5 km SW of Auburn, and a May 30, 1908 event reported as felt in Folsom and Represa (Townley and Allen, 1939). A search of old newspapers by one of the authors (D.L.P.) produced newspaper accounts for the 1908 event. The two earlier events were reported in the newspaper accounts as felt only at Newcastle, which is between Rocklin and Auburn. Figure 2 shows an isoseismal map for the 1908 event based on the newspaper accounts. A maximum reported intensity of IV–V and a total felt area of about 10,000 km² suggest a Richter mag-

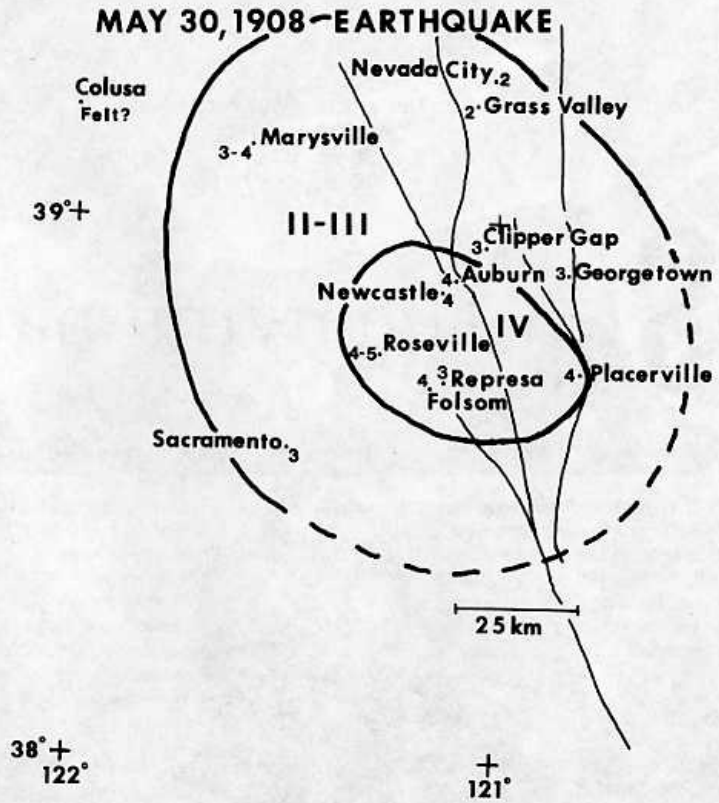

Figure 2. Isoseismal map of the May 30, 1908 earthquake showing Modified Mercalli intensity data determined from newspaper reports and the II and IV isoseismals. The generalized Foothills fault system in the Auburn area is shown in the background.

nitude of about 4 for this earthquake. Although the epicenter cannot be precisely defined, the intensity IV contour suggests that the event occurred on the Foothills fault system between Auburn and Folsom in proximity to the recent microearthquake activity near Rocklin. The epicenter for this event shown in figure 1 corresponds to the center of the intensity IV contour in figure 2.

DISCUSSION

Microearthquake studies in the Sierra foothills since late 1975 have revealed a pattern of ongoing low level seismicity between Oroville and Folsom. The occurrence of several magnitude ~1.0 events during this time period suggest that this portion of the Foothills fault system is active. Historical earthquake reports and instrumental earthquake locations also support this conclusion.

Detailed investigations in the vicinity of Auburn, California have shown microearthquake activity within the Rocklin–Penryn pluton. The main cluster of activity is in the middle of the pluton and is confined to an extremely small source volume. Another cluster of very small events is near the northern margin of the pluton where the Foothills fault system abuts the pluton. Composite focal mechanisms for events within the pluton as well as for one event east of Auburn are compatible with regional geology and trends of the Foothills fault system. These results suggest that the Rocklin–Penryn pluton is presently being deformed by the same regional stress pattern that caused Cenozoic movements elsewhere on the Foothills fault system. The isoseismals of a 1908 earthquake suggest that macroseismic activity has also occurred on the Foothills fault system in the vicinity of Rocklin.

Bennett and others, (1977) presented independent evidence of ongoing crustal movement based on first–order level lines between Roseville and Reno. The leveling data show episodic changes in elevation which approximately coincide with the Bear Mountain and the Melones zones of the Foothills fault system. As with earthquake data, the leveling shows that larger movements are occurring on the Melones fault zone than on the Bear Mountain fault zone.

ACKNOWLEDGMENTS

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