DAMAGE IN ALAMEDA AND CONTRA COSTA COUNTIES, CALIFORNIA, IN THE EARTHQUAKE OF 18 APRIL 1906

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U.S. Geological Survey
OPEN-FILE REPORT 82-63

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INTRODUCTION

Significant damage occurred in the region east of San Francisco Bay in the 1906 earthquake, but the damage has been relatively neglected in the past, probably because the earthquake and fire damages within San Francisco were much more spectacular. Alameda and Contra Costa Counties are not located close to the San Andreas fault, but most towns in both counties suffered major damage. The damage effects include the fall of brick walls and chimneys, the collapse of some buildings, the occurrence of ground failures, and the start of fires.

The damage listing of this report is part of a general study to improve and modernize our understanding of the 1906 earthquake. Similar reports have been prepared for San Mateo County (Nason, 1980a) and Santa Clara and Santa Cruz Counties (Nason, 1980b). Many of the data come from the detailed report on the 1906 earthquake by Lawson and others (1908). Much additional data have been obtained from a search of the local and regional newspapers of April and May 1906.

The damage descriptions are given as direct quotations of the original sources, so that the quality of the original information is directly evident. In addition, the geologic setting and the distance to the 1906 earthquake fault rupture have been determined for each locality, so that these aspects can be analyzed with regard to earthquake damage. The seismic intensity rating at each locality has been determined using both the Rossi-Forel scale, which was used in 1906 (Lawson and others, 1908, p. 161), and the later Modified Mercalli scale.

This compilation of damage shows in detail what happened in the 1906 earthquake in Alameda and Contra Costa counties, and thus shows what could happen in any future earthquake of similar size in the same region. Thus the listing can be useful for earthquake disaster planning both by individuals and by communities.

LOCATION AND GEOLOGIC SETTING

Alameda and Contra Costa Counties are to the east of San Francisco Bay, 23 km to 75 km east of the 1906 earthquake rupture on the San Andreas fault (Figure 1). Contra Costa County is north of Alameda County.

In the western parts of the counties, the geologic setting consists of nearly flat alluvium alongside San Francisco Bay. East of this western edge, the land is mountainous with interior alluvial valleys. The mountain regions north and south of the Livermore Valley are underlain by sedimentary and igneous rocks of the Franciscan assemblage of Mesozoic age (Bailey and others, 1964). The other mountain areas are underlain by younger marine and non-marine sedimentary rocks.

Most of the communities are on the alluvial ground, either near San Francisco Bay or in the interior alluvial valleys. The alluvium overlies the sedimentary bedrock of Mesozoic and Tertiary ages. Near the bay the alluvium is apparently several hundred feet thick at some places (Goldman, 1969), but decreases to zero thickness at the edge of the hills.

Local geology classification. The geology at each locality is classified in this compilation according to the following major groups, which are based on the age and type of rock (categories A to E represent increasing age of the sedimentary rock):

Type A. Alluvium;
Type B. Sediments of early Quaternary age;
Type C. Sedimentary rocks of Middle and Late Tertiary age (Oligocene, Miocene and Pliocene);
Type D. Sedimentary rocks of Cretaceous and Early Tertiary age (Cretaceous, Paleocene and Eocene);
Type E. Detrital sedimentary rocks of pre-Cretaceous age;
Type F. Carbonate sedimentary rocks of pre-Cretaceous age;
Type G. Igneous and metamorphic rocks.

Subdivision of the alluvium. Because the geologic setting of the alluvium and bedrock may be important for earthquake shaking, the geologic setting of the alluvium has been subdivided into several sub-types. For instance, the seismic response characteristics of the thin alluvium in a narrow river valley may be very different from the seismic characteristics of the thick alluvium in a large valley. The local sub-types of alluvium used in this study are:

Type Av. In a large alluvial valley, not near to bedrock;
Type An. In a narrow alluvial valley that is less than 3 km wide;
Type Ae. Near the edge of an alluvial valley, within 0.5 km of surface bedrock;
Type At. In terrace deposits overlying bedrock.
Type Am. Estuarine mud at the edge of San Francisco Bay;

Where the alluvium is thin, the type of underlying bedrock may be important to the seismic shaking, so the type of bedrock under the alluvium is noted in the geologic classifications by a slash with the underlying rock type. For example, At/D indicates terrace alluvium over Type D bedrock and An/C indicates a narrow alluvial valley over Type C bedrock. The choice of 3 km for the width of narrow alluvial valleys is arbitrary.

The local geologic setting has been determined from the geologic maps of the California state geologic atlas of scale 1:250,000 (Sacramento sheet, Strand and Koenig, 1965; San Francisco sheet, Jennings and Burnett, 1961; San Jose sheet, Rogers, 1966; Santa Rosa sheet, Koenig, 1963), with additional information on alluvium from Helley and others (1979).

Distance from the earthquake fault rupture. The fault distance for each locality is the closest distance (usually the perpendicular distance) to the locality from the 1906 earthquake rupture on the San Andreas fault (as shown by Lawson and others, 1908). Since all parts of the San Andreas earthquake fault rupture can be considered as a source for the earthquake, the distance from the fault can be considered as being a measure of the distance from the earthquake source (except for the unknown effect of earthquake source depth). The location of the 1906 earthquake fault rupture relative to Alameda and Contra Costa Counties is shown on Figure 1.

DAMAGE LISTING

In the earthquake damage listing of Table 3, the damage to buildings and other features is compiled and listed alphabetically by locality. A two-letter code has been assigned to each locality for showing locations on the reference map of figure 2. The first letter of the code is the same as the first letter of the locality name.

In Table 3, the types of damage are listed in sequence from building damage to injuries. Many of the descriptions are from the detailed report by Lawson and others (1908), and local newspapers provide much additional data. The 1906 newspapers were examined at the main library of the University of California, Berkeley, and at many community libraries. Direct quotations from the original sources are used, so that the quality of the damage report is evident. The quotations have been simplified by leaving out some words and sentences, as indicated by dots. Additions and insertions are indicated by bracket parentheses [...]. All available information on significant damage has been included, except in the cities of Alameda, Berkeley, Martinez and Oakland, where the local newspapers give a more complete listing than is included here.

SEISMIC INTENSITY SCALES

The earthquake damage has been rated for apparent seismic intensity using both the Rossi-Forel intensity scale that was used in 1906 (Lawson and others, 1908, p. 161) and the newer Modified Mercalli intensity scale. As used here, the seismic intensity system is a progressive rating of the disturbance of the earthquake shaking, with the intention that a higher intensity rating indicates a greater severity of shaking. In this report, the rating is assigned only to the damage that is directly caused by the earthquake shaking, and not to secondary damage that may only be an indirect effect of the earthquake shaking (such as the effects of ground deformation).

Rossi-Forel Intensity Scale. The Rossi-Forel (RF) intensity scale (Table 1) was used in 1906 and is basically simple in content. At the level of significant damage (as in Alameda and Contra Costa Counties) the RF scale is based primarily on the damage to buildings and chimneys. Intensity RF VII is indicated mainly by the fall of some (but not many) chimneys; intensity RF VIII is indicated by the fall of many chimneys; and intensity RF IX is indicated by the partial or complete collapse of some buildings (usually brick buildings in this region).

The shifting of house foundations is another type of damage that can be used when reported, although it is not specifically listed in the RF scale. Correlation of foundation damage with other types of damage at several places in 1906 (Nason, 1980a) indicates that the shifting of a few house foundations correlates with intensity RF VIII.

In this compilation, intensity ratings are not assigned to the occurrence of landslides or other ground failures, as the proper intensity rating of such ground failures is not certain (Nason and Espinosa, 1977). In the 1906 version of the RF scale (Table 1), the occurrence of landslides is listed at intensity RF X, perhaps be-

cause landslides can cause great secondary damage. However, this high Rossi-Forel intensity rating for landslides is often inconsistent with the direct building damage caused by shaking in the same areas as the landslides, so the intensity rating of landslides is uncertain.

In the usage of the 1906 Lawson report, the other types of ground failure, such as the deformations of the ground that are due to liquefaction, are also rated as high intensity. However, the correlation between such ground failures and the shaking damage to buildings is uncertain (Nason and Espinosa, 1977), so intensity assignments are not used with ground failures in this report.

Another major problem in the usage of the RF scale is that the only criteria for intensity RF IX is the partial or complete collapse of some buildings. This applies mainly to brick or masonry buildings, because in this area simple wood buildings are comparatively resistant to major earthquake damage. Thus the RF scale cannot give intensity RF IX ratings in areas where suitable brick buildings are uncommon or absent, such as in many hill areas.

Modified Mercalli Intensity Scale. Beginning in 1931, most seismic intensity studies in the United States have used the Modified Mercalli (MM) intensity scale of Wood and Neumann (1931) and Richter (1958). The MM scale is basically similar to the Rossi-Forel scale in most criteria, but the MM scale has some additions and changes. An important improvement in the MM scale is the recognition that different types of buildings have different earthquake resistance, such that weak buildings will be damaged more than strong buildings for the same severity of seismic shaking. The MM scale clearly indicates that great damage to weak buildings is equivalent to slight damage to strong buildings. In this way the MM scale is an improvement on the RF scale as an indication of the strength of seismic shaking.

Another change is that the Modified Mercalli scale assigns an intensity rating of VI to the fall of loose objects, rather than the VII of the Rossi-Forel scale. This allows a separation of the fall of loose objects from the occurrence of chimney damage, which is also at intensity VII on the Rossi-Forel scale. The rating of chimney damage at intensity VII and the damage criteria for intensity VIII are approximately the same on both the Modified Mercalli and Rossi-Forel scales.

At intensity IX the Modified Mercalli scale is significantly different from the Rossi-Forel scale. The RF scale assigns intensity IX to occurrences of partial collapse in buildings without regard to the strength of the buildings, while the partial collapse of a weak building is rated as only intensity VIII in the MM scale. The amount of chimney damage at places where there was partial collapse of a weak building, for instance at Antioch (this report, page 16), indicates that this lower intensity rating on the MM scale is approximately correct.

The investigation of the 1906 earthquake damage has shown that there are problems in the use of the MM scale, most of which are similar to the problems with the RF scale. A major problem in the MM scale is that high intensity ratings are given to ground failures and the effects of ground failures, when nearby building damage indicates only a lower intensity rating (Nason and Espinosa, 1977).

Another problem with the Modified Mercalli scale is that it is difficult to determine ratings of MM IX at localities where there are only a few buildings to show the damage.

SEISMIC INTENSITY ASSIGNMENTS OF THIS STUDY

As noted in the previous section, there are difficulties with some parts of the existing Rossi-Forel and Modified Mercalli intensity scales. Therefore, in order to clarify usage and reduce the difficulties, several changes have been introduced in determining the intensity ratings in this report:

1). The intensity rating is underlined where the reported damage indicates only the minimum value of the intensity rating but not an upper limit because of an absence of sufficient information. The actual intensity value at this site may have been greater than this minimum.

2). Uncertainties of an intensity rating are specially discussed where there is information that the unusual damage was probably due to the poor quality of construction rather than severe shaking, or if there are other uncertainties. Where there is much uncertainty, the intensity rating is given with a question mark (?).

3). At localities where the intensity rating was either intensity VII or intensity VIII the intensity rating is given as VII+.

4). At localities where all or nearly all chimneys have fallen, which is more than the usual damage for intensity VIII but is not definitely defined as intensity IX in the Rossi-Forel or Modified Mercalli scales, an intensity rating of VIII+ is used.

5). Because of the uncertainties in the intensity ratings of ground failure effects, no intensity ratings have been assigned at localities of ground failures such as landslides or liquefaction. Instead, the occurrences of ground failures are listed separately in Table 4 and are shown on separately on Figure 4.

SEISMIC INTENSITY MAPS

Seismic intensity maps are useful for many purposes, such as for showing the geographic pattern of the earthquake shaking, as judged from the damage caused by the shaking, and for analysis of how the earthquake shaking relates to geographic and geologic features. The seismic intensity map is also useful for earthquake hazard studies, as it can be expected that a future great earthquake will be similar to past great earthquakes.

The main purpose of this investigation is to increase the knowledge of the damage patterns of the 1906 earthquake, and to modernize the seismic intensity maps of the earthquake. The seismic intensity ratings of this compilation (Table 3) are shown on the map of Figure 3.

SEISMIC GROUND FAILURES

Several different types of ground failure were triggered by the 1906 earthquake. These include cracks and fissures in the ground, deformation and settlement of the ground, liquefaction effects, and landslides and rockfalls. The known instances of ground failure in Alameda and Contra Costa Counties are listed in Table 4 and shown on Figure 4. The report by Youd and Hoose (1978) contains more detail on some of the occurrences of ground failures.

Liquefaction and ground deformation effects occurred at several locations near San Francisco Bay, particularly at the Alameda and Oakland waterfronts, where there was major ground deformation and ground settlement of several feet occurred. The processes and mechanisms of liquefaction were not recognized or understood in 1906, so there were not any direct descriptions of the occurrence of liquefaction. However, the descriptions of flow of water and sand out of cracks, for instance at Alvarado (page 34) and Newark (page 36), are good indications of liquefaction.

A large landslide occurred in the hills near San Pablo. There was also an area of ground deformation near Livermore, of unknown cause. A significant report is that landslide failure did not occur in the hill area of Berkeley, in spite of the fact that landslide movements had been expected there because of the landslides that had occurred during the previous winter.

FIRES

Significant earthquake-related fires occurred at several places in Berkeley, Martinez, and Oakland (Table 5). The lack of water at a fire in Oakland may have been because of the breaking of the main water pipeline by the ground failure at Lake Merritt Dam in Oakland.

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TABLE 1: ROSSI-FOREL INTENSITY SCALE

INTENSITY VI. Severe shock; general awakening of sleepers, stopping of clocks, some window glass broken.

INTENSITY VII. Violent shock; overturning of loose objects; falling of plaster; some chimneys fall.

INTENSITY VIII. Fall of chimneys; cracks in the walls of buildings.

INTENSITY IX. Partial or total collapse of some buildings.

INTENSITY X. Great disasters; overturning of rocks; fissures in surface of earth; mountain slides.

ADDITIONAL INTENSITY RATING IN THIS REPORT (1981):

INTENSITY VII+. The intensity rating was either intensity VII or intensity VIII.

INTENSITY VIII+. All or nearly all chimneys fall (more than 90%).

TABLE 2: MODIFIED MERCALLI INTENSITY SCALE
(effects of ground failure removed)

INTENSITY VI. Felt by all; many frightened and run outdoors. Windows, dishes, glassware broken; knicknacks, books, etc. off shelves. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys.

INTENSITY VII. Damage neglible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly-built or badly designed structures; weak chimneys broken at roof line; fall of plaster, loose bricks, cornices, parapets.

INTENSITY VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures; frame houses moved on foundations. Fall of chimneys, factory stacks, columns, monuments, walls; heavy furniture overturned.

INTENSITY IX. Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; (damage) great in substantial buildings, with partial collapse. Buildings shifted off foundations.

INTENSITY X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations.

ADDITIONAL INTENSITY RATING IN THIS REPORT (1981):

INTENSITY VII+. The intensity rating was either intensity VII or intensity VIII.

INTENSITY VIII+. All or nearly all chimneys fall (more than 90%).

TABLE 3

1906 EARTHQUAKE DAMAGE IN ALAMEDA AND CONTRA COSTA COUNTIES

ALAMEDA
Location: AL, Alameda County 3 km south of Oakland.
Distance: 24 km east of the earthquake fault.
Geology: Type Av.

Buildings. "At an old brick building at Park and Santa Clara streets, most of the south wall fell into the street and the north wall fell onto the house next door. The Methodist church lost part of the north wall. The Akeson store was moved out of position and shattered." (Oakland Herald, 1906).

"[Several persons] were taken from under the collapsed roof of the two story building at 1510 Park Street. The three were pinned fast by debris and timbers." (Alameda Daily Argus, 1906a).

"Clarkes pottery in the West End is a wreck. ...The northeast and northwest corners of the structure fell." (Alameda Daily Argus, 1906a).

Houses. The Burdick home dropped 7 feet; the Sturms home collapsed; the French home caved in. (Oakland Herald, 1906).

At the home of C. Reuss "not a dish [was] broken. ...In our whole house the total breakage was one old medicine bottle and one...piece of bric-a-brac. ...Our chimney was cracked once around, and twisted an inch and a half. ...There were no cracks in our plaster worthy even of a little sigh. ...Yesterday I met the owner of five frame houses...on ...which [not] a single chimney had been injured." (Reuss, 1906, p. 206-207).

Smokestacks. "The big chimney at the old oil works in the West End collapsed. ...It broke in the middle and the debris fell at its base. ...[At Clarkes pottery] the big chimney collapsed." (Alameda Daily Argus, 1906a).

Chimneys. "[Investigators] counted 619 fallen chimneys in the city. ...58 [chimneys] were rotated counter-clockwise and 3 clockwise." (Lawson and others, 1908, p. 303).

"In several instances the chimneys crashed through the roofs." (Alameda Daily Argus, 1906a).

"Practically all the chimneys are down." (Alameda Daily Argus, 1906d).

General. "The destruction was confined for the most part to the throw of chimneys and the upper portions of brick walls. A few tanks were also overthrown, and 3 large stacks [were overthrown]." (Lawson and others, 1908, p. 303).

"Numerous tank houses and windmills fell." (Alameda Daily Argus, 1906a).

Injuries. "No lives were lost...but two persons were injured. A night watchman at the pottery works was hurt by falling debris and a lodger at the Leona lodging house was struck by falling bricks. Minor injuries were sustained by a number of people. ...Willam Cunningham ...was badly injured by falling debris while jumping through a window at the Leona Lodging House. ...A brick from the chimney struck him... on top of the head." (Alameda Daily Argus, 1906a).

Water. "Until toward evening the city was without water. ...The water was turned on last night." (Oakland Tribune, 1906e).

Discussion of intensity: Some houses were badly damaged, while other houses were hardly damaged at all, which shows the difficulty in evaluating seismic intensity from damage to houses.

Intensity: Modified Mercalli VIII; Rossi-Forel IX.

ALVARADO

Location: AV, Alameda County 30 km southeast of Oakland, now part of Union City.

Distance: 25 km east of the earthquake fault.

Geology: Type Av.

Buildings. "An old lime-kiln showed diagonal cracks in the brickwork. ...At the Alvarado Water Works the brick buildings suffered considerable damage, the walls cracking in several places." (Lawson and others, 1908, p. 304-305).

Houses. "The frame dwelling of the superintendent was damaged by the collapse of its underpinning. A similar fate befell the Alvarado Hotel." (Lawson and others, 1908, p. 304-305).

Chimneys. "Nearly all brick chimneys in the village fell." (Lawson and others, 1908, p. 304-305).

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

ANTIOCH

Location: AN, Contra Costa County 28 km east of Martinez.

Distance: 70 km east of the earthquake fault.

Geology: Type B.

Buildings. "Out of about 12 brick buildings, the tower of the Catholic Church was somewhat damaged, and one rickety old brick building fell. None of the good buildings were damaged." (Lawson and others, 1908, p. 311).

"Aside from a few cracked walls, broken windows, and demolished chimneys, there was no damage here." (Antioch Ledger, 1906).

Chimneys. "A few chimneys were twisted on their bases, several were thrown entirely and about 25 per cent of them needed repairing after the shock." (Lawson and others, 1908, p. 311).

General. "A couple of windows were broken, a few clocks were stopt, and a few things were thrown from shelves. ...All sleepers were awakened." (Lawson and others, 1908, p.311).

Discussion of intensity: The chimney damage indicates an intensity of RF VII, but there was also the collapse of a weak brick building which might be assigned a higher intensity rating.

Intensity: Modified Mercalli VII+; Rossi-Forel IX.

BERKELEY

Location: BK, Alameda County 8 km north of Oakland.
Distance: 27 km east of the earthquake fault.
Geology: Type Av.

Buildings. "Several brick buildings had their upper walls thrown down or were otherwise damaged by cracks. ...At the High School the walls of the upper story...were badly cracked and partly thrown out. ...A building veneered in part with brick had a great deal of the brick facing of the upper part of the building, and much of a strip of tiling...thrown down. The upper part of the rear wall of [a] brick building...was thrown down. The north wall of the new Masonic Temple, which was in course of construction...was thrown to the north and caused collapse of certain steel girders resting upon it." (Lawson and others, 1908, p. 300-302).

"At the corner of Dwight Way and Shattuck avenue the new Barker building is in a deplorable condition. The whole building still stands, but the upper story is little more than a pile of bricks. It is simply rent through and through. Across the street, the building occupied by Fuller's pharmacy has a big hole in its back wall, extending laterally the entire length of the building, and from the roof downward about five feet. The falling chimney crushed the frame building next door." (Berkeley Reporter, 1906a).

"St. Joseph's Academy building, at Peralta Park, is badly twisted. Several persons were grazed by falling bricks, but no one was hurt." (Berkeley Reporter, 1906a).

Houses. "A cottage at 2011 Ninth St...was completely wrecked. There was not a stick of timber in the structure left standing. The inmates escaped without a scratch." (Oakland Herald, 1906a).

Smokestack. "[At] the Standard Soap Company, Third and Allston Way...the temblor of the 18th partially demolished the large smokestack and also the shock of yesterday afternoon [3:15 PM on 25 April] caused the chimney to shift considerably." (Berkeley Daily Gazette, 1906a).

Chimneys. "A large majority of the brick chimneys were broken or overthrown." (Lawson and others, 1908, p. 300-302).

Shelf items. "An indescribable scene of confusion was presented in many of the leading stores...stocks having been thrown from shelves to the floors which were buried knee deep in debris." (Berkeley Reporter, 1906a).

"All of the books of the public library were thrown from their shelves and scattered about the floor; the shelving was toppled over." (Oakland Herald, 1906).

Windmill. "Frank Esmond's windmill...fell." (Berkeley Reporter, 1906a).

Fire. [See Table 5].

Water. "The water main that leads from the Berkeley reservoir broke, and shot a stream high in the air." (Berkeley Reporter, 1906a).

Injuries. Mrs. Hollenbeck...was severely injured by leaping from a window of the residence. ...She was suffering from a badly sprained back and perhaps internal injuries. ...While rushing from his home... W.J. Phillips...stumbled on the stairs and fell, badly spraining his ankle. ...At San Pablo avenue and Stanford avenue the guard gates at

the railroad crossing fell and struck on the head a man who was driving by on a meat wagon. He was severely injured." (Berkeley Reporter, 1906c).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

BERKELEY INSTITUTION

Location: BI, Alameda County 7 km north of Oakland.
Distance: 30 km east of earthquake fault.
Geology: Type Ae/E.

Buildings. "At the State Institution for the Deaf, Dumb and Blind the upper part of the northwest tower of the building...was wrecked by a considerable part of the brickwork being thrown out on the northeast and northwest corners of the tower. The upper part of a brick gable in the central building...was thrown...into the building. The upper part of the south tower...was demolished." (Lawson and others, 1908, p. 300-301).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

BERKELEY UNIVERSITY

Location: BU, Alameda County 8 km north of Oakland.
Distance: 29 km east of earthquake fault.
Geology: Type Ae/E.

Buildings. "The buildings of the university campus...sustained no serious damage." (Lawson and others, 1908, p. 301).

"Some of the University buildings were badly shattered. ...The north turret of Moss Hall...is cracked and likewise the turret of the main building. ...The whole roof of the main building has been shifted to the north fully four inches." (Berkeley Reporter, 1906a).

"The report that Stiles Hall, the college YMCA building, would have to be torn down, has been proved to be without foundation. A few...repairs will make the building as good as new." (Oakland Tribune, 1906h).

Chimneys. "All chimneys are standing." (Oakland Tribune, 1906g).

"There was not a single chimney thrown, altho one or two were cracked." (Lawson and others, 1908, p. 301).

Library. "The same thing [general fall of the books] happened to the library of the University of California. ...It will take considerable time to rearrange the many volumes that were on the shelves and which are now piled in a shapeless heap in the middle of the floors." (Oakland Herald, 1906).

Discussion of intensity: There is a conflict between the report in the newspaper and the report in the Lawson report, so the intensity rating is uncertain.

Intensity: Modified Mercalli VII?; Rossi-Forel VII?.

BYRON

Location: BY, Contra Costa County 45 km east of Martinez.
Distance: 72 km east of the earthquake fault.
Geology: Type Av.

Chimneys. "The chimney inspection is closed in the Byron district: 119 dwellings were visited by the inspector aggregating 175 fire flues with only 4 condemned." (Contra Costa Gazette, 1906c).

Intensity: Modified Mercalli VII; Rossi-Forel VII.

BYRON HOT SPRINGS

Location: BH, Contra Costa County 46 km east of Martinez.
Distance: 71 km east of the earthquake fault.
Geology: Type C.

General. "One chimney and some plaster were cracked and a picture was thrown from the wall." (Lawson and others, 1908, p. 311).

Discussion of intensity: The Byron Hot Springs consists only of some resort buildings, and the number of chimneys is not known.

Intensity: Modified Mercalli VII?; Rossi-Forel VII?

CENTERVILLE

Location: CV, Alameda County 45 km southeast of Oakland, now part of Fremont.
Distance: 27 km east of earthquake fault.
Geology: Type Av.

Buildings. "The amount of destruction here seems greater...but this is in large measure due to the presence of a number of poorly constructed brick houses. All of these here suffered severely, the walls being in part thrown down. The brick bank was more seriously damaged than most buildings, the walls being partly demolished and the roof having caved in." (Lawson and others, 1908, p. 280).

Chimneys. "With very few exceptions all the brick and tile chimneys were broken off." (Lawson and others, 1908, p. 280).

Windows. "Window panes broke in several stores." (Lawson and others, 1908, p. 280).

Discussion of intensity: The weakness of construction is noted in the report.

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

CLAYTON

Location: CL, Contra Costa County 19 km east of Martinez.
Distance: 57 km east of the earthquake fault.
Geology: Type D.

Chimneys. "No chimneys were thrown down." (Lawson and others, 1908, p. 310).

General. "No dishes nor glassware were knocked off shelves, but milk in pans was skimmed by the rocking motion." (Lawson and others, 1908, p. 310).

Discussion of intensity: It is not known if this is a general town report or a single site report.

Intensity: Modified Mercalli V?; Rossi-Forel V?

CONCORD

Location: CO, Contra Costa County 10 km east of Martinez.
Distance: 52 km east of the earthquake fault.
Geology: Type Av.

Buildings. "The only brick building was cracked." (Lawson and others, 1908, p. 310).

"The bank building is badly cracked." (Contra Costa Gazette, 1906a).

Chimneys. "Most of the chimneys were cracked, and about 50 per cent had fallen." (Lawson and others, 1908, p. 310).

Smokestack. "The bakery was one of the severest sufferers, the huge chimney being thrown down." (Contra Costa Gazette, 1906a).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

CORNWALL

Location: CW, Contra Costa County 22 km east of Martinez, now part of Pittsburg.
Distance: 67 km east of the earthquake fault.
Geology: Type Av.

Chimneys. "One rickety chimney was thrown. ...Most of the houses are small and have terra-cotta chimneys." (Lawson and others, 1908, p. 310-311).

General. "A very few things were thrown from shelves. ...One concrete wall in process of construction fell. Less than half the clocks were stopt, tho nearly all sleepers were awakened." (Lawson and others, 1908, p. 310-311).

Intensity: Modified Mercalli VII; Rossi-Forel VII.

CROCKETT

Location: CR, Contra Costa County 10 km west of Martinez.
Distance: 42 km east of the earthquake fault.
Geology: Type D.

Chimneys. "Chimneys on nearly half the houses were shattered completely while others were twisted and rendered useless." (Contra Costa Gazette, 1906a).

Smokestack. "The refinery...smokestack was cracked the whole length." (Contra Costa Gazette, 1906a).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

DANVILLE

Location: DV, Contra Costa County 23 km south of Martinez.
Distance: 43 km east of the earthquake fault.
Geology: Type An/C.

Chimneys. "Most chimneys were cracked or twisted; a few were broken off completely." (Lawson and others, 1908, p. 310).

Shelf items. "Glassware in saloons and goods in a grocery store were thrown down in quantites." (Lawson and others, 1908, p. 310).

Intensity: Modified Mercalli VII+; Rossi-Forel VII+.

DECOTO

Location: DC, Alameda County 32 km southeast of Oakland, now part of Union City.
Distance: 29 km east of the earthquake fault.
Geology: Type Av.

General. "The damage to buildings was slight, consisting of broken or twisted chimneys and cracking of plaster in a few houses. A few scattering chimneys escaped destruction. ...In the stores and saloons articles were thrown down." (Lawson and others, 1908, p. 304).

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

DECOTO HILLS

Location: DH, Alameda County 32 km south of Oakland.
Distance: 30 km east of the earthquake fault.
Geology: Type D.

General. "The Masonic Home, a large brick structure...suffered but little damage. A few insignificant cracks in the brick walls, 2 chimneys broken off, and 2 chimneys cracked constitute the most serious damage. Plaster was cracked in several rooms; no windows were broken." (Lawson and others, 1908, p. 304).

Discussion of intensity: There are no chimneys on the main buildings today, so these chimneys were probably on auxillary buildings, and it is not known whether there were only four chimneys (in which case the chimney damage would indicate intensity VIII) or many chimneys (in which case the chimney damage would indicate intensity VII).

Intensity: Modified Mercalli VII+; Rossi-Forel VII+.

DUBLIN

Location: DU, Alameda County 31 km east of Oakland.
Distance: 42 km east of the earthquake fault.
Geology: Type Ae/C.

Chimneys. "A few chimneys [were] broken off." (Lawson and others, 1908, p. 309).

Shelf items. "Articles [were] thrown down from shelves and counters." (Lawson and others, 1908, p. 309).

Intensity: Modified Mercalli VII+; Rossi-Forel VII+.

ELMHURST

Location: EL, Alameda County 11 km south of Oakland, now part of Oakland.

Distance: 28 km east of earthquake fault.

Geology: Type Av.

Chimneys. "Most of the chimneys had fallen." (Lawson and others, 1908, p. 303).

Windows. "The windows in the hotels and stores were broken." (Lawson and others, 1908, p. 303).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

EMERYVILLE

Location: EM, Alameda County 4 km north of Oakland.

Distance: 26 km east of earthquake fault.

Geology: Type Av.

Building. "The upper part of the Emeryville town hall, which was nearly completed, was badly damaged. The plastering was knocked down, and one of the large columns in the front of the building was broken square across." (Oakland Herald, 1906).

Smokestack. "The large smokestack at the Key Route power generating plant, built on tidal marsh land, had its upper third thrown off." (Lawson and others, 1908, p. 302).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

FITCHBURG

Location: FB, Alameda County southeast of Oakland, now part of Oakland, exact location uncertain.

Distance: Probably 27 km east of the earthquake fault.

Geology: Probably Type Av.

Chimneys. "The chimneys on the old houses were gone." (Lawson and others, 1908, p. 303).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

FRUITVALE

Location: FV, Alameda County 5 km southeast of Oakland, now part of Oakland.

Distance: 27 km east of the earthquake fault.

Geology: Type Av.

Chimneys. "Hundreds of brick chimneys were leveled to the roof, and many windows shattered." (Oakland Enquirer, 1906b).

Fire. [See Table 5].

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

HAYWARD

Location: HW, Alameda County 25 km southeast of Oakland.
Distance: 28 km east of the earthquake fault.
Geology: Ae/E.

Buildings. "The Public Library was severely cracked in a dozen directions and in places pieces dropped out. ...The rear wall of the Haas Brothers new building was cracked." (Oakland Tribune, 1906c)

Discussion of intensity. The information indicates that earthquake damage occurred, but does not allow definite rating for seismic intensity.

Intensity: Not definite.

IRVINGTON

Location: IR, Alameda County 47 km southeast of Oakland, now part of Fremont.
Distance: 29 km east of the earthquake fault.
Geology: Type Av.

Buildings. "Every brick house was more or less extensively damaged; portions of walls fell in some instances, and cracks in brickwork were common to all. The large brick and store buildings of the Palmdale Winery suffered more severely than any, and large portions of them will have to be rebuilt entirely." (Lawson and others, 1908, p. 280).

"The Palmdale Wine Cellar is practically ruined. Its walls may cave at any moment." (Oakland Enquirer, 1906b) 21 ap p 6

Chimneys. "Only a few chimneys were left standing in the village." (Lawson and others, 1908, p. 280).

Plaster. "Plaster cracked and fell in large flakes in several houses." (Lawson and others, 1908, p. 280).

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

LIVERMORE

Location: LV, Alameda County 45 km east of Oakland.
Distance: 55 km east of the earthquake fault.
Geology: Type Av.

Buildings. "A block of old, weak-looking buildings northeast of the depot suffered no more than a few cracks." (Lawson and others, 1908, p. 308).

"Not a brick or cement building in town was even cracked." (Livermore Herald, 1906).

Smokestack. "The tall brick chimney at McClain & Hanson's floor mill was not injured." (Livermore Herald, 1906).

Chimneys. "Many chimneys were cracked and about 50 per cent thrown down." (Lawson and others, 1908, p. 308).

Cemetery. "Tombstones fell in various directions." (Lawson and others, 1908, p. 309).

Other. "Glassware in saloons and bars was thrown to the floor in quantities. ...In the larger number of cases milk and water were spilt from open vessels, but not in all cases. ...Only a few of the plastered houses had the walls cracked, and in only one case was plaster known to have fallen." (Lawson and others, 1908, p. 308).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

MARTINEZ

Location: MA, Contra Costa County 35 km northeast of San Francisco.

Distance: 47 km east of the earthquake fault.

Geology: Type An/D.

Buildings. "Most of the brick buildings here suffered severely; nearly all are more or less cracked, and the store facing of several was partly demolished. The roofs of the bank and other buildings were wrecked. A small stone house, built of large blocks, was completely ruined. ...Buildings were loosened in general, the fronts of some falling out. ...Parts of a large wooden building, particularly the window sashes, were moved in a southwesterly direction. ...Another building was moved 0.5 inch." (Lawson and others, 1908, p. 310).

"[Damage listing includes] Bank of Martinez--store front and half of brick wall down. Rankin Block--plaster off and upper portion of firewall down, with structure twisted. [Library Association Building]--walls cracked and upper part thrown down. ...The stone annex [of] the Alhambra Hotel...is a total wreck. Fortunately no one was in the building." (Contra Costa Gazette, 1906a).

Adobe house. "The entire side wall was torn out." (Contra Costa Gazette, 1906a).

Houses. "[Two houses] were twisted about on their foundations so that they hang 1 1/8 inches over there bases. ...Several small houses ...had the underpinning knocked from under them. ...Many houses were twisted out of plumb, especially those along Grangers Wharf." (Contra Costa Gazette, 1906a).

Smokestack. "One of the chimneys of the Bull's Head Oil Works lost a corner; the others were undamaged." (Lawson and others, 1906, p. 310).

Chimneys. "Hardly a chimney was left standing." (Contra Costa Gazette, 1906a).

"Most of the chimneys were broken off." (Lawson and others, 1908, p. 310).

General. "The southern part of town [on higher ground] was damaged more than the northern part. ...Many window-panes were broken. ...A clock at the court-house had its pendulum [2 feet long] broken." (Lawson and others, 1908, p. 310).

"The streets are littered with the bricks and stones from the ruined buildings and some sidewalks are impassable. ...Windows were broken in nearly every house." (Contra Costa Gazette, 1906a).

Cemetery. 8 monuments fell and 3 others were disturbed. (Lawson and others, 1908, p. 310).

Fire. [See Table 6].

Injuries. "Not a single life was lost." (Contra Costa Gazette, 1906a).

Discussion of intensity: The Rossi-Forel intensity rating is IX because walls fell from brick buildings and the annex of a hotel apparently collapsed. But since the damaged buildings may have been weakly built, and the chimney damage was that most chimneys fell (probably the newspaper report of chimney damage was an exageration), the Modified Mercalli rating is somewhat less.

Intensity: Modified Mercalli VIII; Rossi-Forel IX.

MILLS COLLEGE

Location: MC, Alameda County 8 km east of Oakland.
Distance: 30 km east of the earthquake fault.
Geology: Type Ae/C.

Buildings. "A stone building there was badly shattered and will have to be taken down." (Lawson and others, 1908, p. 304).

Chimneys. "About half the chimneys were down." (Lawson and others, 1908, p. 304).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

MISSION SAN JOSE

Location: MJ, Alameda County 43 km southeast of Oakland, now part of Fremont.
Distance: 32 km east of the earthquake fault.
Geology: Type Ae/C.

Chimneys. "Nearly all chimneys were thrown down, and plaster in houses cracked." (Lawson and others, 1908, p. 280).

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

MOUNT EDEN

Location: ME, Alameda County 21 km southeast of Oakland, now part of Hayward.
Distance: 26 km east of the earthquake fault.
Geology: Type Av.

Chimneys. "Brick chimneys were broken and thrown. Furniture was thrown flat." (Lawson and others, 1908, p. 304).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

NEWARK

Location: NW, Alameda County 35 km southeast of Oakland.
Distance: 23 km east of the earthquake fault.
Geology: Type Av.

Foundations. "Four houses were twisted off their foundations. The Lincoln school building was turned about at an angle on its base." (Oakland Tribune, 1906d).

Chimneys. "Nearly all brick and tile chimneys...are broken off." (Lawson and others, 1908, p. 279).

"Only two houses in this vicinity that had brick chimneys escaped having them demolished by the earthquake." (Oakland Tribune, 1906d).

Watertanks. "At the depot the water tank fell, the supporting trestle being practically demolished." (Lawson and others, 1908, p. 279-280).

"It is not an uncommon sight to see a water tank that has been thrown to the ground." (Oakland Tribune, 1906d).

Plaster. "Plaster cracked and fell in quantities on the lower floors of hotels and several other buildings." (Lawson and others, 1908, p. 279).

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

NILES

Location: NL, Alameda County 35 km southeast of Oakland, now part of Fremont.

Distance: 30 km east of the earthquake fault.

Geology: Type Ae/C.

Buildings. "There was no serious damage done to [any of the buildings]." (Lawson and others, 1908, p. 306).

Chimneys. "Of all the chimneys in town, 48 per cent fell; of the brick chimneys 80 per cent fell; of the terra-cotta chimneys only 10 per cent went down." (Lawson and others, 1908, p. 306).

General. "In nearly all of the houses such objects as dishes, bottles, vases, and clocks were thrown from shelves. Milk and water were spilt from open receptacles in most cases." (Lawson and others, 1908, p. 306).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

OAKLAND

Location: OA, Alameda County 13 km east of San Francisco.

Distance: 25 km east of the earthquake fault.

Geology: Type Av.

Buildings (partial list). "The upper parts of brick walls, gables, and cornices were in many cases thrown down and cracks in walls were numerous. ...The Prescott school, in course of erection... was rather badly wrecked, as was also the building of the California Flax Works...the walls of which gave way, causing the roof to collapse. ...The southeast tower of the First Baptist Church...had its upper northeast corner thrown out, and was otherwise wrecked. The east and south gables were both thrown out. ...The Central Bank building...had the brickwork of its southwest corner thrown off from the 2 upper stories, and was similarly affected, tho to a less extent, on its northwest corner." (Lawson and others, 1908, 302).

"The Central Bank...was seriously injured on the fourth and fifth stories. The roof and cornice and the top story were almost entirely demolished and the southwest and northwest corners fell into the

street. There are cracks in the front of the brickwork in the fourth and fifth stories. The first, second and third stories are apparently sound. [At the Albany Hotel the first story wall] is cracked and the wall badly bulges outward." (Oakland Enquirer, 1906b).

"[At] the Physician's Building...the entire front of the upper floor [was] hurled into the street below. ...Not a brick or stone building...escaped damage, in most cases a part of the walls of the upper stories being torn away and thrown into the streets." (San Francisco Call-Chronicle-Examiner, 1906).

"The new school building at Thirty-ninth and Market streets was wrecked. The building...was nearing completion, the roof having been placed in position only a few days ago. As a result of the earthquake the roof caved in and portions of the pressed sandstone brick walls fell away." (Redding Courier-Free Press, 1906).

"Two horses...were killed by falling bricks at the Home bakery building." (Oakland Enquirer, 1906b).

"The brick walls of the Hyman, Davis & Co. warehouse on Third st. were completely leveled." (Oakland Enquirer, 1906a).

"Nearly every brick building in town suffered a loss of fire walls, while three or four old buildings were so badly injured that they were subsequently removed and new buildings erected in their place." (Leach, 1917, p. 314).

"The roof over Gates Stables at Thirteenth and Webster streets fell in. A number of horses were killed." (Oakland Tribune, 1906a).

Houses. "The [failure of the] underpinning of some few old frame houses caused these structures to collapse." (Lawson and others, 1908, p. 302).

"A frame building, an old two-story rickedty affair, at the intersection of Hobart street and Broadway, had fallen flat." (Leach, 1917, p. 314).

"At 266 Twelfth street a frame boarding house three stories high was swung entirely off its foundation and completely wrecked." (Berkeley Reporter, 1906d).

Smokestack. "The brick chimney of the California Cotton Mill was crumbled by the earthquake." (Oakland Tribune, 1906a).

Chimneys. "Chimneys fell very generally thruout the city" (Lawson and others, 1908, p. 302).

General. "There were very few breaks in the cast-iron gas mains. Two of these were caused by impacts of heavy debris falling from buildings and poles. One was...where heavy blocks of sandstone fell from the third story and the roof, breaking the main 30 inches below the bituminous rock." (Lawson and others, 1908, p. 302).

Injuries. Five people were killed at the Empire theater. "All were caught by the falling walls of the building, and were buried beneath tons of brick and broken timbers." (San Francisco Call-Chronicle-Examiner, 1906).

"In the Empire Theater lodging house besides the five killed, many persons were injured." (Berkeley Reporter, 1906d).

A.B. Van Slyke...was sleeping on the second floor of the [Empire Theater] building. ...He was caught in the debris caused by the falling of the fire wall of the Kahn building adjoining. He was pushed against the wall and held there by the brick and timbers." (Oakland Enquirer, 1906i).

"Helen Drew...was severely injured by falling brick, which struck her while still in bed." (Oakland Tribune, 1906b).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

OAKLAND CEMETERY

Location: OC, Alameda County 5 km northeast of Oakland.
Distance: 30 km east of the earthquake fault.
Geology: Type E.

Building. "The building of the Oakland Crematory Association adjoining Mountain View Cemetery is wrenched and twisted on its foundations. The chimneys and furnaces are demolished and the face of the building is badly cracked." (Oakland Enquirer, 1906a).

Cemetery. "In St. Mary's Cemetery on a small ridge...many monuments were moved or twisted and several were overthrown. ...Near the top of the ridge many monuments were overturned, and nearly all of them showed twisting or shifting. ...12 monuments in Mountain View Cemetery...were disturbed [shifted or twisted] by the earthquake." (Lawson and others, 1908, p. 302-303).

Intensity: Modified Mercalli VIII; Rossi-Forel IX.

OAKLAND SOUTHEAST

Location: OS, Alameda County 6 km southeast of Oakland.
Distance: 26 km east of the earthquake fault.
Geology: Type Av.

Buildings. "No foundations nor buildings were damaged to any visible extent." (Lawson and others, 1908, p. 303).

Smokestack. "A large smelter chimney...was not damaged by the shock." (Lawson and others, 1908, p. 303).

Chimneys. "In the vicinity of High Street about half of the chimneys fell." (Lawson and others, 1908, p. 303).

Plaster. "Plastering in the houses was severely cracked." (Lawson and others, 1908, p. 303).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

OAKLAND WATERFRONT

Location: OW, Alameda County 1 km south of Oakland.
Distance: 24 km east of the earthquake fault.
Geology: Type Am (alluvial marsh, probably filled).

Buildings (partial list). "The big Sessions coal bunkers on Fallon street...are a wreck. They have caved into a mass of waste. ...The big Butler grain and feed barn has collapsed. ...The tall chimney on the California Cotton Mills on Twenty-third Avenue, collapsed to within 25 feet of the ground, and even the portion left standing is badly cracked. ...[At the Oakland Planing Mill] many sheds are down and a new roof...collapsed. ...The new brickyard and magnesia factory near Clinton station on the estuary...is a total wreck. The walls have collapsed." (Oakland Enquirer, 1906c).

"The Rose Construction brick plant was razed completely. There is hardly one brick left standing on another. At the California Flax Mills at the foot of Kirkham street, the walls were shaken in and the heavy roofing is down on the machinery. ...The warehouse of the Sherman Concentrated Fruit Company at the foot of Oak Street collapsed... and is a total loss." (Oakland Herald, 1906).

"The plant of the Sherman Concentrated Fruit Company...is a complete wreck. It consisted of a two-story frame building 80x100 feet." (Oakland Enquirer, 1906a).

"The Rose Firebrick Company's plant, recently erected on the marsh near Clinton Station, East Oakland, was leveled by the earthquake. ...The piles of brick and mortar crumbled before the temblor and the framework of iron and sheeting was twisted out of semblance to any structure." (Oakland Tribune, 1906a).

Smokestack, injury. "The two smokestacks at the gas works at the foot of Grove Street fell, crashing through the roof of the works, crushing the boiler and killing one of the firemen." (San Francisco Call-Chronicle-Examiner, 1906).

"The huge 95-feet high brick smokestack [at the Rose Brick Co.] tumbled to the earth." (Oakland Tribune, 1906a).

Intensity: Modified Mercalli IX; Rossi-Forel IX.

PIEDMONT

Location: PM, Alameda County 3 km northeast of Oakland.
Distance: 28 km east of the earthquake fault.
Geology: Type E.

Smokestack. "One upper part of the big chimney over the Piedmont power house, which was partially demolished by the earthquake, was torn down yesterday." (Oakland Enquirer, 1906e).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

PINOLE

Location: PI, Contra Costa County 15 km west of Martinez.
Distance: 32 km east of the earthquake fault.
Geology: Type An/C.

Chimneys. "The quake demolished the chimneys in town." (Contra Costa Gazette, 1906a).

Watertank. "A large water tank crashed down through one of the powder mills." (Contra Costa Gazette, 1906a).

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

PLEASANTON

Location: PL, Alameda County 35 km east of Oakland.
Distance: 44 km east of the earthquake fault.
Geology: Type Av.

Buildings. "Nearly every brick building in town was somewhat injured. Cracks in the masonry and the dislodgement of occasional

individual bricks in arches above windows and cornices constitute the principal damage. The only stone house, a 2-story saloon, suffered more severely than any of the brick buildings, the walls being badly cracked at the corners and even partly thrown down at the northwest corner." (Lawson and others, 1908, p. 307-308).

Houses. "Wooden houses suffered no damage except the cracking of plaster." (Lawson and others, 1908, p. 308).

Chimneys. "30 per cent of all chimneys fell; 48 per cent of the brick chimneys fell; 30 per cent of the chimneys were terra-cotta, but only 3 per cent of these fell; of the brick chimneys which did not fall, 30 per cent were cracked." (Lawson and others, 1908, p. 307).

General. "Such articles as vases, clocks, and dishes fell in most cases and milk and water were spilt from open vessels. Practically no plaster fell, but houses that were plastered had numerous cracks in the walls. ...No window panes were lost." (Lawson and others, 1908, p. 307-308).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

POINT RICHMOND

Location: PR, Contra Costa County 25 km west of Martinez.

Distance: 23 km east of the earthquake fault.

Geology: Type Ae/E or E [exact location uncertain].

Buildings. "The large Santa Fe railroad shops were unroofed by the earthquake and part of the machinery ruined." (Contra Costa Gazette, 1906a).

"The Santa Fe boiler house...was wrecked, the walls falling and smashing the machinery." (Los Angeles Examiner, 1906).

Discussion of intensity: The Rossi-Forel rating of the building damage in intensity IX, but the Modified Mercalli intensity rating is less because the buildings might have been poorly constructed.

Intensity: Modified Mercalli VIII; Rossi-Forel IX.

RICHMOND

Location: RI, Contra Costa County 21 km west of Martinez.

Distance: 26 km east of the earthquake fault.

Geology: Type Av.

Buildings. "Some walls fell." (Fridell, 1954, p.51).

"The Southern Pacific station...was lifted off its foundation and turned partly around. Houses were shaken severely and much damage was done." (Contra Costa Gazette, 1906a).

Smokestack. "One of the big smokestacks of the Standard Oil works toppled over but that was the extent of the damage to the plant." (Oakland Enquirer, 1906c).

Chimneys. "Chimneys fell." (Fridell, 1954, p.51).

Discussion of intensity. The description suggests that there were many smokestacks that did not fall, indicating intensity VIII.

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

SAN LEANDRO

Location: SL, Alameda County 15 km southeast of Oakland.
Distance: 28 km east of the earthquake fault.
Geology: Type Ae/E.

General. "Half the windows in the stores were broken, and nearly every chimney was down. All the loose objects in the houses, such as dishes, etc., were thrown down. The plastering was greatly cracked. The houses were not seriously damaged, and only 2 have been condemned." (Lawson and others, 1908, p. 303).

"Those who ran out into the streets say that the landscape was an exceedingly unsettled one, the ground rising and falling like waves of the sea, while the trees waved to and fro like the rigging of a ship in a storm. Some say that the level land was converted into hills and valleys." (Alameda Daily Argus, 1906c).

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

SAN LORENZO

Location: SZ, Alameda County 19 km southeast of Oakland.
Distance: 22 km east of the earthquake fault.
Geology: Type Av.

Chimneys. "Almost all the chimneys in this vicinity were down." (Lawson and others, 1908, p. 304).

Cemetery. "At the San Lorenzo cemetery, about half the tall monuments were down." (Lawson and others, 1908, p. 304).

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

SAN RAMON

Location: SR, Contra Costa County 29 km south of Martinez.
Distance: 44 km east of the earthquake fault.
Geology: Type An/C.

Chimneys. "Most chimneys had fallen." (Lawson and others, 1908, p.309-310).

General. "San Ramon saloon...slid off its foundations. ...Several window panes were broken in the building, and glassware was wrecked in quantites." (Lawson and others, 1908, p.309-310).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

SANTA RITA

Location: SN, Alameda County 35 km east of Oakland.
Distance: 45 km east of the earthquake fault.
Geology: Type Av.

Chimneys. "Chimneys had fallen on all the houses, but as they were not of brick the damage was slight." (Lawson and others, 1908, p. 309).

Shelf items. "In the grocery store and bar-room articles were thrown." (Lawson and others, 1908, p. 309).

Discussion of intensity: Descriptions elsewhere (for instance, at Pleasanton) indicate that non-brick chimneys are damaged much less than brick chimneys, so the general fall of non-brick chimneys here indicates that if the chimneys had been brick, they probably would have all fallen.

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

SELBY

Location: SE, Contra Costa County 11 km west of Martinez.
Distance: 39 km east of the earthquake fault.
Geology: Type C.

Smokestack. "The big smokestack at the smelter was cracked its entire length." (Contra Costa Gazette, 1906a).

Chimneys. "The chimneys on nearly all the houses were razed. At the flats every chimney except one was demolished. (Contra Costa Gazette, 1906a).

Intensity: Modified Mercalli VIII+; Rossi-Forel VIII+.

SUNOL

Location: SU, Alameda County 40 km east of Oakland.
Distance: 37 km east of the earthquake fault.
Geology: Type Ae/D.

Chimneys. "Only a small percentage of the chimneys fell. Over 75 per cent of the chimneys...were broken. Some were twisted in a clockwise direction, while others were apparently thrown straight. ...Many chimneys were cracked but were still in place." (Lawson and others, 1908, p. 307).

General. "Of other objects, few except bottles and vases fell; and a window was broken at the post-office. ...A few windows were broken, notably those of the post-office." (Lawson and others, 1908, p. 307).

Intensity: Modified Mercalli VII+; Rossi-Forel VII+.

TESLA

Location: TS, Alameda County 61 km east of Oakland.
Distance: 63 km east of the earthquake fault.
Geology: Type C.

Smokestacks. "One of the huge brick smokestacks at the pottery works was cracked and half of it fell through the roof." (Livermore Herald, 1906).

Water tank. "A large water tank collapsed." (Livermore Herald, 1906).

Discussion of intensity: The description suggests that there were several smokestacks which did not fall down, which indicates intensity VIII.

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

VERONA

Location: VE, Alameda County 39 km east of Oakland, south of Pleasanton.

Distance: 40 km east of the earthquake fault.

Geology: Type D.

Chimneys. "All the chimneys on the main house of the Hearst residence, 6 in number, were cracked, but none was thrown down." (Lawson and others, 1908, p. 307).

Smokestack. "The chimney of the power plant...was found cracked." (Lawson and others, 1908, p. 307).

Intensity: Modified Mercalli VII+; Rossi-Forel VII+.

VINE HILL

Location: VH, Contra Costa County 3 km east of Martinez.

Distance: 46 km east of the earthquake fault.

Geology: Type D.

General. "The earthquake did much damage...to chimneys, crockery, china, etc. [several fallen chimneys are listed]." (Contra Costa Gazette, 1906b).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

WALNUT CREEK

Location: WC, Contra Costa County 13 km south of Martinez.

Distance: 41 km east of the earthquake fault.

Geology: Type An/C.

Chimneys. "About 50 per cent of all chimneys were thrown down." (Lawson and others, 1908, p. 310).

General. "A water tank at the livery stable fell. Goods in the grocery store were thrown down in quantities. ...Two barns, weak structures, were moved slightly from their foundations. Plaster in several houses was cracked." (Lawson and others, 1908, p. 310).

Intensity: Modified Mercalli VIII; Rossi-Forel VIII.

WARM SPRINGS

Location: WS, Alameda County 46 km southeast of Oakland, now part of Fremont.

Distance: 29 km east of the earthquake fault.

Geology: Type Av.

General. "No buildings were damaged, beyond the falling of two chimneys" (Lawson and others, 1908, p. 282).

"At Josiah Stanford's house the carriage house collapsed, destroying a number of vehicles." (Oakland Enquirer, 1906h).

Discussion of intensity: There is a conflict in the reporting of the amount of damage.

Intensity: Rossi-Forel VIII; Modified Mercalli VIII.

TABLE 4: EARTHQUAKE-CAUSED GROUND FAILURES

IN ALAMEDA AND CONTRA COSTA COUNTIES

ALAMEDA
Location: AL, Alameda County 3 km south of Oakland.
Distance: 24 km east of the earthquake fault.
Geology: Type Av.

Ground failure. "The train and boat service via both moles [piers] is at a standstill on account of damaged tracks on the marsh. Both lines across the marsh were twisted and thrown out of grade." (Alameda Daily Argus, 1906a).

"Great fissures opened on the Webster Street roadway, and for half a mile the track foundations dropped four feet, leaving the rails and ties suspended. The heavy steel rails recently laid...were bent and twisted in serpentine fashion and all rail traffic was suspended on the Webster street marsh." (Oakland Herald, 1906).

"The Versailles avenue station of the narrow gauge line was so twisted and warped that it could not be opened." (Alameda Daily Argus, 1906a).

"Colton Brothers are repairing the Bay Farm Island bridge. The bridge was badly wrecked. ...The ground on this side is badly cracked." (Alameda Daily Argus, 1906b).

"The Webster street bridge and Island bridge are twisted out of shape. Near the latter the quake opened up a fissure in the roadway twenty feet long, through which the sea water is gushing." (Oakland Tribune, 1906a).

ALVARADO
Location: AV, Alameda County 30 km southeast of Oakland, now part of Union City.
Distance: 25 km east of the earthquake fault.
Geology: Type Av.

Cracks, deformation and liquefaction. "Along the banks [of Alameda Creek]...a large number of cracks extend, roughly parallel with the stream. Considerable masses next to the stream-bed slumped toward the same, leaving gaping cracks 1 to 2 feet wide, and carrying with them small outlying buildings. ...Cracks in the ground may be found as far as 250 feet from the creek. They...were easily traced by the streaks of bluish-gray sand which has issued from them, together with considerable quantities of water. According to the Chinese cook...the cracks nearest to his dwelling opened and closed several times in succession during the quake; and large volumes of mud-laden water gushed from them, splashing up some 10 feet in the air at each closing. A large crack of this kind opened under the northwest corner of the dwelling, and the superintendent estimates that fully 500 gallons of water gushed from it, the flow continuing with decreasing volume for about an hour. ...In the roadway south of the mill, water oozed out in a number of places, without the production of visible cracks. The water pipes and hydrants in this vicinity were crusht in several places." (Lawson and others, 1906, p. 305).

Deformation. "The fence...shows that the ground there has been raised in a low hump. The sewer pipe leading west to the creek was detached from the house by a space of 22 inches." (Lawson and others, 1908, p. 305).

"[At the pumping station] on the marsh land near the Bay shore, one mile west of Alvarado...the foundation settled about 2 ft., breaking all the pipe connections. During the quake the channel of the creek disappeared, its bottom being raised to the general level of the adjoining land." (Duryea and others, 1907, p. 249-250).

BAY FARM ISLAND

Location: BF, Alameda County 9 km south of Oakland.
Distance: 23 km east of the earthquake fault.
Geology: Type Am.

Ground failure. "Bay Farm Island shows many cracks and crevices." (Alameda Daily Argus, 1906a).

BERKELEY

Location: BK, Alameda County 8 km north of Oakland.
Distance: 27 km east of the earthquake fault.
Geology: Type Av.

Ground crack. "There is a crack three blocks long in University avenue from Third street down." (Berkeley Reporter, 1906c).

Ground deformation. "The lower alluvial flats of Oakland and Berkeley were seriously disturbed." (Rickard, 1906).

Absence of ground failure. "Town Engineer McClure and Superintendent of Streets Turner have just completed a careful examination of all the streets and culverts in this city and have made the surprising discovery that the earthquake of last month and the large number of minor temblors that have followed the large one, have not damaged the streets or culverts in the least. It was feared that many of the larger concrete culverts...had suffered during the big shake, but the inspection...has shown that absolutely no damage was done. ...Not a water nor a gas main nor a sewer in this city was broken by the seismic disturbance." (Berkeley Daily Gazette, 1906c).

"A surprising feature...is that of the Euclid avenue hill, which about a year ago caused considerable alarm by shifting several feet, throwing houses out of plumb and breaking gas and water mains. ...To the surprise of all, however, the hillside was intact [after the earthquake] and none of the homes damaged any more than those located in other sections of the city. ...Not a water nor a gas main nor a sewer...was broken." (Berkeley Daily Gazette, 1906c).

CLAYTON

Location: CL, Contra Costa County 19 km east of Martinez.
Distance: 57 km east of the earthquake fault.
Geology: Type D.

Crack. "On a hillside...on the west side of Mount Diablo...a crack opened in the ground about 30 feet long...gaping 4.5 inches." (Lawson and others, 1908, p. 310).

LIVERMORE

Location: LV, Alameda County 45 km east of Oakland.
Distance: 55 km east of the earthquake fault.
Geology: Type Av.

Ground failure. "In the field of John Meyer, on the old Alviso Place, about two miles north of town, is what numerous small boys about town have dubbed a 'mud volcano.' It is there as a result of the temblor, and many of the curious-minded have driven out to look at it. It consists of a mound, or small hill, thrown up by subterranean force of some kind to a height of several feet above the surrounding land. The ground is very much broken by large cracks, which run in concentric circles, and through which at various times since the quake have issued gas, water and mud." (Oakland Tribune, 1906i).

"The summit of the hill...was found crowned by a series of concentric deformations, rising one above another. ...The uplift along the two principal cracks was found to be 19 and 16 inches, respectively. ...While the phenomenon is described by many as a 'mud flow' or 'mud spring,' there are no indications whatever of a 'flow,' strictly speaking." (Lawson and others, 1908, p. 308).

MARTINEZ

Location: MA, Contra Costa County 35 km northeast of San Francisco.
Distance: 47 km east of the earthquake fault.
Geology: Type An/D.

Ground deformation and cracks. "The railroad track east of Martinez...was thrown 3 inches out of alinement to the north. Many cracks occurred in the embankment on both sides of the track. A series of 5 small transverse waves was found in the embankment. ...The distance between crests was about 10 to 15 feet; amplitude estimated at 3 inches. This embankment lies in flat marshy land." (Lawson and others, 1908, p. 310).

NEWARK

Location: NW, Alameda County 35 km southeast of Oakland.
Distance: 23 km east of the earthquake fault.
Geology: Type Av.

Liquefaction. "Cracks opened in the ground in the vicinity of 2 small watercourses. ...In every case they emitted the same bluish sand

(with the water). In one place, considerable water was left standing in shallow ponds." (Lawson and others, 1908, p. 280).

"About a mile north of this town a fissure was opened by the earthquake. This fissure is about a mile and a half in length and from eight to twelve inches in width. From the fissure quantities of water are being emitted, although the land is what might be termed a dry district." (Oakland Tribune, 1906d).

"Upon the grounds of Mrs. Richard Gibbons a great number of small geysers made their appearence, some sprouting brackish water and quicksand, others a dark, muddy fluid, and still others a water tasting of borax. On the grounds of the late A. Rose the earth opened and water and sand gushed out, the flow failing after a little time. The same thing happened in the great earthquake of 1868." (Oakland Tribune, 1906g).

Ground deformation. "The track suffered a slight shifting in several places north of the village." (Lawson and others, 1908, p. 280).

NILES

Location: NL, Alameda County 35 km southeast of Oakland, now part of Fremont.
Distance: 30 km east of the earthquake fault.
Geology: Type Ae/C.

Rockfall. "Large boulders [were] dislodged from the hill and crashed through the pipeline of the Spring Valley Water Company." (San Francisco Call-Chronicle-Examiner, 1906).

Absence of ground deformation. "According to the track-boss, the railroad track suffered no displacements anywhere between Niles and Irvington." (Lawson and others, 1908, p. 304).

OAKLAND

Location: OA, Alameda County 13 km east of San Francisco.
Distance: 25 km east of the earthquake fault.
Geology: Type Av.

Ground failure. "Save for the bursting of one 24-inch main located on the south side of the Twelfth Street dam...209 miles of sewers and their numerous feeders stood the shock of the quake and remained intact. [At] the Twelfth Street dam [of Lake Merritt]...the southern half of it, which is built on made ground, sunk a distance of probably eighteen inches." (Fresno Morning Republican, 1906c).

Ground deformation. "The lower alluvial flats of Oakland and Berkeley were seriously disturbed." (Rickard, 1906).

OAKLAND WATERFRONT

Location: OW, Alameda County 1 km south of Oakland.
Distance: 24 km east of the earthquake fault.
Geology: Type Am (alluvial marsh, probably filled).

Ground failure. "The magnesite works at the foot of Ninth Avenue ...have sunk several feet and now the ground on which they stood is under water. ...The land on which the works stand is very unsubstantial, being simply built up by the process of dredging." (Oakland Enquirer, 1906g).

Ground failure (?). "The piles holding up the Sunset Lumber Company were twisted away and will have to be replaced." (Oakland Enquirer, 1906g).

PINOLE

Location: PI, Contra Costa County 15 km west of Martinez.
Distance: 32 km east of the earthquake fault.
Geology: Type An/C.

Settlement. "The railway bridges and culverts...sank two feet." (Los Angeles Examiner, 1906).

Cracks. "At Pinole there were cracks in the ground parallel to the [railroad] track and crossing it, several inches wide where the ground was soft." (Sacramento Union, 1906).

POINT RICHMOND

Location: PR, Contra Costa County 25 km west of Martinez.
Distance: 23 km east of the earthquake fault.
Geology: Type E.

Buildings. "The large Santa Fe railroad shops were unroofed by the earthquake and part of the machinery ruined." (Contra Costa Gazette, 1906a).

Ground failure (probably at the flat ground of type Am on the north side of Point Richmond). "Near the Santa Fe roundhouse, several feet of track sank into the earth." (Fridell, 1954, p.51).

Landslide. "A landslide choked tunnel No. 2 near Pt. Richmond. ...Water mains in Richmond and Pt. Richmond were broken." (Los Angeles Examiner, 1906).

SAN PABLO CREEK

Location: SP, Contra Costa County 15 km west of Martinez.
Distance: 31 km east of the earthquake fault.
Geology: Type C.

Landslide. "The slide is on the east slope of a steep hillslope and extends from the top of the hill nearly to the bottom, about 400 feet on the slope. The width is about 1500 feet. At the northeast corner the scarp is greatest, reaching perhaps 50 feet. ...The slide does not extend all the way down the slope, its lower edges being

fully 100 feet or more above the bottom of the gulch." (Lawson and others, 1908, p. 391-392).

"[Justice Robert Edgar] states that...the mountains have slipped down into the valleys, tearing up great oaks by the roots and changing the topography of the land on the Mills ranch where the most violent disturbance was noted. The place...is about four miles southeast of the town of San Pablo on the San Pablo creek." (Berkeley Daily Gazette, 1906b).

Ground failure. Landslide.

SANTA RITA

Location: SR, Alameda County 35 km east of Oakland.
Distance: 45 km east of the earthquake fault.
Geology: Type Av.

Cracks. "A small, flat levee along...Tassajara Creek...showed several somewhat concentric cracks along which the ground had slipt down and toward the creek from 1 to 3 inches." (Lawson and others, 1908, p. 309).

TABLE 5

EARTHQUAKE-CAUSED FIRES IN

ALAMEDA AND CONTRA COSTA COUNTIES

BERKELEY

Location: BK, Alameda County 8 km north of Oakland.

Fire. "One of the heroes of the early morning quake was A.O. Donough. ...The shock threw over a lighted kerosene lamp which was standing on a table and at once started a lively blaze. Without a moment's hesitation, Donough picked up the blazing lamp and threw it out of the window. He then directed his attention to the blaze which he succeeded in extinguishing." (Berkeley Reporter, 1906a).

"He saw the front of Chris Brun's building crash outward, and a moment later a burst of flame from the chemical laboratory of the El Dorado Oil Works. ...The fire in the laboratory had been caused by the upsetting of chemicals that exploded. The fire department's response was prompt, and the blaze was soon checked. While on the way to answer this alarm, the North Berkeley firemen turned aside to attend to what seemed a dangerous fire in the north end. It was only a chimney fire, however, and after momentary investigation was neglected for the more threatening one." (Berkeley Reporter, 1906a).

FRUITVALE

Location: FV, Alameda County 5 km southeast of Oakland, now part of Oakland.

Fire. "Warren's Drug Store, corner of East Fourteenth street and Fruitvale avenue, was set on fire...but the blaze was checked with but slight loss." (Oakland Enquirer, 1906a).

MARTINEZ

Location: MA, Contra Costa County 35 km northeast of San Francisco.

Fire. "Ravenous flames ate up a portion of Grangers Wharf. ...Six houses were destroyed in the Italian fishing village immediately after the shock, despite the valient work of the local fire boys." (Contra Costa Gazette, 1906a).

OAKLAND

Location: OA, Alameda County 13 km east of San Francisco.

Fire. "Fire broke out...at No. 442 Edward street as the result of the earthquake, and so rapid was the spread of the flames that Mrs. Martin had to jump from a second-story window to save herself from death. The fire started from a gas range which the jarring disconnected. An alarm was promptly turned in and firemen arrived on the

scene, but there was no water. ...The building was razed to the ground. ...The home...at No. 440 Edward street caught fire from the Martin home, as did that of S.C. Brown, at No. 446 Edward street. Both these fires were controlled before they had done much damage." (Oakland Enquirer, 1906).

"With the first shock Miss Benton rose to extinguish a lighted kerosene heater. ...Her foot is badly burned." (Oakland Tribune, 1906f).

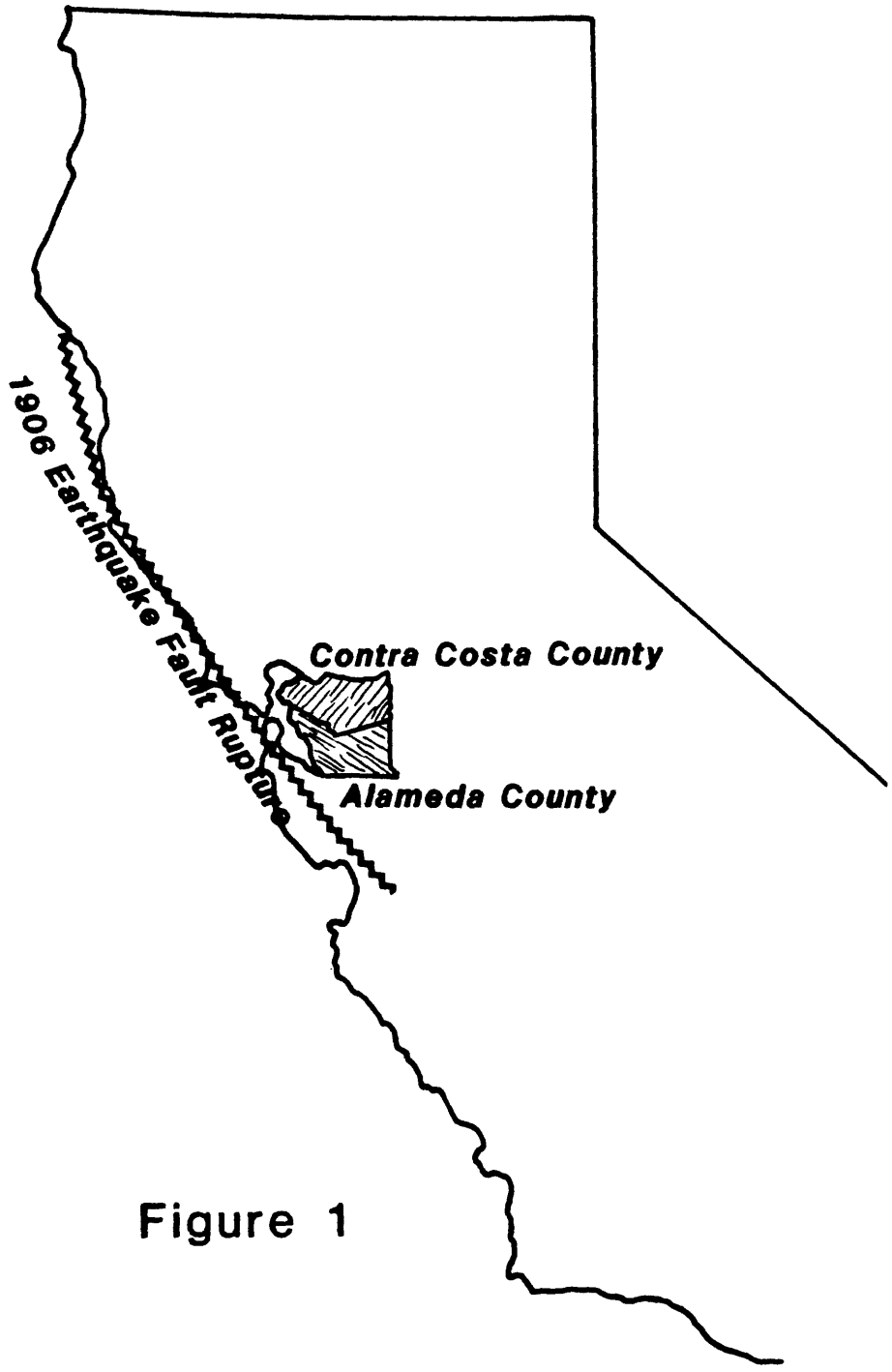
1906 Earthquake Fault Rupture
Contra Costa County
Alameda County

Figure 1

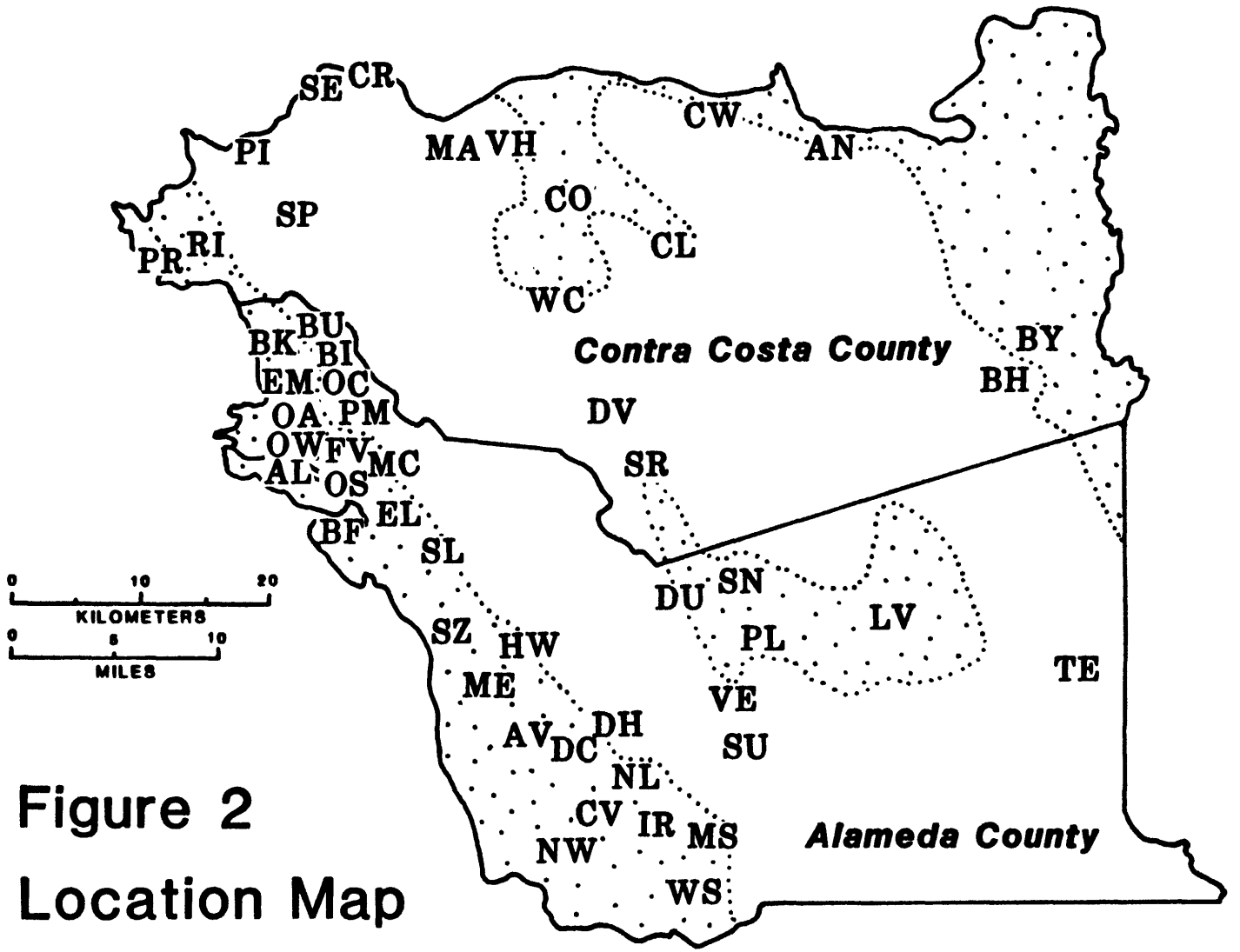

Figure 2
Location Map

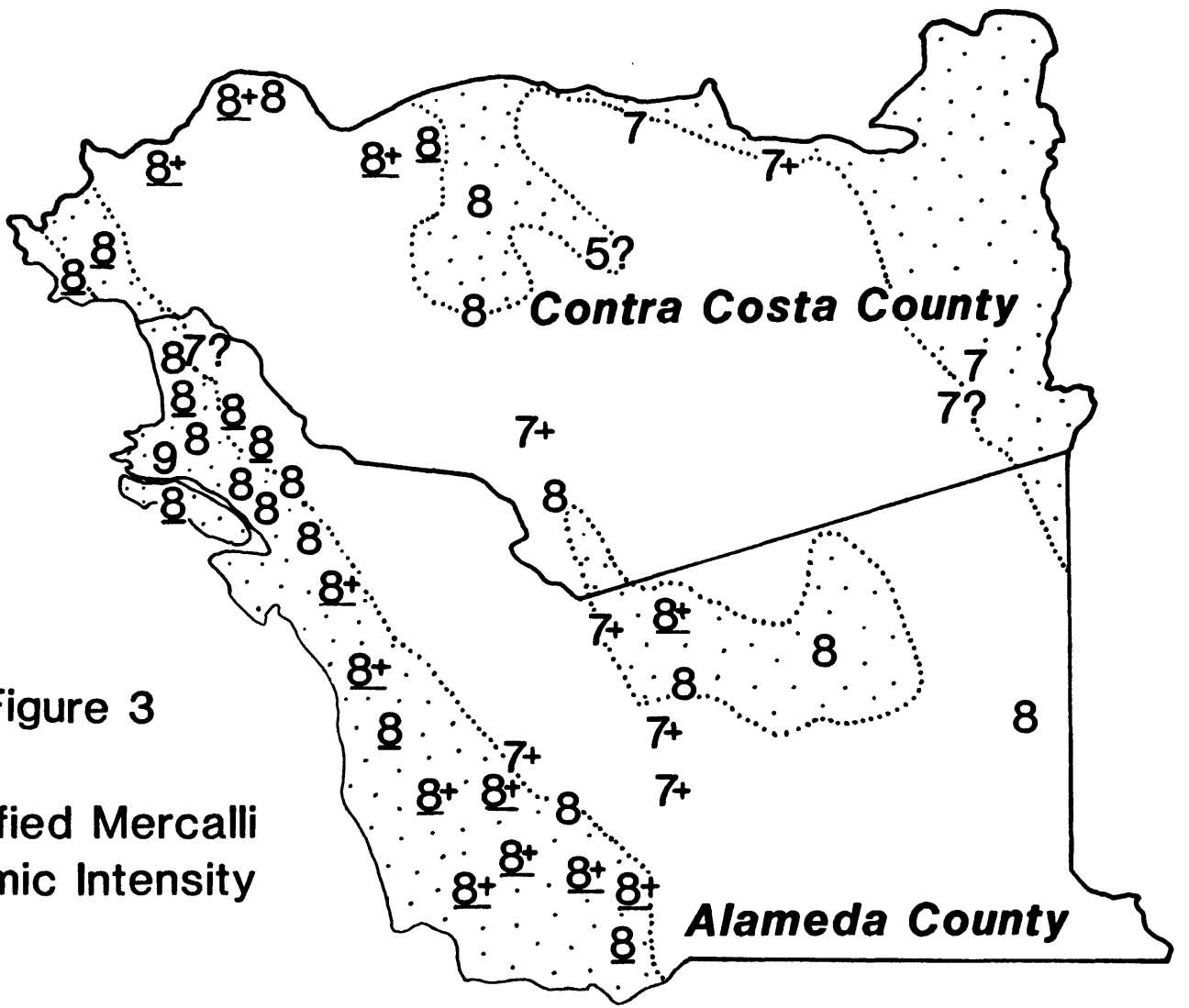

Figure 3

Modified Mercalli
Seismic Intensity