Historic Ground Failures in Northern California Triggered by Earthquakes

By T. L. YOUD *and* S. N. HOOSE

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HISTORIC GROUND FAILURES IN NORTHERN CALIFORNIA TRIGGERED BY EARTHQUAKES

By T. L. YOUNG and S. N. HOOSE

ABSTRACT

A major source of earthquake-related damage and casualties in northern California has been ground failures generated by the seismic shaking, including landslides, lateral spreads, ground settlement, and surface cracks. The historical record shows that, except for offshore shocks, the geographic area affected and the quantity and general severity of ground failures increase markedly with Richter magnitude. Hence, the largest historical event, the 1906 San Francisco earthquake, has been the most important generator of ground failures. Because of recent population growth and land development in northern California, the potential for damage in future events is enormous compared with that existing in 1906.

Reports of the 1906 San Francisco earthquake and other northern California earthquakes and descriptions of ground failures therein are used to (1) identify and clarify the types of ground failures associated with earthquakes, (2) provide a guide for engineers, planners, and others responsible for minimizing seismic hazards, and (3) form a data base for other geotechnical studies of earthquake-triggered ground failures.

Geologic, hydrologic, and topographic setting have an important influence on ground failure development as well as distance from the causative fault. Areas especially vulnerable to ground failure in northern California have been oversteepened slopes, such as mountain cliffs, streambanks, and coastal bluffs, and lowland deposits, principally Holocene fluvial deposits, deltaic deposits, and poorly compacted fills. Liquefaction has been the direct cause of most lowland failures. The historical record suggests that ground failures during future large earthquakes are most likely to occur at the same or geologically similar locations as failures during previous earthquakes.

INTRODUCTION

Earthquakes are one of the most perilous natural hazards affecting northern California. One great (Richter magnitude, M , greater than 8) and several major (M greater than 6) earthquakes have struck that region in historic time (last 200 years). These shocks caused extensive property damage and inflicted several hundred casualties. Because of large population growth and land development in recent years, the potential for damage in northern California is enormous today compared with that existing in 1906, the date of the last major destructive shock.

A principal cause of past earthquake damage and casualties has been seismically generated ground failures in the form of landslides, lateral spreads, differ-

ential settlements, and ground cracks. In this study, earthquake reconnaissance reports and newspaper reports from past events in northern California are reviewed, and ground failures described therein are identified, classified by present criteria, and located on modern maps.

The purposes of this study are (1) to identify and clarify the types of ground failures associated with earthquakes, (2) to provide a guide for engineers, planners, and others responsible for minimizing seismic hazards, and (3) to form a data base for further geotechnical studies of earthquake-triggered ground failures.

Each reported ground failure site has been given a location number, and descriptions of that failure excerpted from the literature are tabulated by location number in tables 5-9. The location number is entered on the appropriate plate near the location of the failure, and a symbol indicating the inferred type of failure is placed as accurately as possible on the plate over the corresponding failure site. This classification symbol is also entered in the descriptions of failures at that location number along with a letter symbol indicating the geographical accuracy with which the failure can be relocated on modern maps. Explanations for the classification symbols are given on each plate and in the notes to the descriptions of failures; also, explanations for the accuracy symbols are listed in these notes.

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AREA OF INVESTIGATION

The region considered in this study (fig. 1) extends from the southern parts of Monterey, Kings, and Tulare Counties (approx lat 36° N.) on the south to the Oregon border (lat 42° N.) on the north and from the Pacific Ocean on the west to the Nevada border or crest of the Sierra Nevada Mountain range on the east. The

FIGURE 1.—Map of California showing Coast Ranges province, areas covered by regional maps, and areas in which ground failures have occurred during historic northern California earthquakes.

area affected by the 1872 Owens Valley, Calif., earthquake was thus excluded from consideration in this report.

Although earthquake vibrations have been felt historically over all of northern California, ground failures of greater than very slight severity (table 1) have been reported only from a narrow strip along the Pacific Coast that lies almost entirely within the Coast Ranges province (fig. 1) (Bailey, 1966, p. 2). This does not mean that severe earthquake-induced ground failures cannot occur in other areas, but rather that they have not in recent times.

Geographically the Coast Ranges province forms a band along the coastline of northern California that extends inland as far as 70 miles (110 km) from the Pacific Coast. The province is composed of several northwest-trending mountain ranges and intermontane valleys. The ranges are made up of Mesozoic and Cenozoic rocks that have been faulted and folded (Christensen, in Bailey, 1966, p. 305-313). The larger valleys commonly are deeply alluviated and traversed by meandering rivers and streams. The most important structural feature in the province is the San Andreas fault, which strikes approximately N. 35° W. and cuts across the general trend of the mountain ranges at a small angle (Oakeshott, in Bailey, 1966, p. 357-372). Most northern California earthquakes are associated with movements on this fault or subsidiary faults in the San Andreas fault system.

Historic earthquakes in northern California that have triggered ground failures are listed in table 1, and approximate epicentral locations are plotted on figure 1; for the 1906 San Francisco and 1868 Hayward earthquakes, the approximate zones in which ground failures occurred are delineated. This figure confirms that the 1906 San Francisco earthquake is by far the most significant event for ground failure studies in this region because of the vast area affected and also the number and severity of the failures generated. The tabulation also shows that earthquakes with magnitudes less than 4 have produced no reported (and thus no consequential) ground failures. Above magnitude 4, severity of generated ground failures generally increases with magnitude.

RAINFALL AND GROUND WATER CONDITIONS IN 1906

Ground water conditions are an important factor controlling development of many seismically generated ground failures, especially those associated with liquefaction. In most upland areas, ground water conditions at any given time are dependent on antecedent climatological conditions, particularly precipitation.

TABLE 1.—Northern California earthquakes of 1769–1970 associated with reported ground failures

[Severity of ground failure is classified as follows: Very slight—a few minor ground cracks or landslides in a small localized area; Slight—several instances of minor ground cracks and landslides over an area of several square miles; Moderate—damaging or potentially damaging ground cracks and landslides over an area of several tens of square miles; Severe—large ground cracks and landslides over an area of several hundreds of square miles or more. Location numbers are assigned to ground failure sites in areas covered by plates 1–5. Descriptions of failures are given by location number in tables 5–9. Data from Coffman and von Hake (1973); Holden (1898); Townley and Allen (1939); Wood, Allen, and Heck (1939)]

Year	Date	Epicentral area	Maximum Modified Mercalli intensity	Richter magnitude	Severity of ground failure	Location No.
1800	Oct. 11(?)	San Juan Bautista			Moderate(?)	35
1836	June 10	San Francisco Bay	IX–X		Moderate(?)	
1838	June	San Francisco Bay area	X		Moderate to severe(?)	172, 202
1852	Nov. 22–24	San Francisco peninsula	VIII		Moderate(?)	244
1853	Oct. 23	Eureka	VIII		Very slight	349
1855	Jan. 24	Downieville			do	
1857	Jan. 9	Fort Tejon	IX		do	253
1861	July 3	Contra Costa–Alameda Counties	VIII		do	168
1865	Oct. 1	Fort Humboldt and Eureka	VIII–IX		do	349
1865	Oct. 8	Santa Cruz Mountains	VIII–IX		Moderate	25, 46, 60, 158, 202, 209, 212
1866	Feb. 17	Klamath River			Moderate(?)	
1868	Oct. 21	Hayward	IX–X		Moderate	91, 149, 151, 153, 163, 170, 171, 172, 174, 176, 198, 199, 200, 201, 202, 205, 209, 224, 225
1883	Oct. 22	Merced River			Very slight	
1885	Mar. 30	Southeast of Hollister	VII		do	33
1890	Apr. 24	Monterey Bay region	VII		Slight	29, 33
1892	Apr. 19	Vacaville	IX		do	255, 256, 257, 259
1892	Apr. 21	Winters	IX		do	256, 258
1898	Mar. 30	Mare Island	VIII		Very slight	251
1898	Apr. 14	East of Mendocino	VIII–IX		do	314
1906	Apr. 18	San Francisco	XI	8.3	Severe	Most locations
1908	Aug. 18	Eureka	VII		Very slight	348
1915	Feb. 21	Near Lassen Peak			Slight(?)	
1915	Apr. 5	Coleville region			Very slight	
1919	Jan. 4	Shasta County			do	
1923	Jan. 22	Upper Mattole & Petrolia	IX	7.3	do	338
1926	July 25	Near Idria, San Benito Co	VII		do	6
1927	Aug. 20	Humboldt Bay	VIII		Slight to moderate	353
1932	June 6	Humboldt County	VIII	6.4	Slight	345
1933	May 16	Fremont	VII		Very slight	165
1947	June 22	Gilroy	VI	5.0	do	47
1953	Dec. 16	Watsonville	VI	4.6	do	28
1954	Apr. 25	East of Watsonville	VIII	5.2	do	27
1954	Aug. 12	do	VI		do	31
1954	Sep. 15	East of Merced	VI		do	
1954	Dec. 21	Eureka–Arcata	VII	6.6	Moderate	340, 349–354
1957	Mar. 22	West of Daly City	VII	5.3	do	132, 133, 232, 235–242
1958	Dec. 11	Southwest of San Francisco	VI	4.7	Very slight	132
1959	Mar. 2	Near Gilroy	VI	5.3	Slight	31, 47
1961	Apr. 5	Humboldt County	VI	5.0	Very slight	334
1962	June 6	Near Lakeport			do	near 310
1963	Sep. 14	East of Watsonville	VII	5.4	do	29, 30
1965	Sep. 10	Pittsburg	VI	4.8	do	180
1967	Sep. 28	Morgan Hill	VI	5.0	do	48
1968	June 25	Petrolia–Honeydew	VII	5.5	do	338
1969	Oct. 1	Santa Rosa	VII–VIII	5.7	do	295
1970	May 18	Fort Jones area	V	4.0	do	

Precipitation varies considerably in the Coast Range province, both in time and in location. Average rainfall is in excess of 100 in. (2,500 mm) per year in some areas near the Oregon border but generally decreases southward to as little as 12 in. (300 mm) per year at some points in the southern Coast Ranges. Locally the average rainfall is variable, generally being greater nearer the ocean and at higher elevations. Rainfall over the entire area is seasonal, with the bulk of the

major storms occurring in the months of October to May (Sprague, 1941, p. 795–796).

Of special interest to this study are the rainfall records for the winter immediately preceding the 1906 San Francisco earthquake, (McAdie, 1906; U.S. Weather Bureau, 1912.) The 1905–06 monthly rainfall records for five stations in the coastal section of northern California (fig. 2) indicate that precipitation during the 1905–06 year was from 7 to 76 percent greater than

FIGURE 2.—Monthly rainfall data from several northern California stations for the 1905-06 water year (U.S. Weather Bureau, 1912), compared with average monthly rainfall data (Environmental Data Service, 1971) for those same stations.

normal at the selected stations and that March was an exceptionally wet month with rainfall ranging from 50 to 200 percent above normal. A statewide rainfall map for March 1906 is plotted on figure 3.

March and April, 1906, daily rainfall records from three coastal stations are plotted on figure 4. These data show that the last major storm prior to the 1906 earthquake occurred during the last few days of March and that no significant precipitation fell in the 17-day

FIGURE 3.—Map showing rainfall distribution in California during March 1906 (after McAdie, 1906, p. 35).

period immediately preceding the earthquake. This information suggests that the ground water level was probably high at the time of the earthquake and that the soils above the water table probably were fairly well drained. These soil moisture conditions contributed to the development of ground failures during the 1906 earthquake.

GROUND FAILURE TYPES

Ground failure is defined as a permanent ground movement (Youd, 1975). In this report only those ground failures triggered by seismic shaking are considered, including various types of landslides, lateral spreads, ground settlement, and ground cracks. Many of these failures are commonly caused by liquefaction, which is defined as "the transformation of a granular material from a solid state into a liquefied state as a consequence of increased pore-water pressures" (Youd, 1973, 1975). Ground failures are categorized herein as follows: Hillside landslides include rotational slumps, block glides, soilfalls and rockfalls, shallow debris landslides, and flows (Varnes, 1958, 1978; Youd, 1975); valley floor failures include lateral spreads, slumping of streambanks, and ground settlement (Varnes, 1958, 1978; Youd, 1975); miscellaneous ground cracks in-

FIGURE 4.—Daily rainfall data at three coastal stations for March and April 1906 (data from McAdie, 1906, p. 32-45).

clude all surficial fissures triggered by seismic shaking (cracks caused by direct tectonic movements were not generally considered) that were, apparently, not generated by another form of ground failure. Other phenomena considered because of their relation to ground failure include sand boils and disturbances of artesian wells. All the classifications given on the plates and in the descriptions of failures (tables 5-9) are those inferred by the authors from written descriptions and modern geological and geotechnical reports and maps.

Hillside ground failures generally are easily recognizable in the literature from the terminology or descriptions given. Most authors referred to hillside landslides as "landslides" with no further details given. In the State Earthquake Investigation Commission report (Lawson, 1908) the subclasses slumps, rock avalanches, and earthflows are used. Some general descriptions of the character and distribution of hillside landslides triggered by the 1906 San Francisco earthquake are contained in notes 1-8 of table 2.

Descriptions of valley floor ground failures vary greatly in their clarity and detail. Slumped streambanks generally are easily recognizable from published

descriptions; however, in some instances classifications were inferred from descriptive evidence such as cracks and vertical separations along stream channels. Evidence used to categorize ground movements as lateral spreads include notations of lurching (most phenomena generally termed as lurching are, in fact, lateral spreads associated with liquefaction (Youd, 1973, 1975)); contraction of stream channels; lateral, extensional or compressional displacements of fences, streets, pipelines, rails, and other constructed works; and laterally shifted intertidal marsh deposits. Published notes describing the typical character and extent of lateral spreads during the 1906 event are given in notes 9-18 of table 2.

Ground movements were classified as settlement on the basis of vertical displacements not apparently associated with landslide movements. Evidence of ground settlement includes relative downward movement of the ground surface around well casings and structural pilings and relative vertical displacement of the earth's surface beneath structures such as roadways and buildings. General notes concerning settlement during the 1906 earthquake are included in notes 9-18 of table 2.

The category of miscellaneous ground cracks includes cracks and fissures that on the basis of published descriptions cannot be related to tectonic faulting, landslides or ground settlement. General descriptions of the character and distribution of many such cracks generated during the 1906 event, both on hillside and in valley floor deposits, are given in notes 19-24 of table 2.

LIMITATIONS OF GROUND FAILURE DATA

Although there are many notations of ground failure in the historical record for northern California, the data still are limited and incomplete for the five following reasons: (1) Most postearthquake investigative efforts were applied to assessing the extent of structural and other damage or tracing out ruptured faults; hence notations concerning ground failures are commonly of incidental nature, and many ground failures not critical to constructed works may have been neglected. (2) The incidences of ground failures, particularly landslides, were so numerous in some localities during the 1906 shock that careful noting of each occurrence was practically impossible (see note 1, table 2). (3) The areal coverage of postearthquake investigations has been uneven, and some omissions exist. Areas in and near centers of population, along major transportation routes, and along major faults have generally received much more attention than less developed, less relevant, or more remote areas. (4) Several major earthquakes occurred before modern investigative procedures were developed or before it became routine to

TABLE 2.—*Excerpted notes containing general descriptions of the types, character, and locations of ground failures associated with the 1906 San Francisco earthquake*

Note	Reference	Quotation
Hillside landslides		
1	Lawson and others, 1908, p. 390.	By far the most common manifestation of landslide phenomena was that here referred to as earth-slump. It would be wearisome to attempt to mention all the various earth-slumps stimulated by the earthquake, even if information were sufficiently detailed to make this possible.
2	Lawson and others, 1908, p. 385.	Thruout the Coast Ranges of California the small residual stability of many earth-slumps was overcome by the vibration of the ground at the time of the earthquake of April 18, and they were caused to slump forward. In many other instances new earth-slumps were started, owing to the same general cause.
3	Lawson and others, 1908, p. 394.	Earth-flows originated in valleys, in gullies, or on hillsides. Where the weight of the earth, combined with the weight of the added water, was sufficient and the substratum of the soil was rendered plastic, gravity caused it to creep like a lava-stream, leaving a hollow in the place from which it came and a fan or tongue of debris down the slope below. Movement was especially apt to ensue where the ground had been previously wet, the intensity of the earthquake shock being particularly great at such points and the tendency of the vibrations being to set the mass in motion. Earth-flows occurred in many places in the Coast Ranges, and probably throughout the region in which the shock was heavily felt. The writer found many of them, large and small, on the San Francisco Peninsula and in the Santa Cruz Mountains, also in the Mount Diablo and Mount Hamilton Ranges.
4	Lawson and others, 1908, p. 398.	Similar [flow] landslides, tho usually of smaller size, occurred throughout the region neighboring the fault visited by the writer, and even in districts at a considerable distance from the fault. Frequently they were not definitely referable to the earth-flow type, but resembled more closely earth-slumps formed without the aid of a suddenly increased water supply. It was often difficult, especially in cases where the movement was slight, or the slide was in the embryonic stage, to determine whether the earthquake at those points had caused a flow of water or not. *** Many slips were formed on hillsides and along the embankments of mountain roads, and along the cracks formed by the shock in moist and loosened soil. Often these slips were arranged one above another, the perpendicular faces due to slipping having the appearance of step faults. In such cases the weight of the moved mass and the amount of water was not sufficient to cause the material to flow. *** In some places bare ridges had their lines of symmetry broken into little knolls and irregularities by these slips, a common occurrence in the hills of soft sand formations in the northern part of the San Francisco Peninsula. All the slips just referred to illustrated the gradation between earth-slumps and earth-flows. Doubtless in many of them a small amount of water did gather as a result of the earthquake.
5	Anderson, 1907, p. 643.	Earth-flows were of frequent occurrence in the Coast ranges, the writer finding them numerous on the San Francisco peninsula and in the Santa Cruz mountains within a score of miles of the fault, and what appeared to be flows of similar origin at a much greater distance from the epicentrum. They were formed on gentle as well as steep slopes, and both in previously dry drainage depressions and on convex hillsides. In the largest flows thousands of tons of earth and rock detritus were removed and carried hundreds of yards, leaving great cavities. In one case a hole ten feet deep was excavated over an area of nearly an acre on a five-degree slope, and the material removed was spread over two acres.
6	Lawson and others, 1908, p. 386.	***There is still another [type of landslide], which is immediately associated with earthquakes as a cause of movement. This is the slide of dry earth and rock upon precipitous slopes or their fall from cliffs. Soil or other loose forms of earth may participate in such landslides, but the material is usually composed chiefly of rock which becomes increasingly shattered with the progress of the slide.
7	Lawson and others, 1908, p. 387.	Earth-avalanches [soil and rock falls] were caused chiefly along the sea-cliffs of the coast on the morning of the earthquake, tho some also occurred on steep canyons within the zone of high intensity. On the coast the earth-avalanches were for the most part simply an exceptional incident in the normal process of cliff recession. Where the upland of the Coast Ranges approaches the shore, the horizontal corrosion of the waves maintains a steep sea-cliff; and the recession of the sea-cliff is effected by the repeated occurrence of earth-avalanches due to the undermining by the sea, combined with the disintegrating action of atmospheric agencies. There are thus always upon the face of the cliff masses of earth or rock, the fall of which is imminent and may easily be precipitated by a severe shock of earthquake.
8	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 133.	Along the seashore immense landslides occurred, throwing vast quantities of earth and rock into the sea.
Lateral spreads and ground settlement		
9	Lawson and others, 1908, p. 386.	Besides these three types of landslide, another ought perhaps to be recognized. This is the form of superficial earth movement which occurred in consequence of the earthquake shock on the alluvial bottom-lands of many streams. It may appropriately be designated an <i>earth-lurch</i> [lateral spread]. It varies from the opening of a mere crack, with a slight movement of the ground on one or both sides, to a violent and complicated deformation of the surface, usually accompanied by cracks and open fissures parallel to the trend of the neighboring stream trench. These cracks and fissures cut the ground up into strips or prisms which lurch toward the stream trench, or, it may be, toward an abandoned slough, the lurch usually being accompanied by a rotation of the prism. They are distinguished from all other forms of landslides by occurring on perfectly flat ground and by the fact that they are apparently referable directly and solely to the horizontal jerk of the earth movement during the earthquake shock.
10	Lawson and others, 1908, p. 400.	EARTH-LURCHES. Of the three kinds of landslides thus far referred to, the first two, earth-avalanches and earth-slumps, occur quite commonly independent of earthquakes. Of the third kind, or earth-flows, the only examples that have been presented are immediately connected in genesis with the earthquake of April 18, although it is conceded that sudden accessions of water to loose earth might arise in other ways and occasion earth-flows. As regards the fourth type, the earth-lurch [lateral spread] it is difficult to conceive for it any other origin than an earthquake, since it is caused directly by the horizontal jerk of the ground and can not be produced in any other way. [Authors in 1906 were not aware of the liquefaction process.] In the detailed account of the distribution of apparent intensity, a brief account of these superficial movements of the ground has been

TABLE 2.—*Excerpted notes containing general description of the types, character, and locations of ground failures associated with the 1906 San Francisco earthquake—Continued*

Note	Reference	Quotation
Lateral spreads and ground settlement—Continued		
10—Continued		<p>given and need not here be repeated. They are best exemplified on the flood plain of the Eel River, west and north of Ferndale; the flood plain of the Russian River; the flood plain of Alameda Creek, near Alvarado; the flood plain of Coyote River near Milpitas; the flood plain of Pajaro River; and the flood plain of the Salinas River. (Plates 136A, B and 137A, B.) In all these localities cracks were formed in the alluvium, generally parallel to the stream trench, and the ground between the cracks was caused to lurch horizontally toward the stream, usually with a rotation of the moved mass, which gave to it the profile of a Basin Range fault-block in miniature, the portion of the moved strip farther from the stream collapsing into the vacuity caused by the lurching.***</p> <p>Lurching of soft ground was also exemplified on the tidal mud flats of Tomales Bay, and on the "made land" of San Francisco; but there being no trench in these cases, the movement caused a ridging of the surface with compensating depressions. In the case of the made land in San Francisco, and perhaps generally, the deformation of the surface due to lurching was complicated by the settling together of the loose material.</p>
11	Himmelwright, 1906, p. 21.	<p>Great damage was sustained by water works in the rupture of mains, and the injury to reservoirs, plants and equipments. Elevated water tanks supported by steel and timber framing were frequently wrecked. The railways also suffered enormous damage through displacements of the roadbed and serious injuries to the bridges. The surface movements were very much more apparent in the cities and towns where the alignment of the streets, railway tracks, pole lines, etc., were materially altered. Street rails were severed by tension in some places and buckled at others. Large areas, constituting many acres, settled as much as from ten to fifteen feet, badly distorting the buildings which did not have deep foundations. *** It is evident that the whole region affected moved generally as a unit, and that the sudden and jarring motions had the effect of causing local disturbances and displacements wherever the soil was soft, incoherent and deep, as in the river bottoms, artificially filled areas, etc. Marked disturbances and deformations of the softer material always resulted along the lines separating a hard, compact material from one that was soft as, for example, the line of contact of the rock formations with the silt of the valleys.</p>
12	Lawson and others, 1908, p. 401.	<p>Beyond the zone of the Rift, cracks were observed at many localities. These were most common on the bottom-lands of the streams, notably the Eel River (plate 138A, B), the Russian River (plate 139A, B), Coyote Creek (plate 140A, B), and other streams at the south end of the Bay of San Francisco, Pajaro River (plate 141B), San Lorenzo River, and the Salinas River. Many other smaller streams might also be mentioned. In these cases the cracks were usually associated with the phenomena of lurching of the alluvial deposits, though many cracks also occurred where no such association was apparent. They were in nearly all cases found to be parallel or sub-parallel to the nearest portion of the stream trench. They very commonly extended for several hundred feet, in some instances for several hundred yards, and were characteristically arranged in linear series. The cracks in the series in some cases overlapped en echelon, and in others they were in groups of parallel cracks in belts a few hundred feet wide. In no case was there any suggestion that they were more than purely superficial phenomena.</p>
13	Duryea and others, 1907, p. 258.	<p>Embankments—Embankments across marshes, or with soft strata underlying them, settled more or less. In some cases the settlement was vertical; in other cases there was considerable horizontal with the vertical movement.</p>
14	Duryea and others, 1907, p. 258.	<p>Settlements of this character [embankments on tidal marshlands] and of more or less severity were common on all railroads operating about the Bay of San Francisco and its tributaries.</p>
15	Hyde, 1906a, p. 705.	<p>It is evident that structures pertaining to railroads suffered severely in common with others. It is a well-known fact that many embankments were seriously distorted in alignment and were reduced in elevation through settlement due to the vibration. Landslides were not uncommon on hillsides and in cuts where both railroads and highways, principally the former, were located.</p>
16	Carey, 1906, p. 299.	<p>The disturbance had the effect of lowering the general level of alluvial land and opening in it numerous cracks. In several instances in the Santa Clara Valley water pipes in wells dug through the uncompacted and unconsolidated valley sands, gravels and clays showed, after the shock, a foot or more of the pipe above the general surface of the ground.</p>
17	Lawson and others, 1908, p. 162.	<p>Along river bottoms and on valley floors, particularly where the ground water is abundant, structures were much more susceptible to damage than similar structures founded on the firm rocks of the valley slopes. This apparently high intensity of the shock in the valley lands was in part due to an actual slumping of the ground, which wracked the buildings independently of any elastic vibration communicated to them from the ground.</p>
18	Duryea and others, 1907, p. 259.	<p>Draw-Bridges—Draw-bridges across the little creeks and inlets around San Francisco Bay, being generally on soft ground, were affected by a slight movement of their piers, in many cases resulting in the bridge binding so that it could not be opened until some repairs were made.</p>

Ground cracks

- 19 Lawson and others, 1908, p. 74. Within the zone of high intensity no marshes and no bottom lands were seen which did not exhibit cracks, and I regard their cracking as a general phenomenon. The elaborate cracking of a roadway across one of the marshes seems specially significant. In the adjacent soft marsh close attention was necessary to discover cracks. To a large extent they were concealed by the vegetation, and it is probable also that many which were opened during the earthquake agitation immediately closed again and were practically obliterated by the welding of the mud. But the road embankment, being free from vegetation and composed of comparatively rigid and brittle material, retained all the cracks made during the agitation, and thus served to record the thorough shattering of an unconsolidated formation when subjected to strong vibration. (Plate 50.)
- Another class of superficial cracks affected hillsides, penetrating only the coating of loose material—decomposed rock and talus. The conspicuous individuals of this type are those that follow contours. Along these there was often a notable width of crack, accompanied by a settling on the down-hill side, and many cracks of this type are still visible. They are in effect the heads of incipient landslides and might with equal propriety be described under another caption. They are numerous throughout the Rift belt and fairly abun-

TABLE 2.—*Excerpted notes containing general description of the types, character, and locations of ground failures associated with the 1906 San Francisco earthquake—Continued*

Note	Reference	Quotation
Ground cracks—Continued		
19—Continued		<p>dant on steep hillsides [north of San Francisco Bay] for more than a mile to the west. East of the Rift they are inconspicuous and believed to be rare. Some of the best examples are on the northeastern slope of Mount Whittenberg, about a mile from the fault-trace, the locality being favorable for observation because of the absence of forest.</p> <p>Superficial cracks of a third type are connected with side-hill roads. (See plate 51.) In such roads there is usually a notch cut in the hillside and the excavated material is thrown outward so as to make an embankment. The roadbed thus consists in part of the natural formation and in part of an artificial and relatively loose embankment. In the loose material, and frequently along the line separating it from the firmer ground, cracks were extensively developed, often accompanied by evident settling of the outer bank. Their magnitude depended in part on the character of the material, but in large part also on the intensity of the earthquake. Where they were of such magnitude as to injure the roadway they were soon obliterated by road repairers, and elsewhere they tended to disappear in consequence of the traffic; but while they lasted they constituted an excellent gage of intensity, and much use was made of them in districts where there were few buildings.</p>
20	Lawson and others, 1908, p. 75.	<p>All thru the Rift there is association of earthquake cracks with fault sags; probably half of the sags were bordered by such cracks on one side or the other, the crack usually following the line of separation between the side slope and bottom slope. In some instances there was a crack on each side of the sag, but more frequently on one side only. Where the sag contained a pond the crack was usually present. With little or no exception these cracks exhibit downthrow on the side toward the sag. (See plate 52B.)</p>
21	Lawson and others, 1908, p. 77.	<p>In the bottom-lands of creeks it happened at many places that a slice of the alluvium was separated by a crack parallel to the bank and slid into or toward the stream. In some cases alluvium lying with a gentle slope adjacent to a marsh slid toward the marsh opening a crack along its upper edge.</p> <p>Mention has already been made of numerous hillside cracks which marked incipient landslides. In such cases the downward motion apparently began during the earthquake agitation, but the momentum acquired was not sufficient to continue the motion after the earthquake stopt. In a very large number of these localities motion was resumed and landslides occurred during a period of excessive rainfall in the spring of 1907. (Plates 54A and 55A.) So far as my observation goes, all of the landslides having this history were wet, the material usually flowing freely down the slope as a thin mud.</p>
22	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 7.	<p>CRACKS. All through the area of high intensity cracks were made, and these were specially numerous near the fault trace. The cracks were also more numerous in soft alluvium than in hard ground, but the number which deeply penetrated the bed rock was large. Perhaps this feature is better expressed by saying that the bed rock was generally and profoundly shattered, but without important dislocation except on the old fault plane. ***</p> <p>At the surface the cracks had great variety of expression. Some were barely perceptible as partings; others gaped so widely that one might look down them several yards. Some were mere pullings apart; others showed small differential movements of the nature of faulting. Some were solitary; others, especially those exhibiting faulting, were in groups. Some straggled and branched irregularly; others were nearly straight for hundreds of feet. Theoretically, some cracks were primary as regards the earthquake and others secondary; that is to say, some were caused directly by the preexistent stresses which produced the main fault and others were caused by the waves constituting the earthquake.</p>
23	Lawson and others, 1908, p. 73.	<p>Cracks.—In preliminary reports I have classified the earthquake cracks as primary and secondary, the primary being occasioned by strains which existed before the earthquake, and the secondary being caused by the earthquake. With the multiplication of observations this classification has become increasingly difficult, and I now find it more convenient to group the cracks as superficial and deep, or superficial and bedrock.</p> <p>Many of the superficial cracks are in alluvium. In the field excursions of April and May, 1906, they were seen in all alluvial formations within the Rift belt and for some distance on each side. The greater number appeared to be merely partings without vertical or horizontal throw. In general they were not parallel with one another nor were they otherwise systematically arranged, except that some of them were apt to occur along the boundary between alluvium and a firmer formation. They were rambling rather than straight and were often branched. They ranged in width from a fraction of an inch to several inches.</p>
24	Lawson and others, 1908, p. 403.	<p>*** It may be well to direct attention more particularly than has hitherto been done to the behavior of water contained in the alluvium of the river-bottoms. One of the most common phenomena in such situations was the expulsion of water in jets from apertures which suddenly appeared in the flat-lying ground. The water was usually thrown into the air for several feet; in some cases it was reported to be as much as 20 feet, and the ejection continued for several minutes after the earthquake. The continuance of the ejection after the shock indicates that an elastic stress had been generated in the saturated ground, which thus found relief in the expulsion of the contained water or that there was a gravitational settling together of the material, which diminished the spaces occupied by water. The vents thus established were very numerous, and were in many instances closely spaced; more frequently a few to the acre, and occasionally isolated. These vents were easily recognizable for weeks and even months after the earthquake, in the form of craterlets. The water in its passage to the surface brought up considerable quantities of fine sand, which, from its prevailing light bluish-gray color, was evidently derived from considerable depth. On the flood plain of the Salinas River, the sand was recognized by the people of the neighborhood to be the same as that of a stratum of sand pierced by wells at a depth of 80 feet. The craters were usually distinctly funnel-shaped and were rimmed by a circular flat ridge of sand which, by reason of its light color, was in marked contrast to the surrounding surface. They varied in diameter from 1 to perhaps 10 feet. In some instances the funnels were several feet deep; in others the feeble action in the closing stages of the eruption had caused them to fill up with sand. They were quite analogous to the craterlets described and pictured in Dutton's account of the Charleston earthquake. (See plates 142A, B and 143A, B.)</p> <p>These craterlets occurred on practically all the saturated alluvial bottoms of the streams within the zone of destructive effects, and also on the tidal mud flats of Tomales Bay. They are significant of the compression to which such water-laden, incoherent formations were subjected by the passage of the earth-waves at the time of the earthquake or by the consequent settling of the ground.</p>

make postearthquake investigations; hence the amount and quality of information decrease with the antiquity of the event. For events prior to the 1906 shock the record is very fragmentary. (5) In at least one instance, the results of a postearthquake investigation appear to have been intentionally suppressed. Concerning the 1868 earthquake, A. C. Lawson (1908, p. 434) noted

Shortly after the earthquake of 1868 a committee of scientific men undertook the collection of data concerning the effects of the shock, but their report was never published nor can any trace of it be found, altho some of the members of the committee are still living. It is stated that the report was suppressed [sic] by the authorities, thru the fear that its publication would damage the reputation of the city. Our knowledge of that earthquake is therefore not very full, and is contained chiefly in the newspaper reports of that day.

The use of one word to describe two genetically different phenomena and ambiguous descriptions of damage are two additional factors that limit, or at least confuse, the interpretation of the historical record. For example, many investigators of the 1906 earthquake referred to the fault rupture as "the crack." Because of this usage, it is difficult in many instances to distinguish between cracks generated by tectonic faulting and those generated by ground shaking. For this reason, nearly all cracks within the fault zone are omitted from consideration in this report.

Some recorded descriptions are inadequate to differentiate whether damage to a structure was caused by deformation wholly within the structure or whether ground failure was also a factor. For example, a typical description might indicate that a building was shifted laterally during the earthquake. Such movement could have resulted from any of several sources including "walking" of the structure off of its foundations, collapse of underpinning, or ground failure.

In spite of the above limitations, the published reports provide an adequate sample of data for determining the general type, character, and distribution of ground failures triggered by earthquakes in northern California. In several instances, the data are adequate for nearly complete delineation of ground failures in a particular area.

DISTRIBUTION AND CHARACTER OF GROUND FAILURES

The 1906 San Francisco earthquake triggered ground failures at numerous locations throughout a 370-mi (600-km)-long segment of the Coast Ranges extending from southern Monterey County on the south to Eureka on the north (see fig. 1). Most of the failures tabulated in this report are from that event. Several other events for which the historical record contains

evidence of more than minor ground cracks include (1) the Oct. 8, 1865, earthquake on the San Andreas fault, which generated ground cracks and sand boils in San Francisco (loc. 202), Santa Cruz (loc. 46), and Watsonville (loc. 25), and small rockfalls and ground cracks in the Santa Cruz Mountains (loc. 60); (2) the 1868 earthquake on the Hayward fault, which caused ground cracks and lateral spreading in San Francisco (locs. 198-202) and cracks and sand boils along Coyote Creek at the south end of San Francisco Bay (locs. 149, 151, 153) and near Hayward (loc. 171) on the east side of San Francisco Bay; (3) two earthquakes two days apart in 1892, which triggered landslides in the mountains and ground cracks and sand boils in creek bottoms in a strip along the west margin of the Sacramento Valley between Vacaville and Capay (locs. 255-259); (4) several moderate shocks in 1890, 1953, and 1954, which generated minor landslides in the Pajaro Gap area (locs. 28-30); (5) shocks in 1853, 1865, 1908, 1927, 1932, and 1954, which generated landslides, settlement, and ground cracks of up to moderate severity in the Eureka area; and (6) the 1957 Daly City earthquake, which generated landslides and ground cracks around Lake Merced (locs. 232-242) and near Daly City (locs. 132-133). A full list of earthquakes causing ground failures is given in table 1.

Mapping of earthquake intensities has been useful in delineating areas of ground failure. Specifically, criteria used for mapping 1906 earthquake intensity are based in part on occurrences of ground failures and, hence, have aided in delineating areas in which ground failures occurred. Two intensity scales, quoted below, were used for mapping the 1906 event—the "San Francisco scale" and the modified Rossi-Forel scale:

San Francisco scale (Lawson and others, 1908, p. 224):

Grade A. Very violent.—Comprises the rending and shearing of rock masses, earth, turf, and all structures along the line of faulting; the fall of rock from mountain sides; numerous landslips of great magnitude; consistent, deep, and extended fissuring in natural earth; some structures totally destroyed.

Grade B. Violent.—Comprises fairly general collapse of brick and frame buildings when not unusually strong; serious cracking of brick work and masonry in excellent structures; the formation of fissures, step faults, sharp compression anticlines, and broad, wave-like folds in paved and asphalt-coated streets, accompanied by the ragged fissuring of asphalt; the destruction of foundation walls and underpinning structures by the undulation of the ground; the breaking of sewers and water-mains; the lateral displacement of streets; and the compression, distension, and lateral waving or displacement of well-ballasted street-car tracks.

Grade C. Very strong.—Comprises brick work and masonry badly cracked, with occasional collapse; some brick and masonry gables thrown down; frame buildings

lurched or listed on fair or weak underpinning structures, with occasional falling from underpinning or collapse; general destruction of chimneys and of masonry, brick or cement veneers; considerable cracking or crushing of foundation walls.

Grade D. Strong.—Comprises general but not universal fall of chimneys; cracks in masonry and brick work; cracks in foundation walls, retaining walls, and curbing; a few isolated cases of lurching or listing of frame buildings built upon weak underpinning structures.

Grade E. Weak.—Comprises occasional fall of chimneys and damage to plaster, partitions, plumbing, and the like.

Modified Rossi-Forel scale (Lawson and others, 1908, p. 161):

In the first place, the scale upon which the gradation of intensity is indicated, that known as the Rossi-Forel scale, is more or less arbitrary. At the outset of the inquiry, the Commission revised and simplified this scale somewhat, with the object of adapting it for general use, and its present form, as amended by the Commission, is as follows:

- I. Perceptible, only by delicate instruments.
- II. Very slight, shocks noticed by few persons at rest.
- III. Slight shock, of which duration and direction were noted by a number of persons.
- IV. Moderate shock, reported by persons in motion; shaking of moveable objects; cracking of ceilings.
- V. Smart shock, generally felt; furniture shaken; some clocks stopt; some sleepers awakened.
- VI. Severe shock, general awakening of sleepers; stopping of clocks; some window glass broken.
- VII. Violent shock, overturning of loose objects; falling of plaster; striking of church bells; some chimneys fall.
- VIII. Fall of chimneys; cracks in the walls of buildings.
- IX. Partial or total destruction of some buildings.
- X. Great disasters; overturning of rocks; fissures in surface of earth; mountain slides.

It is apparent that the scale leaves room for wide variation in the personal equation. Different reporters interpret the same experiences and the same phenomena differently. It was also found that in the periphery of the region affected, where the earth waves were of slow period, pendent objects and liquids were more sensitive indicators of earth movement than direct perception by individuals, altho the latter is placed first in the scale.

The "San Francisco scale" was used only for mapping intensities in San Francisco City and County (fig. 5). The highest intensity grade, grade A, is based almost exclusively on the occurrence of fault ruptures, large landslides, and deep cracks. Grade B is based partly on the occurrence of severe structural damage and partly on the occurrence of ground failures of lateral-spreading and ground settlement types. Grades C through E are based entirely on damage to constructed works. Hence, zones of grade A and B intensity generally delineate areas where faulting and ground failures disturbed the ground surface. Areas zoned grades C through E delineate areas with varying severities of structural damage but with a general absence of significant ground failures. Hence, areas zoned A and B generally coincide with zones of ground failure in San Francisco, whereas intensity grades C through E delineate areas where few significant ground failures occurred.

The modified Rossi-Forel scale was used to map 1906 earthquake intensity throughout the Western United States. Criteria used to assign intensity grades I-IX on the modified Rossi-Forel scale do not include ground failure effects. The highest grade (X), however, is based almost exclusively on occurrences of fault rupturing, landslides, and deep ground cracks. On the maps prepared by the 1906 investigators (fig. 6) (Lawson and others, 1908, atlas, p. 21-23), only a narrow zone along the San Andreas fault is mapped as intensity grade X. This zone generally coincides with the zone of 1906 fault ruptures. Other areas where severe ground failures occurred, such as along the Salinas River, were given a lesser intensity, indicating that averaging of intensities within a given area probably occurred during compilation of the map. For delineation of areas subjected to ground failure, such averaging reduces the usefulness of the map to almost nil because it obscures the data and falsely infers, from direct reference to the scale, that major ground failures did not occur in areas characterized by intensities less than X.

FIGURE 5.—1906 earthquake intensity map prepared for San Francisco County using San Francisco intensity scale (after Lawson and others, 1908, map no. 19).

FIGURE 6.—1906 earthquake intensity map for Western United States based on modified Rossi-Forel scale (after Lawson and others, 1908, map no. 23).

MONTEREY BAY COUNTIES REGION

Monterey and San Benito Counties, the southern parts of Santa Cruz and Santa Clara Counties and the western parts of Fresno and Merced Counties form the Monterey Bay counties region (pl. 1 and table 5, locs. 1-44; figs. 7-17). (Regions in this report were selected largely on the basis of available map sheets and amount of data for any given area.) This region has been shaken in historic times by several moderate- to large-sized earthquakes; however, only two events, the October 8, 1865, shock for which we have but fragmentary information, and the 1906 shock, have produced more than minor local effects. Hence, the discussion in this section is limited almost exclusively to ground failures caused by the 1906 San Francisco earthquake. A summary of statements excerpted from reports on the 1906 shock containing generalized descriptions of ground failures in the Monterey Bay counties region is reproduced in table 3. Specific descriptions of individual failures are contained in the descriptions of failures (table 5, locs. 1-44).

Plates 1 and 2 show that the density and severity of ground failures generated by the 1906 earthquake generally decreased with increasing distance from the causative fault rupture (the southern limit of which was near San Juan Bautista). Thus, the density and severity of failures decreased southward from San Juan Bautista. The southernmost reported failure was slight settlement beneath the Bradley, Monterey County, railroad station (loc. 1). Bradley, not shown on plate 1, is located near the Salinas River, 12 mi (19 km) southeast of San Ardo, which is located near the southern edge of the map.

On a local basis, geologic setting had a greater effect on the density and severity of ground failures than distance to the ruptured fault. Areas with the greatest density and severity of ground failures included low-lying alluvial deposits along the Salinas and Pajaro Rivers and beach and dune deposits near the mouths of these rivers. In fact, one investigator stated that the Salinas River valley was "fissured and disturbed more than any other district in the state" (note 5, table 3, this report; Gilbert and others, 1907, p. 133).

The principal failure types in the river valleys were slumping of streambanks and lateral spreading of flatlands toward channels in a manner similar to that described in reports from the 1964 Alaska earthquake (Kachadoorian, 1968; McCulloch and Bonilla, 1970). These failures were accompanied by considerable ground cracking and differential settlements and by the pervasive eruption of sand boils. The sand boils are evidence that liquefaction played a major role in these failures. Lateral displacements associated with lateral

spreading were as large as 12 ft (3.7 m). The largest displacements were noted near Monterey Bay at and north of Moss Landing (locs. 19, 21). Inland along the Salinas and Pajaro Rivers lateral displacements as large as 10 ft (3 m) were common. These movements considerably damaged bridges and pipelines that crossed the rivers and highways and railroads that paralleled the rivers. Photographs of 1906 ground failures along the Salinas and Pajaro Rivers and the damage they caused are shown in figures 7-10 and 12-17.

A geotechnical section across the Salinas River in the zone of 1906 ground failures (fig. 11) was compiled from foundation investigation borehole logs for the State Highway 68 bridge over the river. This bridge is located 0.5 mi (0.8 km) upstream from a bridge that was severely damaged during the 1906 shock (fig. 10, loc. 12). The geotechnical section shows several layers of loose to dense sands, sandy silt, and clay in a complex configuration extending to depths as great as 80 ft (24 m). The area is characterized by a high water table that ranges in depth from several feet beneath the flood plain to the ground surface at the river. The evident cause of ground failure at this location was liquefaction within a loose granular layer below the water table (Youd and Hoose, 1976).

Effects similar to those along the Salinas and Pajaro Rivers, but of much lesser extent and severity, also occurred along the San Lorenzo River (locs. 43, 44) and Soquel Creek (locs. 41, 42) in and near Santa Cruz and Capitola, respectively. These latter failures caused no significant damage.

Buildings and other works sited on deep unconsolidated deposits generally were damaged more than those sited on shallow unconsolidated deposits over bedrock. This was true even at localities where ground failure was not a factor. For example, A. S. Eakle (Lawson and others, 1908, p. 296) reported that "the town of Salinas suffered greater destruction than any other place in the county." Nevertheless, no evidence was found during this study of any significant ground failures in the city of Salinas during the 1906 event. Most of the older section of Salinas is located in the Salinas River valley, which is underlain by unconsolidated Holocene sediments to considerable depth. Amplification of bedrock ground motions by these sediments likely led to the great damage. Great damage was also reported from Del Monte and the Pacific Grove Light House (A. S. Eakle in Lawson and others, 1908, p. 291, 343), Santa Cruz (Lawson and others, 1908, p. 343), Hollister, and other parts of the lower Santa Clara valley (Lawson and others, 1908, p. 286-290) as well as parts of the San Joaquin Valley, particularly the area surrounding Los Banos (G. F. Zoffman, in Lawson and others, 1908, p. 316, 345).

Local geology may have been an important factor in amplifying or modifying ground motions in these areas, which led to greater-than-normal damage. Ground failures, however, were apparently not a factor.

Other than some cracks along steep bluff faces, upland alluvial terrace and eolian deposits were apparently unaffected by ground failures during the 1906 earthquake. This conclusion is supported by notations and maps (fig. 6) showing that damage was less in the upland areas than in the river valleys and by the absence of ground failure reports from the upland areas, which is considered to be positive evidence because several investigators traveled through those areas and most likely would have noted any significant ground failures. Some specific notes do show an absence of ground failures in some areas. For example, G. A. Waring (Lawson and others, 1908, p. 292) noted that "Castroville [loc. 17] being on solid ground was unaffected"

and A. S. Eakle (Lawson and others, 1908, p. 292) reported that "On the road eastward to Salinas from Del Monte [loc. 12], no visible signs of the earthquake were encountered until the Salinas River was reached."

The mountains in the Monterey Bay counties region apparently were only slightly affected by ground failures during the 1906 temblor. The largest failures reported were landslides near the fault trace west of Chittenden (loc. 31) where several large rockfalls and debris slides filled the lower part of the canyon. A linear array of landslides occurred near the west margin of the San Joaquin Valley (loc. 7), which led some investigators to speculate that there might have been sympathetic movement on a fault in that region. However, no evidence was found to support this speculation (G. D. Louderback in Lawson and others, 1908, p. 319). Many small landslides occurred in the mountainous areas, including a dislodged boulder that crashed through a house, killing one man (loc. 38).

TABLE 3.—*Excerpted notes containing general descriptions of ground failures in the Monterey Bay counties region*

Note	Reference	Quotation
1	Lawson and others, 1908, p. 343.	The finest illustration of the influence exercised by alluvium in the production of high apparent intensity is that afforded by the Valley of the Salinas River and its extension to the valley of the lower portion of the Pajaro River. The Salinas Valley is one of the notable physiographic features of the Coast Ranges. It lies between the Santa Lucia and Gavilan Ranges. It is deeply alluviated and strikingly terraced, particularly in its lower part. The course of the valley was probably determined originally by the fault along the eastern base of the Santa Lucia Range. The river discharges into the Bay of Monterey about its middle part, a few miles south of the mouth of the Pajaro River. On the flood-plain tracts of both rivers, and along the beach of the Bay of Monterey, the intensity was IX. This extended up the river for several miles above the town of Salinas. There were extensive fissures in the alluvium as far as Gonzales, with slumping of the ground toward the river trench.
2	Lawson and others, 1908, p. 296.	(A. C. Lawson)—The flood plain of the Salinas River was caused to <u>lurch toward the stream from both sides</u> , but the effects are most marked on the south side. The result in most places has been the breaking up of the alluvium into monoclinical strips with a vertical scarp on one side, facing the river, and a gentle slope on the other. These have the effect of landslide scarps and terraces, but occur on flat land. In some instances it would appear that the ground had collapsed into the cavity formed by the <u>lurching</u> . There are minor cracks and buckles in the sand and mud flats of the river-bottom. Here numerous craterlets were formed by the sudden ejection of water from the underlying sands, due to the compressive action of the shock. This acute deformation of the ground accentuated the destructive tendency due to the earthquake shock.
3	Duryea and others, 1907, p. 311.	The bottom of the Salinas Valley is a marshy district of river deposits, of small elevation above sea level. Although the region is at a distance of from 10 to 20 miles from the fault trace, there was much differential surface movement, distinct from elastic vibration. In many places along the river banks the loose surface materials were shaken and dislodged. For a considerable area the deposits on the south bank were shifted <u>about 6 ft., and the ground moved northward into the river. In many places large sink holes were formed.</u>
4	Lawson and others, 1908, p. 409.	Salinas, Monterey County (G. A. Daugherty).—In many places water came up thru open fissures; in one place about 8 miles from Salinas, the water covered about 80 acres of land.
5	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 133.	(B. M. Abbott).—Water spouted from holes in the ground to a considerable height, and flooded the fields. The town of Salinas and the alluvial valley of Salinas River were also severely shaken. This region was fissured and disturbed more than any other district in the State.
6	Lawson and others, 1908, p. 295.	Effect upon structures, objects, etc. (G. A. Waring).—It is remarkable how closely the disturbance followed the river channel throughout the Salinas Valley; 2 or 3 miles away from the stream on both sides the intensity was very slight. Southward up the valley the shock gradually lessened, and rapidly died out in the foot-hills on either side.

Text continued on page 23

FIGURE 7.—Damaged rails and pulp flume at Spreckels sugar mill as a consequence of lateral spreading during 1906 earthquake (loc. 11). A. Pulled apart rails showing 3 ft (0.9 m) of differential lateral movement. (Photograph by A. C. Lawson, courtesy of The Bancroft Library, University of California, Berkeley.) B. Displaced pulp flume—caption on photograph states “wrecked pulp flume and leaning tower; ground moved 4 ft [1.2 m] south.” (Photograph courtesy of K. A. Meserole, Menlo Park, California.)

FIGURE 8.—Barley field near Spreckels disrupted by slumping and lateral-spreading failures (loc. 12). Previously published in Lawson and others (1908, pl. 137A) with caption "Lurching of ground toward Salinas River, with consequent collapse." (Photograph by J.C. Bran-ner, courtesy of Stanford University Archives.)

FIGURE 9.—County road along Salinas River, south of Salinas, disrupted by slumping and lateral spreading (loc. 12). (Photograph courtesy of K. A. Meserole, Menlo Park, California.)

FIGURE 10.—South terminal pier of bridge over Salinas River 4 mi (6.4 km) south of Salinas (loc. 12). Surficial deposits shifted about 6 ft (2 m) toward the river. (Photograph by J. C. Branner, courtesy of Stanford University Archives.)

Fig 2

FIGURE 11.—Geotechnical section across the Salinas River at State Highway 68 bridge; (loc. 12) 0.5 mi (0.8 km)

TO SALINAS →

upstream from the bridge damaged during the 1906 shock (fig. 10) (data from Division of Highways, 1964).

FIGURE 12.—Damage at Moss Landing caused by lateral spreading (loc. 19). A. Damaged railroad bridge. Photograph previously published in Lawson and others (1908, pl. 135A) with caption "Lurching of ground toward Salinas River, to left, carried piles from beneath bridge timbers and caused bridge to collapse. Displacement 9 feet [2.7 m]." B. Displaced building. Photograph previously published in Lawson and others (1908, pl. 134A) with caption "House, tree, and fence moved 12 feet [3.7 m] by lurching of ground toward Salinas River." (Photographs by A. C. Lawson, courtesy of The Bancroft Library, University of California, Berkeley). C. Ground ruptures in Moss Landing between Monterey Bay and old Salinas River. View eastward toward bluffs between Elkhorn and Moro Cojo sloughs. (Photograph courtesy of Monterey County Historical Society, Inc., Salinas.)

FIGURE 13.—Ground failure scarp in a former community called Chinatown located near south bank of the Pajaro River across from Watsonville (loc. 25). (Photograph courtesy of Pajaro Valley Historical Association, Watsonville.)

FIGURE 14.—Graben and damaged buildings caused by lateral spread near the Pajaro River at the foot of Marchant Street in Watsonville (loc. 25). (Photograph courtesy of Pajaro Valley Historical Association, Watsonville.)

FIGURE 15.—Slump scarp and sand boil near Pajaro River (loc. 27). Similar photograph previously published in Lawson and others (1908, pl. 141B) with caption "Secondary crack, with drop of 7 feet, in alluvial flood-plain of Pajaro River." (Photograph by Livennon, courtesy of The Bancroft Library, University of California, Berkeley.)

FIGURE 16.—Sand boil near Watsonville. Part of this photograph previously published in Lawson and others (1908, pl. 143B) with caption "Craterlets near Watsonville" (loc. 27). (Photograph by J. C. Branner, courtesy of Stanford University Archives.)

FIGURE 17.—County road bridge over the Pajaro River near Chittenden (loc. 30). Abutment displaced and fractured by lateral spreading of sediments toward the river channel. (Photograph by Livennon, courtesy of The Bancroft Library, University of California, Berkeley.)

SAN FRANCISCO BAY COUNTIES REGION

SANTA CRUZ MOUNTAINS

The Santa Cruz Mountains comprise the northern part of Santa Cruz County and the western parts of Santa Clara and San Mateo Counties (pl. 2 and table 6, locs. 45-135; figs. 18-25). Ground failures in the form of hillside landslides, flows, slumping of streambanks and ground cracks, both on the hills and in the creek bottoms, were numerous and widespread effects of the 1906 San Francisco earthquake in this area. The most common damage caused by these failures was to highway and railroad grades and to bridges. Rockfalls and dry sand flows along the coastal bluffs were particularly disruptive in this respect. For example, the ocean shore railway grade between Lake Merced and Mussel Rock (locs. 131, 132, 133, fig. 24), then under construction, was almost entirely destroyed for a distance of 3 mi (5 km). Somewhat similar landslides were triggered in this same area during the 1957 Daly City earthquake.

Two catastrophic rockfalls occurred in the southern Santa Cruz Mountains. One on Hinkle Creek, a branch of Soquel Creek (loc. 50), buried the Loma Prieta Mill killing nine men, and the other on Deer Creek (loc. 74, fig. 19) became a rock avalanche that moved about 0.25 mi (0.4 km) down a narrow canyon destroying a shingle mill and killing one man.

A number of flow failures were triggered in the Santa Cruz Mountains by the 1906 earthquake (locs. 110-114, 135; figs. 20-22, 25). These failures occurred in wet surficial materials, and many were associated with conspicuous amounts of surface water. In some instances these flows traveled considerable distances at relatively high velocities (for example loc. 135). In other instances the flows traveled rather slowly (for example loc. 113).

Because the flows were generated in wet unconsolidated sediments, generally as a consequence of liquefaction, precipitation records for the Santa Cruz Mountains for the winter preceding the 1906 shock are relevant. Monthly and daily rainfall data for San Francisco, Santa Clara, and Santa Cruz (figs. 2-4) show that precipitation was unusually heavy during the winter, particularly in March, and that a 17-day rain-free period preceded the shock. Had the shock occurred when ground water conditions were significantly different, such as during the dry season of the year, the number of flow failures most likely would have been greatly reduced; on the other hand, had the shock occurred when the ground was even wetter, such as during or immediately after a major storm sequence, even more flows might have developed.

SAN FRANCISCO BAY, SANTA CLARA VALLEY,
AND EAST BAY HILLS AREAS

Included in the San Francisco Bay counties region are Alameda County, the southern part of Contra Costa County, and the eastern parts of Santa Clara and San Mateo Counties (pl. 2 and table 6, locs. 136-182; figs. 26-29). (San Francisco City and County is considered separately in the next segment of the report. Locs. 183-192 are discussed in the section on the "North Bay Counties Region.") The most common failures on the alluvial plain surrounding San Francisco Bay were lateral spreads, slumping of streambanks, ground settlement, and ground cracks (figs. 26-28). These failures were located chiefly along stream channels and marginal to San Francisco Bay. Lateral movements of 2-6 ft (0.6-1.8 m) were reported in the Colma Valley (loc. 136), on the San Bruno Marsh near Baden (loc. 137), along Coyote Creek north of San Jose (locs. 149, 150), at a point on the railway line between Niles and San Jose (loc. 162), and along Alameda Creek (loc. 170). These failures were mostly in sparsely populated areas; however, they caused considerable damage to railroad and highway grades and to bridges. Similar types of failures occurred along the lower reaches of Coyote (locs. 149, 151, 153) and Alameda (loc. 170) Creeks during the earthquakes of 1868 and 1906.

Figure 29 shows a geotechnical section across Coyote Creek at the State Highway 237 bridge. This bridge is very near the site of the old bridge (loc. 149) that was damaged by lateral spreading during the 1906 temblor. The section shows that a loose granular layer just below the water table extends at least 800 ft (240 m) westward from the creek. Cracks and sand boils were reported as far as 2,000 ft (600 m) west of the creek after the 1906 shock (loc. 149). Liquefaction in this or similar granular layers was most likely responsible for the sand boils and ground failures that occurred in that area.

Ground settlements of up to 2 ft (0.6 m) occurred around two well casings 4 mi (6.4 km) apart (locs. 147, 148) near the south end of San Francisco Bay. Flow from these and other wells in the vicinity (locs. 146, 149) was temporarily increased. Settlement of highway and railroad fills was also reported from several locations near the margins of San Francisco Bay (locs. 138, 141; notes 11-18, table 2).

No significant ground failures were reported on late Pleistocene and most Holocene alluvial fan deposits at points well removed from active stream channels. These older, more consolidated and denser materials (Youd and others, 1975) apparently resisted the shaking of the 1906 event without significant yielding. This inference is supported by several specific notations of lack of ground movement. For example, Derleth (in

Jordan, 1907, p. 188) stated that "San Jose's water works, like that of Santa Rosa, was not injured; its sewers were left intact, showing that there was no unequal displacement of the ground [loc. 157]." Other statements showing lack of ground failure are listed under locations 144, 156, and 164 in the descriptions of ground failures (table 6).

The 1906 earthquake reports indicate that ground failures in the hills east of San Francisco Bay and the Santa Clara Valley were few in number and not very severe. Ground cracks were generated at several locations north of Livermore (locs. 166, 167, 180). In addition several shallow debris slides occurred along a road in the hills east of San Jose (loc. 160), and an accelerated movement of an already active slide occurred east of San Pablo (loc. 179).

SAN FRANCISCO CITY AND COUNTY

Because of the considerable amount of damage that occurred in San Francisco (pl. 3 and table 7, locs. 193–248; figs. 30–54) and the greater development of that community compared with the surrounding region, more thorough 1906 postearthquake investigations and more quantitative reports were prepared than for most surrounding areas. This was generally true for earthquakes in 1865 and 1868 as well. Ground failures in San Francisco have been limited mainly to areas underlain by filled over marsh and bay mud deposits, filled-in ravines, loose sand deposits near Lake Merced, sand dunes, and steep slopes. Locations of failures are shown on plate 3 and for the downtown and waterfront sections on figure 30. General notes describing these failures are listed in table 4.

Before examining the nature of seismically triggered ground failures in filled over marsh and bay mud deposits, a brief review of the methods and materials used in constructing the fills is provided from Brown and others (1932, p. 29):

Many difficulties were experienced in grading the streets in the swamp areas. Hittell [1878] states: "When streets were first made the weight of the sand pressed the peat down so that the water stood where the surface was dry before. Sometimes the sand broke through, carrying the peat down under it, leaving nothing but water or thin mud near the surface. More than once a contractor had put on enough sand to raise the street to official grade, and gave notice to the City Engineer to inspect the work, but in the lapse of a day between the notice and inspection, the sand had sunk down six or eight feet; and, when at last a permanent bottom had been reached the heavy sand had crowded over the light peat at the sides of the street and lifted it up eight or ten feet above its original level, in muddy ridges full of hideous cracks. Not only was the peat crowded up by the sand in this way, but it was also pushed sideways, so that houses and fences built upon it were carried away from their original positions and tilted up at singular angles by the upheaval."

The eventual construction of the streets in the lower section of the city caused the existence of many blocks surrounded on all four sides by high earth embankments, undrained, unsightly, with many stagnant pools, and gradually filling with rubbish and trash of all kinds. Captain Folsom was the first to fill in one of the water lots, an expensive piece of work on California Street west of the present site of the Bank of California. Despite the cost, it was recognized as a valuable undertaking and others speedily followed. James Cunningham realized this was a job for a steam shovel (or "steam paddy") and had one brought in by steamer. From 1852 to 1854 and from 1859 until 1873 a steam shovel was working constantly, loading into small railway cars and dumping in the bay, moving more than fifteen hundred cubic yards per day. As the shovel could work profitably only in sand and where there were comparatively long hauls, a large portion of the work was moved more economically by horse and cart even though a man with a horse and cart was paid \$15.00 a day.

There are no official figures on the amount of material moved. Hittell (1878) assumed a transfer of 21,000,000 cubic yards, while Bancroft (1882) estimated this to be 22,000,000 cubic yards. These figures are probably conservative.

Three major ground failure zones have been identified in the filled areas of San Francisco. These zones are designated here as (1) foot of Market zone, (2) south of Market zone, and (3) Mission Creek zone (fig. 30; pl. 3). These zones are generally congruent with three conspicuous zones mapped as intensity grade B after the 1906 earthquake (fig. 5). The most common ground failure types in these zones were lateral spreads and differential ground settlements. Because of the critical locations of these failures, they were responsible for considerable damage including the breaking of several major water pipelines that, in turn, left the city largely defenseless against the conflagration (fig. 49) that followed the 1906 earthquake. (See notes 14–19, table 4.)

In the foot of Market zone, settlements as large as 4 ft (1.2 m) occurred during the 1906 earthquake (loc. 193). During the 1868 earthquake settlements of 1–2 ft (0.3 m–0.6 m) were reported (locs. 199–200), and some settlement also was reported during the 1865 earthquake (loc. 202). Near the waterfront, permanent lateral movements as large as 2 ft (0.6 m) developed during the 1906 shock (loc. 193, fig. 31). The magnitude of these displacements decreased with distance from the waterfront. Some horizontal movements also apparently occurred in the foot of Market zone in 1868 (locs. 198, 200). Before a thorough investigation could be made, much evidence of 1906 ground failures and most of the consequent damage in the foot of Market zone were destroyed by the fires that devastated the area and by workers during cleanup operations.

A geotechnical section beneath Market Street from the bay to Second Street (fig. 32) shows that a layer of fill composed mostly of loose fine sand with some rubble particles underlies the foot of Market zone. The fill is approximately 20 ft (6 m) thick near the waterfront and thins with distance inland, feathering out near

Sansome Street. In March-July 1964, the ground water level was at a depth of about 8 ft near the waterfront and increased in depth to about 18 ft at Sansome Street. The ground water level was probably at about the same depth in 1906. Beneath the fill are layers of soft silty clay (bay mud) with some sand lenses. These sediments are in turn underlain by more firm materials. Liquefaction within the sand fill or an underlying sand layer is the only tenable explanation for the ground failures that developed in this area (Youd and Hoose, 1976). One evidence that liquefaction occurred in the foot of Market zone during the 1868 earthquake was the ejection of water from cracks and fissures (loc. 201). These ejections were probably a form of sand boils. No sand boils were reported in the foot of Market zone in 1906. However, some could have occurred only to be destroyed during the fire and ensuing cleanup operations or for some other reason were not reported.

The south of Market zone lies in an area of filled-over marshland extending from Rincon Hill near Fourth and Brannan Streets westward approximately 1 mi (1.6 km) to near Market Street (locs. 205-212; figs. 33-36). Differential settlements in this zone were as large as 5 ft (1.5 m), and lateral displacements as large as 6 ft (1.8 m). The ground failures in that area were remarkable in two respects. First, the slope down the axis of the zone (from near Eighth and Mission Streets to Fourth and Brannan Streets) was only 0.8 percent (0.5°). Second, the lateral movement was not into a free face, but rather into Rincon Hill, a sandstone outcrop (Schlocker, 1974). At the head of this lateral spread, extensional features such as open cracks and pulled-apart rails, sidewalks, and curbs (loc. 205) were common. Where the failure butted into Rincon Hill, compressional features such as buckled rails and curbs indicated that the lateral displacement was absorbed by compression.

The U.S. Post Office Building at the corner of Seventh and Mission Streets (loc. 210, fig. 35) is astride the north margin of the south of Market zone. During the 1906 earthquake the ground in front of the Post Office settled 4 or 5 ft (1.2 or 1.5 m) and moved laterally about 2 ft (0.6 m), damaging the stone skirting around the base of the building (fig. 35A, C) and pulling the sidewalk apart at the construction joints (fig. 35B). The building, which is apparently founded on a grillage foundation carried down to a firm granular layer (Gilbert and others, 1907, p. 97-98), sustained little structural damage and is still (1977) in use.

A geotechnical profile across the south of Market zone at the latitude of the James Lick Skyway (fig. 36) shows a 5-8-ft (1.5-2.4-m)-thick layer of rubble fill in the ground failure area. The rubble is underlain by a 7-11-ft (2.1-3.4-m)-thick layer of generally loose sand

that is also probably artificial fill. Underlying the sand is a deep layer of soft peaty clay (bay mud). The water table in March 1952 was only a few feet deep across most of this section. Liquefaction within the loose sand layer is the only tenable explanation for the ground failures in this area (Youd and Hoose, 1976).

The Mission Creek zone, which apparently contained several ground failure segments, extended up the sinuous former channel of Mission Creek from Old Mission Bay to near the intersection of 19th and Guerrero Streets (locs. 214-217; figs. 37-51). Settlements as large as 6 ft (1.8 m) and lateral movements at least as large as 6 ft (1.8 m) occurred at several locations within this zone. The average slope from 19th and Guerrero Streets to the freeway is 0.6 percent or 0.3°. Ground failures within this zone were responsible for some serious and spectacular damage, much of which is well recorded on photographs.

Figure 37 is a schematic diagram of present streets in the lower part of the zone showing approximate locations and directions from which the photographs in figures 38-41 were taken. These photographs show southwestward lateral spreading across both Ninth and Dore Streets between Bryant and Brannan Streets. The lateral spreading did not extend as far south as 10th Street, where there was but little evidence of ground failure (loc. 214).

Figure 42 is a schematic diagram of several streets in the midsection of the Mission Creek zone showing approximate locations and directions in which photographs in figures 43-47 were taken. These photographs show the magnitude, location, and character of the lateral-spreading ground failure in this area. Lateral movements of up to several feet developed down the axis of the zone and in some areas toward the axis, causing compressional deformation at some locations (figs. 43, 44, 47) and extension features at other locations (figs. 45, 46).

The damage at Valencia Street was the most catastrophic of any that occurred in the Mission Creek zone (loc. 216; figs. 48A, 48B). Vertical and horizontal displacements here were both as large as 6 ft (1.8 m). Two main arterial water pipelines laid beneath the street were severed by the ground failure cutting off the water supply to a major part of the city which was soon to be in flames (fig. 49). Also, the catastrophic collapse of the four-story Valencia Street Hotel (loc. 216; fig. 48A) occurred at this location. This collapse may have been at least in part a consequence of the large ground movements that extended beneath the structure. Tens of people were killed in the collapse and the ensuing consumption of the building by fire.

At the head of the Mission Creek zone, a substantial three-story brick building (fig. 50) was carried laterally

6 ft (1.8 m) along with the curb, walk, and street in front of the building (loc. 217). There is no evidence indicating that lateral spreading continued up the old Mission Creek channel beyond this location.

A geotechnical section across the Mission Creek zone at Mission Street (fig. 51) shows a layer of very loose fine sand fill underlain by layers of soft clayey sand and soft silty sand, which are in turn underlain by alternating layers of firm clean clayey sand. In February 1964 the water table was as shallow as 5 ft (1.5 m) beneath the ground surface in that part of the section where the 1906 lateral-spreading failure took place. Liquefaction within the loose sand fill or possibly the soft silty sand layer beneath the fill is the evident cause of ground failure in this zone (Youd and Hoose, 1976).

Two ground failures in filled ravines, though small in size, produced rather spectacular results. One near the intersection of Vallejo Street and Van Ness Avenue (loc. 221, fig. 52) was characterized by differential settlements as great as 2 ft (0.6 m) and lateral displacements as great as 3 ft (0.9 m). The other, on Union Street between Pierce and Steiner Streets (loc. 222, fig. 53), had vertical and lateral displacements as great as 10 ft (3 m) and moved down a rather steep slope into an unfilled vacant lot.

Several lateral spreads and rotational slumps, some of which were converted into flow failures, occurred around the shoreline of Lake Merced during both the 1906 and 1957 earthquakes (locs. 232, 242; fig. 54). These failures caused considerable damage to highway embankment and bridge structures around and across

the lake. Liquefaction within natural and artificially placed sand surrounding and beneath the lake has been identified as the cause of many of the 1957 failures (Bonilla, 1960) and is the probable cause of the 1906 failures.

After an earthquake in 1852 fissures were found between Lake Merced and the Pacific Ocean (loc. 244) through which the waters of Lake Merced were flowing into the sea. It is unclear whether these ruptures were generated by an earthquake or by other factors such as previous heavy rain storms that may have caused overtopping of or piping through the natural embankment between the lake and the ocean (Soulé and others, 1854).

The sand dune section of western San Francisco was very sparsely developed in 1906. As a consequence, only fragmentary descriptions of ground failures in that section are available from the 1906 reports, and some of these descriptions are vaguely stated. The reports indicate that some areas of instability developed near the ocean (locs. 246, 247) and some cracking and lateral spreading occurred farther inland (locs. 230, 243). Liquefaction probably contributed to the development of these failures as evidenced by the eruption of sand boils at several locations (locs. 243, 247).

Several hillside landslides occurred on the steeper slopes in San Francisco during the 1906 event (locs. 218, 226–229). These failures were responsible for structural damage to the Cyclorama, a building in Golden Gate Park (loc. 228), and a retaining wall at Laguna Honda reservoir (loc. 229).

TABLE 4.—*Excerpted notes containing general descriptions of ground failure and consequent pipeline breaks in San Francisco*

Note	Reference	Quotation
1	Lawson and others, 1908, p. 253.	It is evident that the intensity varies with the geology, or with the areal distribution of rocks and soils. The areas that suffered most severely were those upon filled ground. Areas upon marshy ground showed destructive effects similar to artificial filled land. Next in intensity to areas of filled land are those upon incoherent sands. The damage in sandy areas was due partly to the shaking of sand like jelly and partly to settling and sliding.
2	Jordan, 1907, p. 238.	In San Francisco considerable tracts of "filled" land were shaken together and thus made to settle a few feet, and were at the same time slidden [sic] several feet toward the bay.
3	Hall, 1906, p. 32.	Locating, by the street system, the points of surface movement*** the writer has demonstrated that every subsidence or movement of note caused by the recent earthquake is either just along the edge of or within an area which formerly was swamp, salt marsh, mud flat or bay estuary in character. It is interesting to see how the platting of the earthquake's footmarks of this kind in our streets of today outlines the limits of the former soft spots of the formations on which San Francisco was built, and how the specially soft spots are again revealed by the greater movement now presented. [Continued under locs. 193, 205, and 216 in "Specific descriptions of ground failures in San Francisco City and County," table 7.]
4	Carey, 1906, p. 297.	Re-surveys in San Francisco show that property lines are considerably displaced where the land is loose or "made," while on the hills little or no dislocation is observed.
5	Hyde, 1906b, p. 739.	EARTHQUAKE EFFECTS.—Within this filled district, the vibrations of the earthquake caused a general but irregular settlement. The streets naturally followed the changes in elevation and a wave-like effect was produced. Observations on Market, Mission, East and other streets frequently indicate an amplitude of wave height of two feet, while occasional places are found with greater differences in elevation. In the Mission district, and in certain other parts of San Francisco, as, for instance, along the courses of former tidal streams, large areas of filled land exist. In such cases, the effect produced by the earthquake was not generally in the form of waves, as already described, for the eastern portion of the city was basin-like, representing local settlement in the streets and adjacent areas, and in some cases, decided misalignment. The most important wave-like distortions were observed on lower Market and Mission Sts., and on East St. along the present water front.*** Where the ground was hilly and solid, it was not decidedly affected by the earthquake shock.

TABLE 4.—*Excerpted notes containing general descriptions of ground failure and consequent pipeline breaks in San Francisco—Continued*

Note	Reference	Quotation
6	Jordan, 1907, p. 123.	STREET AND SURFACE DEFORMATIONS. Great distortion of the surface was best observed in the streets, and was found on the filled areas and in some places, on the sand dunes. The best localities for observation were:—(1), Market Street near the Ferry Building, Fig. 11 [loc. 195]; (2), the water front on both sides of the Ferry Building, Fig. 12 [loc. 193]; (3), the corner of Howard and Spear Streets, where the J. A. Folger Company's building was saved from fire [loc. 203]; (4), the corner of Mission and Seventh Streets, the location of the General Postoffice [loc. 210]; (5), Van Ness Avenue at Eddy Street [loc. 219]; (6), the north end of Van Ness Avenue and the streets on the hillside slope in that vicinity downward to the water front on the north [loc. 221]; (7), Howard Street, between 17th and 18th Streets, Fig. 13 [loc. 215]; (8), Valencia Street, between 18th and 19th Streets, where the Valencia Hotel was wrecked with great loss of life, and the main water pipes were sheared [loc. 216]; (9), Fourteenth Street, between Mission and Howard Streets [loc. 214]; and, (10), the water front near the Potrero District. I might enlarge this list, but these are the typical examples. Examples 5 and 6 represent surface distortions on sand dunes. The rest are examples of filled ground deformations. Upon the filled ground the surface was very generally thrown into billow-like waves, a type of disturbance which was best seen near the Ferry house. Upon the sand dunes the surface was shifted by sliding motion so that cracks and fissures appeared upon the streets at right angles to the direction of sliding. It was in these areas that the sewers and water pipes of the gridiron system were so generally crushed and broken. Even had the main conduits survived, water could not have reached the hydrants in the lower Mission District. The brick sewers were uniformly helpless to resist destruction in these regions and the cast iron water and gas pipes fared no better.
7	Jordan, 1907, p. 98.	The billow-like effects that appeared in the streets of San Francisco near the Ferry house are most excellent examples of deformations in soft, incoherent materials. The sliding and rolling effects observed on some of the sand dunes and especially along the hillside at the northern end of Van Ness Avenue may be cited as allied phenomena. [loc. 221]
8	Preliminary Report, 1906, p. 15.	The most violent destruction of buildings, as everybody knows, was on the made ground. This ground seems to have behaved during the earthquake very much in the same way as jelly in a bowl, or as a semi-liquid material in a tank. The earth waves which pass through the highly elastic rocks swiftly with a small amplitude seem in this material to have been transformed into slow undulations of great amplitude which were excessively destructive. The filled in material and the swampy foundation upon which it rests behaved, in other words, as a mass superimposed upon the earth's surface, rather than as a part of the elastic crust itself. In a less degree the same thing is true of the sand dune areas, where the ground was frequently deformed and fissured.
9	Leslie's Weekly, 1906e.	1. [Picture caption] "Solid asphalt pavements were broken up like ice in a spring thaw." 2. [Picture caption] "The Valencia Street Hotel, in which ruins 200 people were reported killed." [loc. 216] 3. [Picture caption] "Curbstone lifted clear of the asphalt, which remained level." 4. [Picture caption] "Porch of house demolished, the rest nearly uninjured." 5. [Picture caption] "Toppling like houses of cards."
10	Chicago Record-Herald, 1906b.	[Picture caption] SUNKEN FLATS SHOWING HUGE FISSURES MADE IN THE STREET*** Reproduced from the Los Angeles Times.
11	Seattle Post-Intelligencer, 1906a.	[Picture caption] FISSURE IN SAN FRANCISCO STREET CAUSED BY EARTHQUAKE: "Flat Building on Left Sank One Story into the Ground."
12	Derleth, 1906a, p. 503.	In many parts of the city, side hills resting upon original sand dunes have been bodily moved and deformed by wave-like and sliding motions.
13	Gilbert, Humphrey, Sewell, and Soulé, 1907, pl. 56.	Author's summary of pertinent data on map. Principal earthquake breaks in streets are marked at the following places on this map. Valencia Street between 18th and 19th: Seventeenth Street between Mission and Capp: Howard street between 17th and 18th: Shotwell Street between 17th and 18th: Seventeenth Street between Folsom and Harrison: Harrison Street between 17th and 18th: Fifteenth Street between Harrison and York: Fourteenth Street between Mission and Harrison: Eleventh Street between Harrison and Bryant: and the corner of Seventh Street and Mission Street. [See also loc. 214]
14	Duryea and others, 1907, p. 253.	In San Francisco, all serious fractures of water mains, as a result of the earthquake, were due to lateral displacements, or subsidences of filled or soft ground across which, unfortunately, the main supply pipes *** passed. The displacement laterally amounted in places to as much as 6 or 7 ft.; vertically, it amounted to several feet.
15	Schussler, 1906, p. 1.	The most serious injury sustained by the [water] works were the ruptures caused by the earthquake, in hundreds of places, in our city main pipe distributing system, especially where the streets crossed filled ground and, particularly, where such filled ground covered former deep swamps, which swamps, during the earthquake, subsided, tearing off sewers as well as water and gas pipes.
16	Schussler, 1906, p. 33.	The city pipe distributing system was broken and in many instances torn and twisted off, especially in places where the ground, over which the streets had been constructed, had been poorly and loosely filled over old deep swamps and soft marshes. There were also a number of breaks in the streets that passed with deep loose fills over former ravines.
17	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 19.	The failure to control the fire by reason of the crippling of the water supply was not due to the failure of the system outside of the city, but to the breaks in the distributing mains within the city, which rendered unavailable about 80,000,000 gallons of water stored within the city limits. These breaks occurred (see the map, Pl. LVI) wherever the pipes passed through soft or made ground. No breaks occurred where the cast-iron pipe was laid in solid ground or rock.
18	Derleth, 1906a, p. 503.	The damage by the earthquake which was the direct cause of the city's great fire loss, occurred in the water system. The main conduits entering the city were greatly damaged, and the pipes running through soft materials were very generally destroyed.
19	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 56.	The importance of proper construction and distribution of the water mains in districts liable to earthquakes is demonstrated by the fact that the greatest damage in San Francisco, fully 85 per cent of the total, was by fire. The action of the earthquake in starting the fires which grew to a great conflagration seems insignificant compared to the breaking of the water mains, which left the city defenseless against the flames.

TABLE 4.—*Excerpted notes containing general descriptions of ground failure and consequent piepline breaks in San Francisco—Continued*

Note	Reference	Quotation
20	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 66.	From what was left of the ruins themselves, and from the testimony of competent observers, including engineer officers who were ordered into the business district of San Francisco immediately after the earthquake and before the fire had destroyed the evidences of earthquake damage, I think it is quite certain that the earthquake damage was extensive and severe. There were no available data on which to base an accurate estimate, but I formed a general impression that the damage done by the earthquake alone was at least as great as 10 per cent of the total damage by fire and earthquake combined. The damage from the earthquake, however, was localized in a remarkable degree.
21	Duryea and others, 1907, p. 324.	On the areas over the old tide flats, the walls of the old 3-story and 4-story brick buildings were built on "rafts" made of layers of plank. These settled, and the space between them was arched up like the back of a turtle, sometimes as much as 6 ft. between walls 30 ft. apart.
22	San Francisco County, 1908, p. 732.	The Board of Public Works realized that a vast amount of emergency work confronted them, and for which work the funds available were wholly inadequate to defray the cost. They determined that conditions forced upon them the immediate performance of the following work regardless of the moneys set aside to their department:*** 10. The survey monuments that had been shifted by the movement of streets must be reset before lot surveys for building reconstruction can be furnished. The following sewers were found to be in bad condition, and upon which repairs were made: Fourteenth street between Valencia and Howard streets. [loc. 214]***. Eighteenth street between Church and Valencia streets—[loc. 216]***. Mission street between Eighteenth and Nineteenth streets. [loc. 216]***. Powell street between North Point and Beach streets—***. Vallejo street adjacent to Van Ness avenue—175 feet of brick sewer and 125 feet of 18-inch pipe sewer were reconstructed. [loc. 221]. Diamond street northerly from Chenery street—1,500 feet*** reconstructed. Seventh street between Folsom and Harrison streets—[loc. 212]***. Eighth street between Bryant and Brannan streets—[loc. 214]***. Crossing of Bryant and Fourth streets—[loc. 205]***. Crossing of Seventeenth and Howard streets—[loc. 215]***. Hayes street between Broderick and Baker streets. Crossing of Seventeenth and Mission streets—[loc. 214]***. Crossing of Central avenue and Turk street.*** Valencia street between Eighteenth and Nineteenth streets—130 feet of 5-foot sewer collapsed. [loc. 216]. Eleventh street between Harrison and Bryant streets—70 feet broken. Union street between Steiner and Pierce streets—[loc. 222]***. Four gangs of sewer cleaners worked on Fourteenth street between Folsom and Howard streets [loc. 214], and Valencia street between Eighteenth and Nineteenth streets.
23	San Francisco Chronicle, 1906c.	On Fourteenth street, between Valencia and Harrison streets; on Harrison street, between Twelfth and Thirteenth streets; on Eleventh street, between Harrison and Bryant streets; on Ninth street, between Bryant and Brannan streets; on Dore street, between Bryant and Brannan streets; on Laguna street, between Greenwich and Lombard streets; on Shotwell street, between Seventeenth and Eighteenth streets; on Seventeenth street, between Folsom and Harrison streets; on Howard street, between Seventeenth and Eighteenth streets.
24	Huber, 1930, p. 270.	[1868 earthquake] Then as to the destruction of property. Not a single strongly and honestly built house on the solid land of the city has been materially injured, while very few houses of any kind on the solid land have been injured at all. The damage done was chiefly confined to the old and inferior structures, pretentious and imposing as some of them may have been, erected upon the flats formed by filling in about 200 acres of water lots along the northeast front of the city. This filling, owing to the deep substratum of mud, was essentially unsubstantial and unsafe, and even the piles driven through it have proved, as in the case of the Custom House, not to be a sufficient foundation for large brick or stone houses in a place liable to earthquakes.
25	Huber, 1930, p. 270.	Beginning with the issue of October 23, 1868, the San Francisco Bulletin publishes a detailed itemized list of estimated damage to buildings, the individual buildings being listed by blocks. ***the principal damage occurred on land reclaimed from San Francisco Bay and which is known to afford unsatisfactory foundation conditions.
26	Holden, 1898, p. 78.	1868, October 21, San Francisco. The shock was longer and more severe than that of October 8, 1865. Several persons were killed by falling cornices. *** The surface of the earth visibly undulated. ***Hon. Horace Davis writes that the destruction in S. F. was greatest along the old beach-line of the city, beyond which the soil had been filled in.
27	Davidson, 1906, p. 180.	I was one of the committee of investigation of the 1868 earthquake, and it demonstrated that the <i>course of greatest dislocation at the surface of the ground was on the line of contact between the "made" land or the alluvial soil with the rocky stratum.</i> This is repeated in this [1906] earthquake***.
28	Wood, Allen, and Heck, 1939, p. 6.	1865 October 8. *** IX at least. At San Francisco the greatest damage was to the less strongly constructed buildings on made land; structures on solid ground, or well constructed, suffered little damage; water mains and gas pipes broke in several places because of shifting ground, and a crevice opened in one street.

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FIGURE 18.—Hillside landslide in redwood forest about 4 mi (6.4 km) above Alma (loc. 55). The landslide has dammed Los Gatos Creek from the south. (Photograph by J. C. Branner, courtesy of Stanford University Archives.)

FIGURE 19.—Deer Creek landslide that advanced about 0.5 mi (0.8 km) downstream destroying the Hoffman Shingle Mill and taking one life (loc. 74). Photograph previously published in Lawson and others (1906, pl. 124D) with caption "Deer Creek, Santa Cruz Mountains. Earth-avalanche from Grizzly Peak." (Photograph by B. Bell, J. C. Branner collection, courtesy of Stanford University Archives.)

FIGURE 20.—Flow failure in hills southeast of Half Moon Bay (loc. 110). Note that the displaced sediments piled up in a ridge on the gently sloping terrain rather than spreading out. Similar photograph previously published in Lawson and others (1908, pl. 132A) with caption "Earth-flow in hills east of Half Moon Bay." (J. C. Branner collection, courtesy of Stanford University Archives.)

FIGURE 21.—Flow failure east of Half Moon Bay (loc. 111). A. Cavity with 10-ft (3-m)-high walls from which sediments flowed. Note the man (circle) standing at left edge of cavity. Photograph previously published in Lawson and others (1908, pl. 132B) with caption "Earth-flow in small valley near Half Moon Bay." B. Panoramic continuation of A showing ridge of deposited debris. Note the pick leaning against debris in center of picture and man standing on rim of cavity behind debris at right. (Photograph by R. A. Anderson, J. C. Branner collection, courtesy of Stanford University Archives.)

FIGURE 22.—Flow failure down a hillside slope on the Nunez Ranch 4 mi (6.4 km) east of Half Moon Bay (loc. 114). Note the man (lower circle) standing at the base of the deposited debris and a second man (upper circle) standing on the lower edge of the cavity at the top of the slide. Additional incipient flow failures, with much smaller movements, also occurred on the convex hill to the left of the principal landslide. Photograph previously published in Lawson and others (1908, pl. 133B) with caption "Earth-flow 4 miles east of Half Moon Bay." (Photograph by R. A. Anderson, J. C. Branner collection, courtesy of Stanford University Archives.)

FIGURE 23.—Rockfalls along coastal bluffs between Ocean Avenue, San Francisco, and Mussel Rock (loc. 132). (Photograph by H. O. Wood, courtesy of The Bancroft Library, University of California, Berkeley.)

FIGURE 24.—Landslide on steep hillside near Mussel Rock (loc. 132). These and similar landslides destroyed several miles of highway and railroad grades during the 1906 earthquake. (J. C. Branner collection, courtesy of Stanford University Archives.)

FIGURE 25.—Cavity of flow failure on the south side of San Bruno Mountain above Mt. Olivet Cemetery near Colma (loc. 135). (Photograph by A. C. Lawson, courtesy of The Bancroft Library, University of California, Berkeley.)

FIGURE 26.—Rails of electric railway on marsh west of San Bruno that were buckled by compression during 1906 earthquake (loc. 141). Buckling was most likely a consequence of lateral spreading. Photograph previously published in Lawson and others (1908, pl. 97C) with caption "Roadbed and rails of electric railway on marsh west of San Bruno." (Photograph by R. B. M., Branner Collection, courtesy of Stanford University Archives.)

FIGURE 27.—Ground cracks in the vicinity of Coyote Creek west of Milpitas (loc. 149). *A.* Cracks caused by slumping and lateral spreading near the creek channel. *B.* Cracks in road several hundred feet west of Coyote Creek. (Photographs from J. C. Branner Collection, courtesy of Stanford University Archives.)

FIGURE 28.—Sand boils in field between Milpitas and Coyote Creek (loc. 149). Note bridge over Coyote Creek in center background. Photograph by J. C. Branner, previously published in Lawson and others (1908, pl. 143A) with caption "Craterlets in fields near Milpitas." (Courtesy of The Bancroft Library, University of California, Berkeley.)

FIGURE 30.—Aerial photograph of commercial and shipping district of San Francisco showing locations of lateral-spreading and ground settlement failures that disrupted the city during the 1906 earthquake. Liquefaction within subsurface saturated granular layers is the evident cause of the failures.

FIGURE 31.—Cracks and separations in roadway pavement near the San Francisco waterfront caused by lateral spreading in the foot of Market zone (loc. 193). Photograph previously published by Givens (1906) with caption "break and two-foot [0.6 m] sink in East Street near Ferry Building" and by Schussler (1906, p. 91) with caption "street on water front badly broken up."

FIGURE 32.—Geotechnical section beneath Market Street in the foot of Market zone

(loc. 193) (data from Dames and Moore, Inc., 1964; geology inferred from Schlocker, 1974).

FIGURE 33.—Disruption of block pavement and sidewalk on Columbia Street just south of Folsom Street (loc. 205). Photograph previously published in Lawson and others (1908, pl. 89A) with caption "Columbia Street, just south of Folsom Street, San Francisco. Slumping, depression, and furrowing of block pavement." (Photograph by H. O. Wood, courtesy of The Bancroft Library, University of California, Berkeley.)

FIGURE 34.—Rails on Fifth Street near Harrison Street, San Francisco, pulled apart by extensional movements associated with lateral spreading of underlying sediments (loc. 205). (Photograph by G. K. Gilbert.)

FIGURE 35.—Damage to San Francisco Post Office, Seventh and Mission Streets, caused by ground failure (loc. 210). *A.* View of southeast entrance showing differential, vertical movement of lower, nonstructural facing around building. *B.* View northeastward in front of building showing differential, vertical, and lateral movement of sidewalk. (Photographs courtesy of H. J. Degenkolb and Associates, San Francisco). *C.* View northeastward in front of Post Office showing settlement around building and lateral displacement of sidewalk to the southeast. (Photograph courtesy of San Francisco Public Library.)

FIGURE 37.—Schematic diagram of area between Ninth and Tenth Streets and Bryant and Brannan Streets in lower part of Mission Creek zone, San Francisco (loc. 214), showing approximate locations and directions from which photographs in figures 38–41 were taken.

FIGURE 38.—View along Dore Street from Bryant Street toward Brannan Street, San Francisco (loc. 214). *A*. Photograph after the 1906 earthquake showing undulations as large as 6 ft (1.8 m) in street. As much as 6 ft (1.8 m) of lateral movement also occurred at this location. Similar photograph previously published in Lawson and others (1908, pl. 89D) with caption "Looking along Dore Street, from Bryant toward Brannan. Undulating and fractured condition of pavement due to earthquake. Houses thrown off their underpinning and pitched out of the vertical." (Photograph from J. C. Branner collection, courtesy of Stanford University Archives). *B*. Dore Street today (September 1974) from approximately the same location as fig. 38A, showing ramps of the James Lick and Central Freeways and other structures constructed since 1906. *C*. Building at corner of Bryant and Dore Streets damaged by differential vertical and lateral movements. (Photograph by H. O. Wood, courtesy of The Bancroft Library, University of California, Berkeley.)

FIGURE 38.—Continued

FIGURE 39.—Scarps and right-lateral displacements caused by lateral spreading at two points on Bryant Street near the intersection of Ninth Street (loc. 214). A. Between Ninth and Tenth Streets (?). B. Between Eighth and Ninth Streets. (Photographs by G. K. Gilbert.)

FIGURE 40.—Views along Ninth Street between Bryant and Brannan Streets (loc. 214). A. View northwestward from near Brannan Street showing lateral displacement of street, rails, curb, walk, and buildings. Photograph previously published by Gilbert and others (1907, pl. 5) with caption "Results of earth flow, Ninth Street, San Francisco," and in Lawson and others (1908, pl. 91B) with caption "Ninth Street, between Bryant and Brannan. Westward lurching of land toward former creek channel where Dore Street now is." (Photograph by G. K. Gilbert.) B. View northwestward showing building damage, some of which is due to southwestward lateral displacement of the

ground. (Photograph courtesy of San Francisco Public Library.) *C.* Close-up view of damage in midsection of block. (Photograph courtesy of Charles A. Smallwood.) *D.* Close-up of damage at northwest end of block. Photograph previously published in Lawson and others (1908, pl. 91A) with caption "Ninth Street, between Bryant and Brannan. Undulation and fissuring of pavement and sidewalks. Houses over trough have been dropt from their underpinning." (Photograph by G. K. Gilbert.)

FIGURE 41.—View northeastward on Brannan Street, corner of Ninth Street (loc. 214). The scarp and settlement in the foreground marks the southern boundary of the ground failure on Ninth Street. (Photograph by G. K. Gilbert.)

FIGURE 42.—Schematic diagram of area between 17th and 18th Streets and Capp Street and South Van Ness Avenue in the central part of Mission Creek zone, San Francisco, showing locations and directions from which photographs in figures 43–47 were taken (loc. 215).

FIGURE 43.—Buckling of rails by compression on Howard Street (South Van Ness Avenue) near 17th Street (loc. 215). Photograph previously published in Gilbert and others (1907, pl. 6B) with caption "Buckling caused by earth flow, Howard Street, San Francisco." and in Lawson and others (1908, pl. 92B) with caption "Looking south on Howard Street from near Seventeenth Street. Compressional flexure of car rails." (Photograph by G. K. Gilbert.)

FIGURE 44.—Looking north on Howard Street (South Van Ness Avenue) from near 18th Street toward 17th Street, San Francisco (loc. 215). Rails offset laterally by lateral-spreading ground failure. (J. C. Branner Collection, courtesy of Stanford University Archives.)

FIGURE 45.—Scarps showing vertical movement and northward lateral movement (loc. 215). View eastward on 18th Street. Intersection of Howard Street (South Van Ness Avenue) is in the middleground. (Courtesy of San Francisco Public Library.)

FIGURE 46.—Scarps, lateral and vertical displacements in Capp Street between 17th and 18th Streets (loc. 215). Photograph previously published by Zeigler (1906) with caption "Capp Street, near Seventeenth, damaged by earthquake" and in Schussler (1906, p. 95) with caption "Capp Street sunken."

FIGURE 47.—Buckled curbstone on Capp Street near 18th Street (loc. 215). Buckling was caused by sediments shifting toward old channel of Mission Creek. (Photograph by G. K. Gilbert.)

FIGURE 48.—Valencia Street between 17th and 18th Streets (loc. 216). A. View northward shortly after earthquake showing collapsed Valencia Street Hotel in which tens of people were killed. Note lateral displacement of street in front of hotel. (Photograph courtesy of Berkey Photo Service, previously Bear Photo.) B. View southward after fire showing lateral and vertical displacements of 6 ft (1.8 m) and two temporarily repaired arterial water pipelines that were ruptured by the ground movements, cutting off the water supply to a major part of the city. (Photograph by Moran, courtesy of The Bancroft Library, University of California, Berkeley.)

FIGURE 49.—San Francisco in flames after 1906 shock. Fire fighting efforts were hampered by the unavailability of water, a consequence of the many major pipeline breaks that were caused by ground failures. (Photograph from P. E. Hotz collection, U.S. Geological Survey.)

FIGURE 50.—Lateral spread at the Youth's Directory on 19th and Guerrero Streets (loc. 217). Photograph previously published in Lawson and others (1908, pl. 94A) with caption "View along Nineteenth Street, from Guerrero Street. Both ground and buildings moved north about 6 feet [1.2 m] toward center of old marsh, with component of movement down the channel." (Photograph by A. C. Lawson, courtesy of The Bancroft Library, University of California, Berkeley.)

FIGURE 51.—Geotechnical section across Mission Creek zone at Mission Street between 15th and 20th

Radiolarian chert and shale
Alternate beds of hard brittle chert, 1-5 in. thick,
and brittle, crumbly shale, 1/8 to 1/2 in. thick.
Locally includes bodies of massive chert

Dry unit weight-lb/ft³

Approximate water table

Standard penetration-blows/ft

Water table in borings at time of drilling
(January-February 1964)

Location of borings from which cross
section is constructed

Streets (loc. 216). (Data from Harding Associates, 1964; geology inferred from Schlocker, 1974.)

FIGURE 52.—Disruption of Van Ness Avenue over a filled in ravine (loc. 221). Lateral movements as great as 3 ft (0.9 m) and vertical movements as great as 2 ft (0.6 m) occurred at this location. Photograph previously published by Zeigler (1906) with caption "Break in asphalt paving on Van Ness Avenue near Vallejo Street."

FIGURE 53.—Slump in Union Street between Pierce and Steiner Streets (loc. 222). Photograph previously published in Lawson and others (1908, pl. 88B) with caption "Slip of a fill on Union Street, just west of Steiner Street, San Francisco." (Photograph by H. O. Wood, courtesy of The Bancroft Library, University of California, Berkeley.)

FIGURE 54.—Flow failure along shoreline of Lake Merced triggered by the 1957 Daly City earthquake (loc. 236). Photograph previously published in Bonilla (1960, p. 22) with caption "Damage to roadway by landslides along south arm of Lake Merced. View looking northwest." (Photograph by M. G. Bonilla.)

NORTH BAY COUNTIES REGION

The north bay counties region includes Marin, Napa, Solano, Sonoma, and Yolo Counties, northern Contra Costa County, and the southern parts of Mendocino and Lake Counties (pl. 2 and table 6, locs. 183-192; pl. 4 and table 8, locs. 249-311; figs. 55-66). Several mountain ranges and intermontane valleys, a long segment of the Pacific Coast, and the northern segment of San Francisco, San Pablo, and Suisun Bays are in this region. The epicenter of the 1906 San Francisco earthquake (near Olema, Marin County) and several segments of San Andreas fault rupture between Bolinas Lagoon and Point Arena are also included.

Only four events have been documented in addition to the 1906 shock that have triggered even as much as very slight ground failures in the north bay counties region. These shocks include an event near Mare Island (loc. 251) in 1898, a swarm of shocks along the west edge of the Sacramento Valley (locs. 255-259) in 1892, and the 1969 Santa Rosa earthquakes (loc. 295). Hence, the 1906 event is by far the most important event for earthquake-related ground failure studies in this region.

Hillside landslides have been the most common form of seismically triggered ground failures reported in the north bay counties region. Furthermore, it is likely that only a fraction of the 1906 occurrences of these failures were documented. One of the landforms most vulnerable to seismically generated landslides is the coastal bluffs. In 1906 extensive landslides, mostly rockfalls, were observed along the bluffs near Bolinas Lagoon (loc. 188) and between Bodega Head and Point Arena (loc. 300). Flows also occurred at at least two locations both near Tomales Bay (loc. 274, fig. 64). A large landslide north of Santa Rosa, the Maacama landslide (loc. 298), is noteworthy because (1) it involved considerable displacement of a large mass of rock that in turn dammed up a creek, (2) it is particularly well described, and (3) it is readily relocatable in the field today.

Differential settlement, lateral spreads, and ground cracks were common failure types in lowland alluvial areas. In many instances, sand boils were associated with these failures, indicating that liquefaction was a factor in their formation. For example, the flood plain of the Russian River inland for 25 miles (40 km) from the Pacific Ocean (loc. 299) was severely disturbed by these types of lowland failures.

Some of the largest lowland ground failures in 1906, both in areal extent and amount of movement, were generated beneath and marginal to Tomales Bay (locs. 255, 259, 266, 267, 269, 271, 278, 280). Settlements as large as 8 ft (2.4 m) were common beneath roadway fills (locs. 269, 279). Lateral displacements as large as 30 ft (9.1 m) or more caused considerable damage. For example lateral spreading toward the Lagunitas Creek channel (loc. 266) shortened a bridge by 6 ft (1.8 m), buckling the structure at its north end. A large failure occurred beneath Tomales Bay near Inverness (loc. 271, figs. 61-63) where westward lateral displacements as great as 25 ft (7.6 m) occurred beneath two boat piers 800 ft (240 m) apart. Gilbert (in Gilbert and others 1907, p. 8; and in Lawson and others, 1908, p. 79 (quoted under loc. 271, table 8)) concluded that these movements were caused by shifting of bay bottom sediments westward, upslope, at least 30 ft (9 m) as a consequence of earthquake vibrations. It seems unlikely to us that unconsolidated sediments at this locality would slide uphill during an earthquake. Hence, we offer an alternate possible explanation that the movements may have been caused by a combination of lateral spreading of shoreline sediments into the bay and down-channel movement of bay bottom sediments. This down-channel movement is consistent with that observed in other areas during the earthquake and is conformable with gravity rather than in opposition to it.

Other areas where significant 1906 lowland ground failures occurred include the margins of Suisun Bay, where lateral movements of a few inches (loc. 252) and vertical movements of several feet (loc. 254) were found, and the west edge of the Cotati Valley near Sebastopol (loc. 293), where rows of trees in an orchard were shifted several feet laterally.

Santa Rosa (loc. 295) sustained more damage than surrounding areas during earthquakes in 1868 (Lawson and others, 1908, p. 439), 1906 (Lawson and others, 1908, p. 199-203), and 1969 (Huffman and Youd, in Cloud and others, 1970). There is no evidence that ground failures were a factor in producing the greater damage in any of these events. In fact, several specific notes show an absence of ground failure in the main part of Santa Rosa in 1906 (Derleth, in Jordan 1907, p. 188 (loc. 295)) and in 1969 (Huffman and Youd, in Cloud and others, 1970, p. 54 (loc. 295)). Hence, earthquake damage in Santa Rosa has been a consequence of ground shaking, rather than ground failure.

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FIGURE 55.—Cracks at Bolinas Lagoon (loc. 187). Photograph previously published in Gilbert and others (1907, pl. 4A) with caption "Secondary cracks, shore of Bolinas Lagoon" and in Lawson and others (1908, pl. 49B) with caption "Cracks made by earthquake in tidal mud near head of Bolinas Lagoon." (Photograph by G. K. Gilbert.)

FIGURE 56.—Cracks along the edge of a sag pond near Bolinas (loc. 187). Photograph previously published in Gilbert and others (1907, pl. 4B) with caption "Secondary cracks, with settling, Bolinas" and in Lawson and others (1908, pl. 52B) with the caption "Earthquake cracks in Bolinas at edge of an earthquake sag." (Photograph by G. K. Gilbert.)

FIGURE 57.—Buildings tipped into the water at the Bolinas waterfront (loc. 189). (Photograph by G. K. Gilbert.)

FIGURE 58.—Cracks and settlement at the head of a lateral spread between Olema and Inverness (loc. 266). (Photograph by G. K. Gilbert.)

FIGURE 59.—Cracks generated by lateral spreading southwest of Point Reyes Station (loc. 266). Photograph previously published in Lawson and others (1908, pl. 50B) with caption "Faults in road embankment, southwest of Point Reyes Station. Fault-trace is beyond fence. Ground lurched toward marsh of Bear Valley Creek." (Photograph by G. K. Gilbert.)

FIGURE 60.—Cracking and subsidence of road grade across a marsh southwest of Point Reyes Station (loc. 267). Photograph previously published in Lawson and others (1908, pl. 50A) with caption "Road embankment broken by shaking of soft ground beneath. Southwest of Point Reyes Station and 10 rods [50 m] from fault-trace." (Photograph by G. K. Gilbert.)

FIGURE 61.—Ridged bottom of Tomales Bay after 1906 earthquake (loc. 270). Similar to photograph previously published in Gilbert and others (1907, pl. 8A) with caption "Earthquake ridges on tidal flat, Tomales Bay" and in Lawson and others (1908, pl. 54B) with caption "Ridged mud plain 1 mile [1.6 km] from Inverness. Looking east-southeast. Mr. Hamilton's barn at right. April 28, 1906. Tide is low. Pools occupy the deeper troughs." (Photograph by G. K. Gilbert.)

FIGURE 62.—Shifted sediments of Tomales Bay (loc. 270). Photograph previously published in Gilbert and others (1907, pl. 7A) with caption "Shifted bottom of Tomales Bay" and in Lawson and others (1908, pl. 55B) with caption "South part of Inverness shoal, at low tide, April 28, 1906. Looking north-northwest. Lane of water separates firm, gravelly beach from mud shifted shoreward by earthquake." (Photograph by G. K. Gilbert.)

FIGURE 63.—Boat piers at Inverness displaced during earthquake (loc. 271). A. Martinelli's pier. Photograph previously published in Lawson and others (1908, pl. 57A) with caption "Martinelli's pier at Inverness. Originally straight; shifted and broken by earthquake. Repaired before photograph was taken." B. Bailey's pier.

Photograph previously published in Lawson and others (1908, pl. 57B) with caption "Bailey's pier at Inverness. Originally straight; shifted and much broken by earthquake. In subsequent repairs curvature caused by earthquake was retained." (Photographs by G. K. Gilbert.)

FIGURE 64.—Hillside flow failure 2 mi (3.2 km) west of Inverness and 1 mi (1.6 km) south of Sunshine Ranch (loc. 274). A hillside bog was set in motion by the shock and flowed down the slope as a stream of mud. (Photograph by G. K. Gilbert.)

FIGURE 65.—Hillside landslide in roadcut (loc. 276). Photograph previously published in Lawson and others (1908, pl. 53B) with caption "Landslide from road-cliff about two miles [3.2 km] west of Inverness. Slide occurred at time of earthquake." (Photograph by G. K. Gilbert.)

FIGURE 66.—Landslide on the Hutton Ranch, east side of Garcia River Valley (loc. 307). Toe of landslide with transported trees is at left. Toe of slide also caused "wrinkling" of barley field in foreground. (Photograph by F. E. Matthes, courtesy of The Bancroft Library, University of California, Berkeley.)

NORTH COAST COUNTIES REGION

Included in the north coast region are all of Humboldt County and northern Mendocino County (pl. 5 and table 9, locs. 312–354; fig. 67). This region is generally mountainous with narrow intermontane valleys. The San Andreas fault trends offshore near Point Arena at the south margin of the region. The 1906 rupture on that fault extended as far north as Point Arena and probably continued for some distance northwestward off the Mendocino Coast. Surface ruptures as a result of tectonic faulting occurred at Shelter Cove in 1906 (Oakeshott, in Bailey, 1966, p. 361), indicating that seismic energy was released at least that far north along the coast.

Major landslides were noted along the coastal bluffs from Point Arena to Cape Mendocino (locs. 312, 332, 337). These slides were generally of the rockfall type and were most notable on the higher bluffs between Point Delgada and Cape Mendocino (loc. 332).

A large landslide called the Cape Fortunas landslide occurred in the coastal hills just north of False Cape, which is located about 30 mi (50 km) southeast of Eureka (loc. 339, fig. 67). The reports (Lawson and

others, 1908, p. 390) indicate that this slide, which was about 1 mi (1.6 km) in length and 0.25–0.5 mi (0.4–0.8 km) wide, moved as much as 1,300 ft (400 m) horizontally into the ocean. However, the total difference in elevation between head and toe of the landslide was only about 500 ft (150 m); hence the lateral component of movement was several times larger than the vertical component. The Cape Fortunas landslide thus may have had some similarities with lateral spreads that developed in the Anchorage, Alaska, area during the 1964 Alaska earthquake (for example, the Turnagain Heights landslide (Hansen, 1966, p. A59–A66; Seed, 1968)).

Very few hillside landslides were reported in 1906 at inland locations in the north coast area. This may have been a consequence of distance from the source of seismic energy release, sparse investigative coverage, or local geologic conditions. Locally, landslides were reported in areas such as Petrolia (loc. 338) both in 1906 and during earthquakes in 1923 and 1968. Moderate-sized landslides were also reported locally in the Eureka and Arcata areas during events in 1927 and 1954 (locs. 353, 354).

FIGURE 67.—Cape Fortunas (False Cape) landslide, one of the largest landslides triggered by the 1906 shock (loc. 339). A. View toward by Lawson and others (1908, pls. 127A, B) with caption "Earth-slump at Cape Fortunas, Humboldt County."

During the 1906 shock, considerable lateral spreading, differential settlement, and ground cracking developed in flood plain sediments near the mouth of the Eel River (locs. 340, 344). These failures, which were similar to ground failures generated along other major rivers in northern California, were accompanied by the pervasive eruption of sand boils, indicating that liquefaction was a factor in their development. Differential vertical displacements as large as 3 ft (0.9 m) were common in the Ferndale area where the effects were particularly severe. No measurements of differential lateral movements were given, but the abundance of open fissures indicate that significant lateral displacements must have also occurred. During the 1954 earthquake, settlements as large as 0.5 ft (150 mm) occurred in the older part of Eureka, which is constructed on fill. Several waterlines were broken in that area, presumably as a result of ground displacements.

SUMMARY AND CONCLUSIONS

Historically, major ground failures triggered by earthquakes in northern California have been limited to the Coast Range province; however, minor failures have occurred at numerous localities throughout the region. The historical record shows that except for offshore shocks, the size of the geographic area affected and the number and the general severity of ground failures increase markedly with Richter magnitude. Hence, the largest historical event, the 1906 San Francisco earthquake, has been the most important generator of ground failures. That shock triggered failures over a 370-mi (600-km)-long zone extending from southern Monterey County on the south to Eureka on the north and inland as far as 60 mi (100 km) from the Pacific Coast.

Geologic, hydrologic, and topographic setting has great influence on ground failure development. Areas

scarp. B. View toward toe showing extension of toe into Pacific Ocean in background. Similar photographs previously published (Photographs by A. S. Eakle, courtesy of The Bancroft Library, University of California, Berkeley.)

especially vulnerable to ground failure have been oversteepened slopes, such as streambanks and coastal bluffs, and lowland deposits, principally Holocene flood plain deposits, deltaic deposits, and poorly compacted fills, where liquefaction has been the major cause of ground instability.

Hillside landslides triggered by the 1906 earthquake were too numerous for the postearthquake investigators to document each occurrence. Most of the landslides occurred in the Coast Ranges within a few miles of the ruptured fault. Because there was little development in the mountainous areas and because most of the landslides were small or involved little displacement, damage from hillside landslides was small compared to other damage sources. Nevertheless, where hillside landslides impinged on the works of man, the results were generally disastrous. For example, 10 men were killed and 2 lumber mills destroyed by landslides in the Santa Cruz mountains, and 3 mi (4.8 km) of the Ocean Shore Railroad was practically obliterated by landslides along the coastal bluffs south of San Francisco.

Liquefaction was a primary factor in the development of many ground failures including flows, lateral spreads, slumping of streambanks, and ground settlements. Lateral spreads were the most common and most damaging liquefaction-induced ground failure. Flood plain and loose sand fill deposits were the landforms most vulnerable to this type of failure. Bridges, roadways, pipelines, and buildings suffered considerable lateral-spreading damage. Pipeline breaks were particularly critical in San Francisco, cutting off the water supply to a city that was soon afterward in flames. Recent borehole data show loose saturated sand beneath five lateral-spreading sites. Flows developed on several sandy hillsides but did little damage because of sparse development in the affected areas.

Several instances have been reported of the same type of failure occurring repeatedly at the same location in more than one earthquake. For example, landslides similar in nature and location occurred during both the 1906 San Francisco earthquake and the 1957 Daly City earthquake on steep slopes near Daly City (locs. 132, 133) and around the margins of Lake Merced (locs. 232-242). Ground cracks and slumping of streambanks occurred along Coyote Creek between San Jose and San Francisco Bay (loc. 149) during both the 1868 and 1906 events. Lateral-spreading failures of the types that developed in San Francisco during the 1906 shock (locs. 193-217), but with smaller displacements, also developed during shocks in 1868 (locs. 198-202, 205, 209) and 1865 (locs. 202, 209, 212). This evidence indicates that if geologic, hydrologic, and topographic conditions remain unchanged, similar types

of ground failures are probable at these locations during future strong earthquakes.

Because of recent population growth and land development, the potential for landslide and other ground failure damage during a large earthquake is enormous now compared to that in 1906.

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TABLES 5–9; FIGURES CITED IN TABLES

TABLE 5.—*Specific descriptions of ground failures in the Monterey Bay counties region*

Location number is assigned to each reported ground-failure site. Corresponding numbers are found on plate 1. Figure number refers to figure in this report showing damage described under "Quotation" column. Failure type is indicated by the following symbols. Corresponding symbols are found on plate 1.

☒ Hillside landslides including rotational slumps, block glides, debris avalanches, and rockfalls	☒ River stretches with extensively fissured flood plains; pattern indicates stretches of river affected and not width of disturbed zone
☒ Streambank landslides including rotational slumps, and soil falls	☒ Sand boils
☒ Lateral spread	☒ Disturbed wells
☒ Ground settlement	☐ Absence of ground failure noted
☒ Ground cracks not clearly associated with landslides, lateral spreads, settlement or primary fault movements	☒ Miscellaneous effects
	☐ Arrows showing extent of area affected. Symbol shows failure type

Accuracy with which failure sites can be located is given as follows: A, a site that can be accurately relocated; B, a site that can be relocated to within a few kilometers and probably could be located more accurately with further investigation; C, a site where the information is insufficient to allow precise location. Plate numbers in the "Reference" column refer to plates in the original source material.

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
1		✱	B	1906	Lawson and others, 1908, p. 298.	The railway station at Bradley, standing on made ground, <u>settled 2 inches at one end.</u>
2		✱	C	1906	Lawson and others, 1908, p. 298.	At San Ardo * * * the river bed is thought to have sunk about 2.5 feet, tho evidence of this was not obtained.
		⊙	C	1906	Lawson and others, 1908, p. 409.	At San Ardo, quicksand was thrown up in a well, seeming to lessen the flow considerably.
3		↔	B	1906	Lawson and others, 1908, p. 297.	(S. A. Guiberson, Jr.)--As superintendent of the pipe line, I am in a position to say that we have no breaks whatever in any place between Coalinga and the Salinas river, and there were no fissures of any kind along the line between these points. This I know positively, as I have line riders who were instructed to look closely for any disturbance of this nature. The line of fissures seems to have ended north of Priest Valley.
4		✱	C	1906	Lawson and others, 1908, p. 293.	* * * the Salinas river bed sank nearly 6 feet at King City, and the wide sandy bottom at Three Mile Flat was much cracked * * * .
		✱	C	1906	Lawson and others, 1908, p. 297.	The river-bed sank nearly 6 feet in the vicinity of King City.
5		⊙	C	1906	Lawson and others, 1908, p. 291.	<u>Priest Valley.</u> * * * There were slight landslides and cracks along the edge of the creek banks.
		⊞	C	1906	Carey, 1906, p. 297.	* * * At Priest Valley * * * fissures in the ground [were] reported.

TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
6			C	1926	Townley and Allen, 1939, p. 241.	1926 July 25. 9:58 a.m. VII. Near Idria, San Benito Co. This shock caused rocks to roll down hillsides in the Idria-Panoche region * * *
7			B	1906	Lawson and others, 1908, p. 319, plate 125B.	<p><i>Cantua Creek, Fresno County</i> (S. C. Lillis). The shock was severely felt in this region, and its direction was southeast-northwest. A series of landslides caused by the earthquake were reported by Mr. Lillis, extending from the northwest corner of T. 18, R. 14 E., M.D.M. to the middle part of T. 15, R. 11 E., a distance of about 23 miles. The features were not at first recognized by Mr. Lillis as landslides, and as they occurred on the east side of the Coast Ranges, on the border of a portion of the San Joaquin Valley, where the intensity was abnormally high, the hypothesis was entertained that there might have been a supplementary fault in that region along the edge of the mountain range. The remarkable alinement of the features lent support to this suggestion. The region was, however, subsequently visited by Prof. G. D. Louderback, in company with Mr. Lillis, and the features reported by the latter were found to be landslides. Professor Louderback furnishes the following note regarding them:</p> <p>The phenomena reported by Mr. Lillis are several landslides. In each case the effect of the movement can be followed in detail and sharply delimited. The form of the moved body is typically that of the landslide in each case, with the cliff at the upper end curved and concave toward the lower part of the slope. The mass has moved away and downward, leaving in some instances an open space or fissure, partially filled at the present time (May, 1907) by caving. The back cliffs, followed around, gradually pass into lateral planes of movement, which themselves are sometimes gaping on the more elevated side, showing a forward and slightly lateral movement of the mass. (See plate 125B.)</p> <p>No general fissure, fault, or rift was observed passing thru or near these landslides, altho a careful search was made for such features. I suspected at first that there might be such a rift-line, because the landslides are approximately along one line or belt. This appears, however, to be due to the fact that one particular formation is especially favorable to landsliding, all the slides that I saw along the lower part of the range being associated with a thick reddish-brown shale of a definite stratigraphic horizon (Tejon?). The general structure of the range causes the rocks of any given horizon to outcrop along a line roughly parallel to the range front (approximately northwest-southeast). The landslides all lookt fresh, and according to Mr. Lillis several of them (and probably all of those under consideration) were caused on April 18, 1906. I made a trip across the hills from the valley to New Idria and noted nothing that appeared to be a recent seismic line.</p>
8			C	1906	Lawson and others, 1908, p. 293.	* * * the southernmost extension of continuous cracks along the [Salinas River] bank was found to be about 2.5 miles south of Gonzales bridge. From here to the mouth of the river the cracks are parallel with the river banks.
9			A	1906	Lawson and others, 1908, p. 293.	The movement at Gonzales bridge was mostly on the west bank of the stream. A wire fence trending north and south was torn 6 inches apart here, and wooden piles at the southwest end of the bridge, said to be driven down 75 feet, have been torn loose and moved from plumb, their original upright position. At the northeast end of the bridge the piles are undisturbed, but the surface soil and a wire fence have moved relatively 18 inches northward. (See fig. 59.) [That figure, not reproduced in this report, shows a plan view of the bridge and approximate relative movements of the piers.]

TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						North of Gonzales bridge the fissures are mostly on the west side of the stream channel, and reach a maximum width of 18 inches. No evidence of shearing could be found.
	■	C		1906	<i>Salinas Daily Index</i> , 1906b.	EARTH CRACKED AT GONZALES. Albert Hansen came to the Index this morning. He had come from Gonzales. The bridge there was broken at the further end, and large areas of land opposite Gonzales across the river were under water. The river bed has opened and for miles the earth is cracked open from inches to feet in irregular cracks.
10	←○→	C		1906	Lawson and others, 1908, p. 293.	In the creek bottoms west of Chualar, sand craterlets begin to appear and become numerous along the stream northward.
	⊠	C		1906	<i>Salinas Daily Index</i> , 1906a.	STOPPED THE TRAIN. Passenger train no. 3 was near Chualar when the shock occurred and the engineer says that the track moved back and forth with a worm-like movement.
11	◁	B		1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 21, plate XII,A.	The road leading to Spreckels's sugar mill, 4 miles south of Salinas, was also greatly damaged by the slips. Spreckels's sugar mill (Pl. XII,A) is located on soft alluvium.
	◁	B		1906	Duryea and others, 1907, p. 311.	From the Salinas highway bridge to Spreckels, a distance of about 1 1/2 miles, the surface of the ground was scarred so much that the roadway became impassable for vehicles.
	○	B		1906	Lawson and others, 1908, p. 295.	South of the Spreckels factory, the low bottom-land between the banks of the river is considerably cracked, although there is no prominent vertical dropping of the land along the cracks. This low land lies west of the present course of the stream, and is intersected by sloughs and former water courses. All of the ground is of a deep sandy nature, consequently it was much disturbed and fissured by the quake, and the fissures became filled with water and sand, forming a quicksand, this wet sand frequently being spouted into the air. No one noticed gases coming up. The position of the cracks is now marked by patches of light, bluish-gray sand in the field, from the drying out of the quicksands. Houses on this low land were thrown out of plumb, and chimneys were destroyed. The cracks diminish in number as one goes southward, and practically end in the vicinity of the Gonzales bridge.
7A	◁	A		1906	Lawson and others, 1908, p. 297.	The ground [at Spreckels sugar mill] to the south had been much heaved and otherwise deformed, causing the wrecking of trestles, pumping-house, and other structures. The rails of a track at the rear of the building were pulled apart, due probably to the slumping of the ground toward an old slough of the river. In the bottom of this slough water gushed forth at numerous places at the time of the earthquake. It is said by those who witnessed this phenomenon that the water spouted repeatedly as high as 20 feet, and that the outflow of water lasted for 10 minutes after the shock. The places where the water spouted forth are marked by areas of fine, light, bluish-gray sand, which is said to be known only at a depth of 80 feet in the various well borings of the vicinity. In these areas of fine bluish sand are often funnel-shaped depressions or craterlets from which the water issued.
7B	○	B		1906	Lawson and others, 1908, p. 293.	Near Agenda, [about 3 mi (5 km) southeast of Spreckels and about 1/2 mi (.8 km) northeast of Buena Vista School] in the lowlands, is a cracked area nearly a mile from the river, probably along an old water course; while sand craterlets are scattered thru the orchards. At Spreckels the movement caused much damage to flumes, sewers, and water-mains; and from here to Blanco the deep soil of the adjacent fields is much cracked and in places sunken and dotted with sand craterlets.
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TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		◀ (B)		1906	Derleth, 1906d, p. 712.	There is also a rupture in the carriage way to the dumps, clearly showing the existence of a decided ground movement at the time of the earthquake.
		◀ B		1906	Salinas Daily Index, 1906a, p. 1.	AT SPRECKELS * * *. The trestle of the elevated railway, upon which is conveyed the lime rock, is about three feet out of line and the railroad track that leads to the Spreckels bridge across the river was twisted into the shape of an interrogation point.
12		⋮ B		1906	Lawson and others, 1908, p. 295.	(A. S. Eakle.)--The effect of the earthquake upon the alluvium was well shown along the banks of the stream from the Salinas to the Gonzales bridges. Along the east side of the river for a short distance south of the Salinas bridge, 4 miles south of the town, the land is cracked at the edge of the bank, the cracks paralleling the course of the river; but comparatively little cracking was observed on this side of the river. Along the bank and down in the river-bottom itself, on the western side of the stream, fissures were very prominent. The county road southward from the Salinas bridge runs along the embankment about 10 to 20 feet above the stream bed. The road is an oiled one, and the oil had formed a hardpan upon the underlying sand. In the vicinity of the bridge the road has been shattered by the quake for a distance of 200 yards. The breaks are in the nature of a caving in of the road on the north side of the crack, as if hollow spaces existed beneath, leaving a vertical escarpment on the south side. The main sinking is at the most southerly fissure. Here the road has sunk bodily to a depth of 10 feet, leaving a high vertical bank diagonally across the road, and this sunken area extends for some distance into the adjoining field on the west. There is no upheaval of the road in any place to compensate for the sinking.
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	9	●				
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10		◀ A		1906	Lawson and others, 1908, p. 296, plate 123A.	At the bridge, a large trussed structure in 2 spans having a bearing of N. 27° E., the south pier, consisting of 26 piles incased in planking, was thrust to the south [relative to northward movement of ground] between 6 and 7 feet, so that the entire pier was inclined as shown in plate 123A. The piles were not broken at the ground level. The north and middle piers were apparently not affected. An oil pipe which crossed the bridge was buckled and twisted at the south end of the bridge, and when this was repaired the pipe was found to have been shortened 7 feet. The pipe line extends from the San Joaquin Valley to the Bay of Monterey. A few hundred yards to the south of the bridge is a pumping station, and at this point some of the connections of the pipes were broken and displaced. The direction of the shortening of the bridge span and the pipe is roughly normal to the direction of the San Andreas Rift, on the other side of the Gavilan Range. Mr. S. A. Guiberson, superintendent of the line, reports that the pipe was broken in about twenty places in the vicinity of the river, and that at some of these breaks the pipe was pulled apart.
		◀				
		◀ B		1906	Lawson and others, 1908, p. 297.	(S. A. Guiberson, Jr.)--* * * The conditions prevailing along the Salinas River, and some of the peculiar circumstances attending the breaking of our [oil pipe] line in about twenty places, are of interest. I was on the ground the following day, and only regret that I did not have time to have some of the peculiar features photographed. In places our line had been broken and the ends were 3 feet apart; at the same time the ends of the pipe would be hammered up, showing that there had been an opening and closing movement at that point, while at other points the line would overlap as much as 4 feet. One of our stations is in this zone of disturbance, and the engineers, being on duty, had an excellent opportunity to see what most of us who were in bed merely felt. They state that these fissures were opening and closing, and that the water and sand would go 20 feet in the air as they closed.
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TABLE 5.—*Specific descriptions of ground failures in the Monterey Bay counties region—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		◀	A	1906	Lawson and others, 1908, p. 293, plate 123A, plate 136, plate 137.	The county bridge south of Salinas was rendered unsafe by the move- ment of the piers at the southern end. (Plate 123A.) On the west bank near the bridge a series of peculiar cracks have torn up the road and adjacent field, along what is probably the path of an old water course. These are shown in plates 136, 137.
		◀	A	1906	Lawson and others, 1908, p. 292.	On the road eastward to Salinas from Del Monte, no visible signs of the earthquake were encountered until the Salinas River was reached. The Salinas bridge was moved southerly several feet, according to report, and the framework was broken so as to render the bridge unsafe.
		◀	A	1906	Duryea and others, 1907, p. 311.	Fig. 1, Plate LV, shows the south abutment of the Salinas bridge. The ground at this point moved about 6 ft. into the river, * * *. A 3-in. oil pipe line which crossed the bridge was ruptured on the south approach, one length of pipe being bent in the form of the letter S. The northern approach to the bridge was not affected.
		◀	A	1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 21, plate VIII,B.	The alluvial or soft soil forming the banks of rivers generally moved toward the river under the earthquake vibrations, the set- tling of the ground being most marked (Pl. VIII, B). The country in the vicinity of Salinas River presented interesting features of this character. The county road crosses the river near Salinas on a wooden bridge, and the slipping of the banks carried the south abutment 6 feet toward the river. The ground was badly cracked and there were a number of slips in the neighborhood.
		●				
		◀	A	1906	Derleth, 1906d, p. 712.	The land on the south bank of the Salinas river for a considerable area has moved into the river in a northerly direction, on an aver- age, through a distance of about 6 ft. Figs. 15 and 16 show the south abutment of the Salinas highway bridge. The ground has moved under the super-structure about 6 ft., bending the pile bent foundations as shown in the pictures without seriously injuring the trusses. A 3-in. oil pipe-line crossing the bridge was ruptured on the south approach, one length of pipe being bent like the letter "S." The northern end and approach to the bridge were hardly affected. In fact, the northern bank of the river shows little disturbance at this point. From the Salinas bridge eastward a distance of about 1 1/2 miles to Spreckels, the south bank of the river is continuously scarred and rent so that the old road is impassable for vehicles.
		✱	B	1906	<i>Monterey County Democrat</i> , 1906, p. 2.	The Salinas County Bridge at Hilltown is reported unsafe. The earth this side of the river sank about four feet and the approach on the other side moved some five feet from its former position. * * * On the Buena Vista side a fissure four feet wide and of unknown depth extends for several hundred feet. Near Agenda the earth opened twenty five feet across from which gushes a stream of cold water completely saturating and covering the neighborhood.
		○				
		✱	B	1906	<i>Monterey County Democrat</i> , 1906, p. 2.	Near the county bridge across the river just opposite the factory [Spreckels] the earth is depressed in some places twenty-five feet and extends back into the hills several hundred feet. * * * The earth has also sunk in many places along the river bank on both sides of the Salinas river.
		✱	B	1906	<i>Salinas Weekly Index</i> , 1906, p. 1.	Hiram Corey, of Las Palmas ranch across the Salinas river, had to come to town today on horseback, because of the impassibility of the roads. At his place no damage was suffered except the toppling over of some chimneys. Mr. Corey reports that there is a depres- sion of ten feet for a quarter of a mile at the Jacks prune orchard. The road is impassable and he had to make a detour into the orchard to get into town. He reports that the sediment land at Spreckels and in front of Las Palmas, which was dry yesterday, is flooded today, and that the county's iron bridge at Hilltown is out of commission for teams.

TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		◀	A	1906	<i>Salinas Daily Index</i> , 1906a, p. 1.	BRIDGE CONDEMNED. The county bridge across the river suffered badly and had been closed to travel by order of supervisor J. A. Hughes. The heavy piling is thrown ten feet out of alignment and the timbers were snapped off as though they were toothpicks. The approach at the south end has been lifted about three feet and by the force of the temblor has been shoved six feet southward. The bent supporting the approach was snapped off and the long approach is suspended, making it unsafe for travel.
		◀				GREAT FISSURE OPENS. A peculiar freak of the quake is the deep fissure that crosses the county road and continues through the fields along through Blanco [loc. 13] almost to the mouth of the Salinas river. This is a depression in the ground ranging in width from nearly a hundred yards at the crossing of the road to fifteen feet out in the field. In traveling the road after turning toward the bridge from Hilltown, one is suddenly confronted with a precipice six feet in height. The ground has sunk and after climbing down the embankment the earth is torn and riven, showing how great must have been the force of the shock. A portion of the high embankment across the river has caved in and gone out of sight. At another place there is another deep fissure, through which water and quick sand oozes.
13		✱ ○	C	1906	Lawson and others, 1908, p. 293.	Between Blanco and Neponset the cracking and settling of the low land flooded the adjacent fields and gave rise to stories about the Salinas River having risen several feet. The "boiling up" of the water thru sand craterlets was also soon distorted into a story about the water of the Salinas River being boiling hot.
14		✱ ◀	C	1906	<i>Chicago Evening American</i> , 1906, p. 3.	Between Seaside and Del Monte the tracks have settled fully four feet and the rails have been twisted all shapes. [See also loc. 16 for adjoining text.]
15		◀ ✱	B	1906	Lawson and others, 1908, p. 294.	It may be said, regarding the soil movement along these streams, that along the Salinas River from Gonzales to near Blanco, everything shows a movement down the river. From Blanco to Neponset the movement seems to have been a settling of the alluvial materials, while from Neponset to the mouth of the Pajaro River [see loc. 20] the ground (in several places, at least) moved eastward or inland.
		◀	A	1906	<i>Salinas Daily Index</i> , 1906d.	The bridge at Neponset is wrecked out of line and although it is in use repairs will have to be made on the same as soon as laborers and material can be obtained.
		◀ ○	A	1906	Lawson and others, 1908, p. 293.	At Neponset and Salinas the piling under the county bridge was moved in some of the bents at least 10 feet toward the river. A section man who stood in the midst of the cracks at the end of the Neponset bridge was drenched with spurting water.
		◀	A	1906	Lawson and others, 1908, p. 293.	Both the railway and county bridges at Neponset were moved, the northern concrete piers of the former 2 inches east and the central wooden pier of the latter apparently 4 feet south.
16		◀	C	1906	Lawson and others, 1906, p. 293.	From Morocoho [Nashua] to Moss Landing fissures rarely show in the marshy land, but the narrow gage railway track has been shifted a few inches in several places.
		○	C	1906	Ransome, 1906, p. 295.	Between Castroville and Monterey the ground is said to have opened and shut and mud to have spurting from the fissures.

TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
				C	1906	<i>Chicago Evening American</i> , 1906, p. 3.
		✱				Watsonville, Cal. April 19.--As we passed through the country between Monterey, Castroville and Tajaro [sic] we saw unmistakable signs of the terrific wrenching given to that section by yesterday's tremendous upheavals of the earth.
		✱				Great sinks, extending along the tracks as far as the eye could reach and ranging from four to six feet in depth, have been left in the surface of the earth, a mute testimony of the awful twisting and wrenching of the internal forces. For distances of from one-quarter to three-quarters of a mile the road bed has dropped from four to six feet.
		○				MUD GEYSERS EXCITED INTO SUDDEN ACTION. Between Castroville and Monterey, along the railroad tracks and into the fields, mud geysers have been excited into action spouting a boiling hot, bluish, shale-colored mud to a height [sic] of from ten to twelve feet.
						In places these geysers are from four to ten feet apart and in other sections they are fifty feet or more apart.
		◀				At Fairman Section Foreman H. J. Hall and Roadmaster Goldman saw these geysers in violent action.
						The mud was spouted through the sand and loam. I saw this mud along the tracks for several miles, with here and there places where the geysers had been recently at work.
						The railroad tracks for almost the entire distance are twisted out of all semblance of tracks.
						Between Seaside and Del Monte the tracks have settled fully four feet and the rails have been twisted all shapes. [See loc. 14.]
17		□		C	1906	Lawson and others, 1908, p. 292.
				B	1906	<i>Chicago Evening American</i> , 1906, p. 3.
		◀				CREVASSE OPENS AND CLOSES IN THE EARTH. Near Castroville, while the disturbance was at its height, Foreman H. J. Hall grabbed his two children and left the section house.
						As they passed through the door they saw the earth open and a crevasse, which Hall described as fully six feet wide, open and close several times.
		○				I visited the scene at midnight and found the section house standing in a pool of geyser mud. This mud was like quicksand, and of unknown depth.
		✱		C	1906	<i>San Jose Herald</i> , 1906a, p. 5.
						* * * The LePoncet [sic] bridge [see loc. 15] is in bad condition. The Jajaro [sic, see loc. 24, 25] bridge is gone. Castroville bridge is in a bad condition. There has been a heavy slide at Newria [sic, see loc. 6] besides several other trifling damages.
18		○		C	1906	Lawson and others, 1908, p. 295.
		◀				<i>Prunedale</i> . (H. H. McIntyre).-- * * * Water started flowing in many places where there had been none, or but little before. There were 2 small landslides from springy places, the direction of the slip being from north to south.
19				C	1906	Lawson and others, 1908, p. 293.
		◀				At Moss Landing, where the river runs parallel with the shore line [the Salinas River discharged into the ocean north of Moss Landing in 1906], the strip of land is seamed for miles. A crack, or rather a sink, about 20 feet wide and 4 or 5 feet deep ran under the buildings and rent them asunder. The office building between this crack and the river has been moved bodily--land and all--about 12 feet toward the river. Some of the cracks run into the ocean.

TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
12A		◀	B	1906	Lawson and others, 1908, p. 293, plate 134B, plate 135A, plate 135B.	At Moss Landing many small cracks occur in the mud on the west side of the river, and the condition of the wharf indicates an eastward movement of the sand-spit. (See plates 134B, 135A, B.) It is reported that at places along the pier where the water was formerly 6 feet deep, it now has a depth of 18 or 20 feet.
		◀	B	1906	Lawson and others, 1908, p. 401, plate 134A.	Along the beach or sand-spit which separates the Salinas River from the Bay of Monterey at Moss Landing, there was a marked lurching of the spit toward the trench of the river as illustrated in plates 134A, B and 135A, B.
12B		◀	B	1906	Lawson and others, 1908, p. 292, plate 116D.	The wharf at Moss Landing buckled up and partly collapsed, while the warehouses were wracked or fell westward.
		◀ ✱	B	1906	Gilbert, Humphrey, Sewell and Soulé, 1907, p. 21.	Along the Bay of Monterey the whole shore slipped about 12 feet into the bay, the movement buckling the rails on a railroad trestle and the cars dropping about 5 feet. A frame house and surroundings moved 12 feet, still maintaining their relative positions. [This occurred at Moss Landing where the movement was into the Salinas River rather than into the bay.]
		◀	B	1906	Jordan, 1907, p. 299.	At Moss Landing, near Salinas, there were great horizontal disturbances of the sandy ground; the office of the station agent being displaced about 15 feet relative to the adjoining fence.
		◀	A	1906	<i>Salinas Daily Index</i> , 1906d.	The fill leading up to the bridge crossing the mouth of the Salinas river at Moss Landing has been shattered and will have to be rebuilt. This fill and the flood gate there was put in about twenty years ago and its reconstruction will entail a great expense.
12C		◀	A	1906	Mr. Albert Vierra Sr., Personal commu- nication.	Authors summary of notes taken during an interview with Mr. Albert T. Vierra, Sr., of Moss Landing, Dec. 3, 1974. Mr. Vierra was 12 years old at the time of the earthquake. Two areas between Monterey Bay and the Salinas River were extensively cracked and shifted many feet eastward into the river. (In 1906, the Salinas River joined with the Pajaro River about 1 mile (1.6 km) north of Moss Landing and then flowed northwestward into Monterey Bay.) The first area extended from Moss Landing to approximately the tide gate on the Old Salinas River. The second area is still expressed as a promontory into Bennett Slough near the tide gate off Jetty Road north of Moss Landing. Many large pieces of blue mud were extruded up through some fissures. The ground east of the Salinas River was little disturbed. The outer part of the pier, which extended into Monterey Bay, broke off and shifted several feet out to sea. The pier was constructed on pilings over 100 ft (30 m) deep. The present roadway across the Old Salinas River is constructed on the old narrow gage railroad bridge which was damaged in the 1906 shock (fig. 12A).
		○ ◀				
		◀ ✱	B	1906	<i>Evening Sentinel</i> , 1906c, p. 6.	David C. Vierra of Moss Landing reports that * * * [at Moss Land- ing] the fills at the bridge on the county road have fallen in. A great change has been made in the dam and most of the old land in the slough has sunk and new land risen in its place.
		◀ ✱ ○	B	1906	<i>Salinas Daily Index</i> , 1906e, p. 2.	At Moss Landing the results of the quake were the most severe in this immediate vicinity. * * * The bridges were torn up and the rails of the narrow gage road were twisted into all conceivable shapes where not broken altogether. The wharf was broken off and piles cast upon the beach. The ground along the beach sank several feet in places an (sic) again in other places fissures two and three feet wide and several hundred feet long were rent in the earth. The roads were cracked for miles around. Where there were sand dunes a few days ago, now there are deep holes with water bubbling through them, in fact, water bubbles forth from all the cracks and fissures. The loss of property at the landing will probably reach \$10,000.

TABLE 5.—*Specific descriptions of ground failures in the Monterey Bay counties region—Continued*

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
20	✱	C		1906	Lawson and others, 1908, p. 293.	North of Moss Landing the ground settled nearly 2 feet in places, as shown by marks on railway piles at several slough crossings and by the sagging of the track below grade line in several other places. The stretch of narrow-gage track parallel to the coast has been disturbed for nearly its whole length; in some places it is wavy, in others the entire roadbed has shifted.
	◀					
		A		1906	Mr. Hans Struve, 1974, personal communication.	Author's summary of notes taken during an interview with Mr. Hans Struve of Moss Landing, Dec. 3, 1974. Mr. Struve was 14 years old at the time of the earthquake. The marshlands, riverbanks, and some farm land along McClusky slough and along the Pajaro River near its juncture with the Salinas River north of Moss Landing were extensively cracked. Fresh water came out of some fissures. The bottom of the Pajaro River came up at a point just north of its juncture with the Salinas River causing the Pajaro to change course and empty into Monterey Bay near the present mouth of the river.
	○					
	◀					
21		C		1906	Lawson and others, 1908, p. 293.	At one point about 5 miles south of Watsonville, where the railroad track is only about 200 yards from the beach, a stretch 100 yards long running northwesterly had shifted a maximum of 12 feet to the northeast. Fences, telephone poles, and track all moved together. The sand-dunes facing the beach directly opposite the place where this movement occurred look as if they had been struck by a single large wave.
	◀					
22		A		1906	Mr. Jarvis McGowan, 1973, personal communication.	<p>Author's summary of notes taken during an interview with Mr. Jarvis McGowan, Sr., of Monterey County July 27, 1973. Mr. McGowan was 5 years old at the time of the 1906 earthquake. On the day of the earthquake Mr. McGowan made an inspection tour with his father of the family ranch and other nearby sites of earthquake damage. The McGowan ranch is on a tract of land between the Pajaro river and a line of bluffs, 0.7 mi (1.1 km) south of the river. The ranch boundaries are 0.9 mi (1.4 km) and 1.2 mi (1.9 km) west of Highway 1.</p> <p>The most severe damage noted by Mr. McGowan was to the narrow gage railroad that formerly ran along the south bank of the Pajaro river where the flood control dike is now located. The approximately 4 ft (1.2 m) high embankment was thrown into waves and shifted laterally at many locations. These effects occurred from Watsonville west to near the mouth of the Pajaro river. The disturbance to the railroad was much more severe than to a fence which paralleled the tracks about 16 ft (5 m) to the south. At some locations the railroad grade was shifted away from the fence toward the river; at other locations the grade appeared to have shifted toward the fence. A 25-acre apple orchard on the McGowan ranch immediately south of the railroad was greatly disturbed. Every row of trees in the orchard was thrown out of line. In some areas the trees were pushed together, in others they were pulled apart. The orchard was so badly disarranged that it had to be taken out.</p> <p>Picket fences were used in 1906 to separate fields and ranches. Damage to north-south trending fences was greater than to east-west trending fences. Damage also attenuated with distance from the river, for example the fence along Trafton road which runs along the base of the bluffs was damaged very little. Typical damage was a lateral displacement at some point along north-south fence lines with the northern segment being shifted relatively westward, commonly about 3 ft (0.9 m). In some places the fences were pulled apart and broken, in others they were deformed in gentle curves. There did not appear to be any particular pattern to the fence disruptions nor were all north-south fences affected.</p>
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	◀					

TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		○				Some fissures were found in the fields but these were not major disturbances. An employee at the ranch who was on the bluff at the time of the earthquake reported that cracks opened and closed causing water to spurt several feet into the air. (Free ground water in that area was encountered at about a 4 ft (1.3 m) depth in 1906.) Circular or oblong zones of subsidence also disturbed the fields at several locations. In those areas the ground sank as much as 1.5 ft (0.5 m). Some open cracks were found along the top of the bluffs, but no landslides were directly triggered by the earthquake. However, during the following winter, a period of above normal rainfall, a number of landslides occurred including one that carried the McGowan home from a location near the top of the bluffs to a location part way down the slope. (The home was later moved to its present location at the base of the bluffs.)
		✱				
		✱	A	1906	Lawson and others, 1908, p. 293.	In the Pajaro Valley, on the McGowan ranch, at a bend of the river, an acre or more of orchard has sunk about 2 feet.
23		✱	C	1906	Lawson and others, 1908, p. 294.	Cracks [between Watsonville and the ocean] appear again along the Pajaro River and the railway track has sunk in several places.
24		◀ ✱	B	1906	Lawson and others, 1908, p. 294.	The side rods of the narrow-gage bridge 1 mile south of Watsonville are buckled as by a compressive force, and the roadbed at both approaches has settled at least 2 inches.
25	13 14	✱	B	1906	Lawson and others, 1908, p. 292, plate 116A.	At Watsonville * * * considerable settling of the ground took place in Chinatown on the southern side of the river.
		✱	B	1906	Lawson and others, 1908, p. 294.	In Chinatown, on the south side of the river, the settling of the ground was marked.
		✱	B	1906	Lawson and others, 1908, p. 294.	* * * evidence of settling is found at the broad-gage railway bridge at Watsonville, the southeast end of which sank more than a foot. The track was also twisted into an S-shape. The concrete foundation under the engine and stack at the power-house at the northwest end of the bridge settled, but the concrete work was little hurt.
		◀	A	1906	Duryea and others, 1907, p. 259.	The Southern Pacific Bridge across the Pajaro River, at Watsonville, consisting of four 80-ft. wooden spans on pile piers, had the second pier from the east end moved (up stream) about 3 ft.
		◀	A	1906	Duryea and others, 1907, p. 312.	The [highway] bridge at Watsonville was distorted in a similar manner [to the Salinas bridge, loc. no. 12] due to the shifting of the bank deposits.
		✱	A	1906	Salinas Daily Index, 1906d.	Supervisor J. L. Mann * * * reports that the damage done to the Monterey side of the Pajaro river bridge was * * * caused by a sink which extends along the bank of the river on this side and allows Chinatown to drop about four feet. This sink, or fissure, followed the bank of the river and enters under the approach from this side, throwing the whole bridge out of line. * * * another fissure followed the Watsonville side of the river, but was not so bad as on this side.
		◀				
		✱	C	1906	Ransome, 1906, p. 295.	The district drained by the Pajaro River, between the town of Hollister and Monterey Bay, was much disturbed. The railroad for distances up to a mile was depressed from 4 to 6 feet.

TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		○	C	1865	Lawson and others, 1908, p. 448.	At Watsonville there was a heavy shock. The earth opened in several places (secondary cracks), throwing up water.
		◁	A	1906	<i>Salinas Daily Index</i> , 1906a, p. 1.	The wagon bridge, the Southern Pacific and the Pajaro Valley rail- road [loc. 24] bridges across the Pajaro river are rendered impassable.
26		✱	C	1906	<i>San Jose Mercury</i> , 1906a, p. 8.	Between Endicotts [sic] and Watsonville the road bed is said to have sunk from two to fifteen feet.
		✱	B	1906	<i>Evening Sentinel</i> , 1906c, p. 6.	WATSONVILLE. One thousand feet of S.P. Co.'s track between Laguna and Ellicott sank from 5 to 15 feet. A considerable area of ground of J. P. Thompson's property has been covered with water. The tracks of the Southern Pacific Co. in all directions are widen- ing [sic] like snake tracks.
		◁				
		✱	C	1906	<i>Evening Sentinel</i> , 1906d, p. 8.	Between Ellicotts and Watsonville the roadbed is said to have sunk from two to fifteen feet.
27	15 16	■	C	1906	Lawson and others, 1908, p. 294, plate 141B, plate 143B.	Between Pajaro and Vega the ground cracked along the 2 to 6 foot bluff, marking the old river bank on the south side of the present channel, and the side toward the river has settled several feet. This is well shown in plate 141B. This displacement has caused numerous sand craterlets and pits (plate 143B); the largest pit noted being oval in shape, 6 by 20 feet in diameter, and 4 feet deep.
		○				
		○				
		■	C	1954	Coffman, 1973, p. 175.	1954. April 25. East of Watsonville. * * * ground cracked, and loose earth slid onto the road.
28		✱	C	1906	Lawson and others, 1908, p. 294.	Northeast of Vega the movement seems to have died out, the last evidence found being mud caps on some old piles in the channel of the stream, showing a settlement of the ground amounting to 8 inches. Between Vega and Chittenden no evidence of movement of the river-bed could be found.
		■	C	1953	Coffman, 1973, p. 175.	1953. December 16. Watsonville. * * * Boulders were strewn on the road some 5 miles west of Chittenden Junction.
29		✱	B	1906	Lawson and others, 1908, p. 279.	The track at the southern end of the Pajaro bridge sank from 2 to 4 feet for a distance of 150 yards, and between Chittenden and the bridge the track was bent in an S-shaped curve in several places. The concrete piers of the bridge were cracked, and the granite cappings shifted as before noticed. (See plate 65B and fig. 43.) [Damage to bridge piers most likely was caused by fault movement.]
		✱	C	1890	Coffman, 1973, p. 159.	1890. April 24. Monterey Bay region. * * * centered near Chittenden * * *. The railroad was damaged through settling of ground and displacement of a bridge.
			C	1890	Bailey, 1966, p. 361	On April 24, 1890, a strong earthquake damaged Watsonville, Hollister, and Gilroy. Mr. Joe Anzar, who was a young boy living in the San Andreas rift valley in the nearby Chittenden Pass area at the time of that earthquake, was interviewed in 1963 by Olaf P. Jenkins and [Gordon B.] Oakeshott. Anzar clearly remembered ground breakage, which caused Anzar Lake to drain, and landslides, which closed the railroad and highway where the fault trace crosses Chittenden Pass. He judged the motion to be stronger (at his home) than during the San Francisco earthquake of 1906.
		■				

TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
		■	C	1963	Coffman, 1973, p. 181.	1963. September 14. Vicinity of Chittenden and Soda Lake. * * * Landslides were reported in the Soda Lake and Pajaro Gap areas.
30	17	◀	B	1906	Lawson and others, 1908, p. 111.	The damage to the concrete abutments of the county bridge across the Pajaro River is due to this crowding in of the alluvial banks of the stream.
		◀	B	1963	Coffman, 1973, p. 181.	1963. September 14. Vicinity of Chittenden and Soda Lake. * * * Bridge footings of a highway bridge across the Pajaro River were damaged slightly.
31			B	1906	Lawson and others, 1908, p. 110.	Several cracks a foot or less in width show on the ridge, but the fault seems to set off about 100 yards to the northeast and to consist of east and west cracks, having loosened the whole slope for nearly a mile northward of Chittenden, causing great landslides.
		■				
		■	B	1906	Lawson and others, 1908, p. 388, plate 126A.	Inland from the coast there were numerous earth-avalanches caused by the earthquake on the walls of steep canyons. One of the most noteworthy of these was on the north side of a short but deep canyon west of Chittenden and close to the line of the fault. (Plate 126A.) The rocks composing the side of the canyon are the bituminous shales of the Monterey series. The slope rises very steeply for about 500 feet and was quite dry before the earthquake, altho it was covered with spring vegetation. Areas of bare rock appeared thru this vegetation. At the time of the shock several earth-avalanches were started, and these slid suddenly down the slope, part of the material filling the bottom of the canyon and part remaining on the less steep lower portions of the slope. The larger masses were broken off up near the brink of the canyon. There was apparently little or no rotation of the sliding mass. The result was to gorge completely the lower part of the canyon with rock debris, to widen the upper part of the canyon, and to expose extensive surfaces of unweathered rock.
		■	C	1954	Coffman, 1973, p. 176.	1954. August 12. East of Watsonville. Rockslides were reported on a road near Logan.
		■	C	1959	Coffman, 1973, p. 179.	1959. March 2. Near Gilroy. * * * Minor earthslide occurred on Chittenden Pass Road east of Watsonville, and boulders fell on Hecker Pass Highway between Gilroy and Watsonville [loc. 47].
32		⊙	B	1906	Lawson and others, 1908, p. 279.	There is much sulfur, oil, gas, and water in the hills here [vicinity of Chittenden]. A marked increase was noted in the flow of oil and water, and more gas and sulfur became associated with them.
33		⋮ ⊙ ←→	C	1906	Lawson and others, 1908, p. 111.	The disturbance affected the banks of the Pajaro River from Chittenden to Sargent, causing a cracking and sloughing of the banks into the stream but not a settling of the stream bed. The San Benito River was similarly shaken for about 3 miles up from its junction with the Pajaro. Cracks are also noticeable all along the Riverside road wherever it runs close to the river bank.
		⊙	C	1906	Lawson and others, 1908, p. 294.	Near Chittenden the banks are caved in.
		◀ ✱	C	1890	Holden, 1898, p. 150.	1890 * * * April 24 * * * between Pajaro and Sargents. It is reported that the [railroad] track was moved a foot out of line, and that the ground settled six inches in places. The bridge, fifty feet high, is impassable at both ends, the rails being pulled a foot apart.

TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
		C	1885	Coffman, 1973, p. 159.	1885. March 30. * * * Cracks occurred in soft banks of the Pajaro and Benito Rivers.
34			C	1906	Lawson and others, 1908, p. 295.	In the hills between San Juan and Natividad the ground is not cracked, except for a few places on hillsides where there was some sloughing off.
35			C	1906	Lawson and others, 1908, p. 111.	In the lowland to the southeast there is little evidence of the fault, but crossing at right angles the county road running north and south about a mile east of San Juan, is a band of small cracks 15 feet wide, causing the road to sink 8 inches and making a marsh of the field beyond.
	C	1800	Townley and Allen, 1939, p. 21.	1800 October 11 to October 31. [VIII or IX. San Juan Bautista.] * * * [All the buildings were damaged and cracks appeared in the ground near the Pajaro River -- <i>Hutchings' California Magazine</i> , 5, 310.]
	C	1800	Coffman, 1973, p. 155.	1800. October 11(?). San Juan Bautista. * * * Cracks were observed in the ground of the rancharia; a deep fissure was reported along the slope of the Pajaro River.
36			C	1906	Lawson and others, 1908, p. 288.	One old settler remembers when the business part of Hollister was a slough. An artesian belt also passes thru the town, which may have affected the intensity along its path.
	C	1906	Lawson and others, 1908, p. 289.	There were no changes in the ground at Hollister save some slight cracks in the vicinity; * * *
37			C	1906	Lawson and others, 1908, p. 289.	Paicines, tho south of Tres Pinos, * * *. Water is said to have spouted up in the flat land along the [San Benito] river, 0.25 mile from the stream.
38			C	1906	Lawson and others, 1908, p. 289.	* * * a small peak near Santa Ana showed a landslide down its steep face, plainly visible at a distance of 6 miles. A huge rock, rolling down a hill in Santa Ana Valley, crashed thru a house and killed a man.
39			C	1906	Lawson and others, 1908, p. 110.	The road at Corralitos is said to have been slightly cracked, and in the low hills between Valencia and Corralitos a few cracks were found; but the fault evidently runs fully 0.5 mile east of Corralitos. The mountain roads east and northeast of Corralitos were rendered impassable by landslides and by bridges being injured.

40			C	1906	Lawson and others, 1908, p. 292.	On the higher ground between Watsonville and Aptos, the shock was little felt. There was no movement along Aptos Creek, both wagon and railway bridges being unaffected.
41			B	1906	Lawson and others, 1908, p. 292.	* * * Capitola * * *. Much earth fell from bluffs near the town, but there was no appreciable effect on the surf. At the country bridge across Soquel Creek, the ground at the east abutment shoved inward, cracking the concrete and buckling a water-pipe.

42			B	1906	Lawson and others, 1908, p. 292.	The east abutment of the concrete wagon bridge over Soquel Creek cracked vertically, showing that the soil movement extended this far up the creek.

TABLE 5.—Specific descriptions of ground failures in the Monterey Bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
43			A	1906	Lawson and others, 1908, p. 271.	At the Southern Pacific bridge, crossing the San Lorenzo River, there is a network of fissures varying from 2 to 15 inches in width, running thru the sandy soil. The direction of the main fissures is east and west, and they are on the south side of the river, which is nearest the bay. The ground has settled about 10 inches from the abutments and piers of the bridge. The depth of the fissures was indeterminable, as they had filled with sand.
	✱					
	○					
	⋮		B	1906	<i>Evening Sentinel</i> , 1906a,	There are many cracks in the earth in various parts of the city [Santa Cruz], as for instance near the depot, and at the corner of Front St. and Soquel Av. Near the Riverside Hotel the street has dropped several inches. * * * The railroad embankment extending from Casino [on arcade] to river has sunk.
	✱					
	□		B	1906	<i>Evening Sentinel</i> , 1906b,	Along the water front there were quite a number of friekish [sic] pranks of the temblor. The earth along the esplanade was opened in places and left gaping wide.
	○		B	1906	<i>Evening Sentinel</i> , 1906e,	At the Riverside Hotel, ground in the orchard opened and river bottom sand and water were thrown up upon the surface of the ground, the earth closing again. A similar occurrence happened at Watsonville [loc. 25], and well drillers say that the soft blue soil exuded is such as is found not less than 100 feet beneath the surface of the earth.
	□		A	1906	Lawson and others, 1908, p. 270.	At the north end of the bridge crossing the San Lorenzo River, at Third Street, there were 4 fissures running practically parallel and almost due east and west. These fissures are about 700 yards in length, and vary in width from 2 to 8 inches. They run thru an apple orchard and are in sandy soil, the softness of the land near the river-bed being apparently responsible for their presence. The river at this place runs about east.
44	✱		B	1906	Lawson and others, 1908, p. 294.	Along the San Lorenzo River, at Santa Cruz, this settling action [as along the Pajaro River] also took place for a mile or more upstream from its mouth.
	□		A	1906	Lawson and others, 1908, p. 270.	In going thru the town of Santa Cruz in the direction of Boulder Creek, a fissure at the intersection of Bulkhead and River Streets was noticed. This fissure was about 1.5 inches wide and ran east and west.
	⋮		C	1906	<i>Santa Cruz Surf</i> , 1906, p. 5.	[Picture caption] Fissures in soft mud of river bank. [See also locs. 45 and 46.]

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region*

Location number is assigned to each reported ground-failure site. Corresponding numbers are found on plate 2. Figure number refers to figure in this report showing damage described under "Quotation" column. Failure type is indicated by the following symbols. Corresponding symbols are found on plate 2.

■ Hillside landslides including rotational slumps, block glides, debris avalanches, and rockfalls	⋮ River stretches with extensively fissured flood plains; pattern indicates stretches of river affected and not width of disturbed zone
● Streambank landslides including rotational slumps and soil falls	○ Sand boils
◄ Lateral spread	⊗ Disturbed wells
✕ Ground settlement	□ Absence of ground failure noted
▬ Ground cracks not clearly associated with landslides, lateral spreads, settlement or primary fault movements	⊠ Miscellaneous effects
	◄◄◄ Arrows showing extent of area affected. Symbol shows failure type

Accuracy with which failure sites can be located is given as follows: A, a site that can be accurately relocated; B, a site that can be relocated to within a few kilometers and probably could be located more accurately with further investigation; C, a site where the information is insufficient to allow precise location. Plate numbers in the "Reference" column refer to plates in the original source material.

Santa Cruz Mountains

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
45		■	B	1906	Lawson and others, 1908, p. 271.	(R. Collom.)--Going north from Santa Cruz, a small fissure ran north-west and southeast on the Boulder Creek road, about 0.75 mile north-west of the California Powder Works. Along the lower end of this road were several small and unimportant landslides. In general, the shock in this region does not seem to have been as severe as it was farther north.
		■				
46		●	B	1906	Lawson and others, 1908, p. 271.	(G.A. Waring.)--The city of Santa Cruz furnishes excellent evidence of the effect of soil formation on the intensity of the earthquake shock. * * * The San Lorenzo River was churned into foam, the banks cracking and settling several inches; and sand, said to have come from a depth of 100 feet, was forced up in several places. The bed of the river is also said to have sunk several inches, and the current to be slower than before. A 6-inch water-main, running east and west across the river at the covered bridge, was broken at each end of the bridge and moved 5.5 inches eastward.
		○				
		◄				
		○	C	1865	Lawson and others, 1908, p. 448.	At Santa Cruz * * * The lowlands along the river opened and spouted water like geysers. Some wells went dry or were filled with sand. [See also locs. 43 and 44.]
		⊗				
47		■	C	1947	Coffman, 1973, p. 172.	1947. June 22. * * * Hecker Pass was reported closed by slides.
		■	C	1959	Coffman, 1973, p. 179.	1959. March 2. Near Gilroy. * * * Minor earthslide occurred on Chittenden Pass Road east of Watsonville [loc. 31], and boulders fell on Hecker Pass Highway between Gilroy and Watsonville.
48		■	B	1906	Lawson and others, 1908, p. 283.	The Saunders ranch is 3.5 miles southwest of Madrone, on the Madrone road. * * * portions of what appeared to be quite solid and massive rock outcrops were thrown from the steep hills near the house.
		■	C	1967	Coffman, 1973, p. 183.	1967. September 28. Rockslides occurred in the Morgan Hill area.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains--Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
49		✕	C	1906	Lawson and others, 1908, p. 288.	Two miles west of Uvas P.O., and half a mile east of the summit * * * in wet places there was a noticeable settling of the ground.
50		☑	B	1906	Lawson and others, 1908, p. 389.	Near Olive Springs, 12 miles north of Santa Cruz, an earth-avalanche demolished Loma Prieta Mill and killed several men.
		☑	B	1906	Lawson and others, 1908, p. 271.	At Santa Cruz the inhabitants reported that near Olive Springs, 12 miles north of Santa Cruz, a landslide demolished Loma Prieta Mill and killed 9 men.
		☑	B	1906	Lawson and others, 1908, p. 278.	* * * the [fault] crack goes into Hinkley's Gulch, in which the Loma Prieta Mills are situated, and which are buried under the slides.
		☑	B	1906	Lawson and others, 1908, p. 110.	On the northern side of Bridge Creek Canyon there are typical cracks from 1 to 8 inches wide, and here also occurred a great landslide which buried the Loma Prieta Mill.
		☑	B	1906	Jordan, 1907, p. 30.	[Picture caption] Wreck of Loma Prieta Sawmill, Hinkley's Gulch, Santa Cruz County.
		☑	B	1906	Jordan, 1907, p. 31.	[Picture caption] Site of Loma Prieta Sawmill, covered to a depth of 125 Feet.
		☑	B	1906	Salinas Daily Index, 1906d.	Loma Prieta Lumber Company's Mill. The mill, boarding house and other buildings of the plant were situated in a gulch, and were overwhelmed by a portion of the mountain--1500 feet long, 400 feet wide and 100 feet deep which slid down upon them. The mill and everything in the gulch were forced up the opposite slope of the mountain and there buried to a depth of one hundred feet. Pine and redwood trees 100 feet high came down with the slide and are now standing over the mill site as though they had grown there. Nine men were killed * * * .
		☑	B	1906	Salinas Daily Index, 1906b.	LOMA PRIETA CO'S LOSS. When the earthquake occurred yesterday morning it caused a large mountain of earth to slide into the canyon and completely covering the new mill. Continuing its course up the mountain on the other side it covered what is known as the bunk house and buried ten men, who were asleep at the time.
51		☑	C	1906	Lawson and others, 1908, p. 278.	The slides which obliterated Fern Gulch at Skyland do not seem to have come from the [fault] crack, but seem to lie to the west of the crack.
52		☑	C	1906	Lawson and others, 1908, p. 278.	Skyland, Santa Cruz County * * * Large landslides occurred in the neighborhood.
53		◀	B	1906	Lawson and others, 1908, p. 276.	Gulches appear to have been contracted, as the bridges crossing them show that they were squeezed. The banks of Burrell Creek appear to have approached each other, so that the creek has become very much narrowed. Water-pipes were broken and twisted, and filled with dirt.
54		☑	C	1906	Lawson and others, 1908, p. 110.	Here [ridge just west of Skyland?] * * * great landslides occurred, and redwoods were snapped off or uprooted.

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**Santa Cruz Mountains--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
55	18	☑	B	1906	Lawson and others, 1908, p. 110.	A large landslide also occurred close to Wright Station, partly damming up the stream.
		☑	B	1906	Lawson and others, 1908, p. 276.	Just north of Wright's Station, on the west bank of Los Gatos Creek, there was a landslide 0.5 mile wide which had slid into the creek and dammed it. The top of this slide was near the Summit school-house and was close to the main fault-line.
		☑	B	1906	Lawson and others, 1908, p. 389.	A large slide close to Wright Station partly dammed the stream.
56		☑	B	1906	Lawson and others, 1908, p. 278.	At Freely's place, 4 or 5 miles north of Morrell's, some 15 acres of woodland have slid into Los Gatos Creek, making a large pond. There are many other slides in the neighborhood and many broken trees.
		☑	B	1906	Jordan, 1907, p. 27.	Into this [Los Gatos] creek, from the Feely ranch, some ten acres of land was thrown in a great landslide. At the head of the creek is the long tunnel which cuts under the saddle, from Wright's to Laurel.
		☑	C	1906	Carey, 1906, p. 297.	Landslides were abundant, especially in the Santa Cruz Mountains, where the topography is more rugged. One slide, a few miles from Wright's Station, involved eight to ten acres of ground.
57		◀	B	1906	Lawson and others, 1908, p. 275, plate 139C, plate 139D.	On the ranch of Dr. Tevis [presently the site of Alma College], about a mile from Alma Station, where the land is rolling and wooded, the ground was fissured and the bottom of an artificial lake was upheaved. (Plate 139C, D.) The cracks and fissures, of which there are many, run mostly north and south, and vary in length up to 100 feet, and in width from 0.5 inch or less to 20 inches. While a good many of the openings were parallel to the slopes and were caused by the ground starting to slide, others crossed the roads and could be traced some distance up the banks. A board fence was splintered where it crossed a fissure. The upheaval of the lake was caused by a closing together of the sides, shown by the heaving up of parts of the retaining dam at the lower end of the lake. The rise of the bottom is roughly 10 feet. [Some cracks described above may be fault ruptures.]
58		☑	B	1906	Lawson and others, 1908, p. 388.	Mr. Carey also reports another earth-avalanche located on the Petty ranch, about 4 miles southeast of the one just described [Deer Creek landslide, loc. 74]. Here a huge rock mass, which embraces an area of about 12 acres at the headwaters of Cauley Gulch, broke away from a ledge and dropt, leaving a vertical scarp of 40 feet or more. The rock mass in this case was not shattered. It practically maintained its integrity. The narrow gulch below was unfavorable for free downward movement. As the block readjusted itself, its upper surface became nearly level, but was lower at the foot of the scarp than at its outer edge, thus indicating that it had suffered rotation.
59		☐	C	1906	Lawson and others, 1908, p. 109.	The whole ridge west of the reservoirs [about 2 miles south of Congress Springs] was severely shaken, however, for cracks 4 or 5 inches wide opened near Grizzly Rock and several large slides occurred in its neighborhood [loc. 74]. One water-pipe running north and south on the Beatty place was broken, while one trending east and west was unhurt. No cracks were found crossing the ridge between Grizzly Rock and White Rock. The cracks were next found on the road about a mile east of B.M. 2135 of the U.S. Geological Survey, but they do not show in the vineyard to the southeast.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains--Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
60	○	C		1865	Holden, 1898, p. 67.	1865, October 8. At Mountain Charley's, on the Santa Cruz road, the earth opened in several places, and steam and water were thrown up through the cracks.
	■	C		1865	Coffman, 1973, p. 157.	1865. October 8. At Mountain Charley's, the earth opened and boulders obstructed the road.
61	■	C		1906	Lawson and others, 1908, p. 110.	Great slides on both sides of Aptos Creek have almost made a valley of the canyon for fully 0.75 mile. Following across the ridges and canyons, the discontinuous line of slides and sinks in upland marshy places marks the course of the fault-line down into the lowland.
	■	C		1906	Lawson and others, 1908, p. 389.	On the western slope of the ridge just west of Skyland, several earth-avalanches were caused by the shock; and great slides of a similar character occurred on both sides of Aptos Creek for 0.75 mile. Besides these, there were many smaller earth-avalanches in many parts of the Santa Cruz Mountains which can not be enumerated.
62	■	C		1906	Lawson and others, 1908, p. 278.	About four miles south of Wright Station * * * The ridge on which we camped was full of cracks, ranging up to 2 and 3 feet in width, and in length from a few rods to 0.25 mile, all trending west of north to northwest. * * * The canyon south of us was filled with landslides. In this canyon the stratification of the rocks is plainly shown. The strike is northwest-southeast and the dip is almost vertical. The cracks coincide in direction with the strike of the strata. Cold water was flowing from some of the cracks. I obtained a small bottle of crude oil from Mr. Sutton, which he said was dipt up from the ground on his neighbor's ranch, several hundred gallons of oil having run out of the ground since the earthquake, where there had been no sign of oil before.
	○					
63	■	C		1906	Lawson and others, 1908, p. 272.	Landslides and cracks are reported between Scott Valley and Felton, and the dam across a small lake was cracked.
64	□	C		1906	Lawson and others, 1908, p. 268.	At Ben Lomond no fissures nor other such evidences of the earthquake were to be seen. Inquiry showed this condition to continue in the country about the town.
65	■	B		1906	Lawson and others, 1908, p. 269, map 22.	At the dam on Big Creek (at 48, map No. 22), no harm had been done * * * . A half mile from this point cracks caused by slides were noticed on a very steep bank.
66	■	B		1906	Lawson and others, 1908, p. 274.	A long, narrow landslide above a house 0.75 mile northeast of the mouth of Waddell Creek had landed against the end of the house, taking out a strip of earth below a spring and causing a good supply of water to issue forth. This slide appeared to be partly due to the large amount of water present.
67	■	B		1906	Lawson and others, 1908, p. 274.	Half a mile southeast of where the main road crosses Finney Creek, a ledge of shale had been knocked into the gulch. The largest piece which fell had an unbroken surface of about 4 square feet. The almost horizontal edges of shale beds near a house at this point were knocked down.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
68		■	C	1906	Lawson and others, 1908, p. 389.	At the north end of Ben Lomond Mountain, a slide carried trees and brush down to the creek.
		■	B	1906	Lawson and others, 1908, p. 269.	(H. W. Bell.)--- * * * Near a deserted mill at the north-end of Ben Lomond Mountain, a small landslide had carried trees and brush down to the creek, and tall trees had fallen along the road.
69		■	C	1906	Lawson and others, 1908, p. 269.	[Near Bloom's Mill on Waddel Creek] A steep bank beside the road showed small cracks, which could apparently have been easily made in the loose soil.
70		■	A	1906	Lawson and others, 1908, p. 268, map 22.	A small earthslide had started (at 45, map No. 22), and a crack, perhaps due to the same slide, was noticed.
		←□→	A	1906	Lawson and others, 1908, p. 268.	Mr. Bloom, owner of a sawmill at the edge of the Big Basin, reports that the shock was less severe in the Big Basin region than at Boulder Creek; that there were no landslides on the road between the two places; and that, tho he had been nearly to the summit on the day of the earthquake, he had seen only one crack where the earth had started to slide.
71		■	C	1906	Lawson and others, 1908, p. 268.	Near the junction of the first road leading from Boulder Creek into the Big Basin, an old landslide which covered about 2 or 3 acres, dating back to the previous winter, had been widened by the shock and its direction had changed.
72		■	C	1906	Lawson and others, 1908, p. 389.	At Boulder Creek a large portion of the soil was shaken loose from an abrupt hill 150 feet high, and fell to the level of the creek, carrying trees with it.
		■	C	1906	Lawson and others, 1908, p. 268.	(R. Collom.)--At Boulder Creek, on the east side of the stream, a small hill of about 150 feet elevation rises rather abruptly. * * * Near the top [of the hill], a large portion of the surface soil had been shaken loose, and had slid to the level of the creek, carrying trees with it.
73		■ ○	C	1906	<i>Sunday Mercury and Herald,</i> 1906.	The earth opened during the great shock in the Bear Creek road, five miles above Boulder Creek to a depth of two and one-half feet. From the fissure immense quantities of inky black water is pouring.
74	19	■	A	1906	Lawson and others, 1908, p. 388, plate 124D, plate 125A.	On Deer Creek, in the Santa Cruz Mountains, an extensive earth-avalanche started near Grizzly Rock and moved westward down a steep, narrow canyon for about 0.25 mile. (Plates 124D and 125A.) It then changed its course thru an angle of about 60° as it entered a wider canyon of lower grade, and following this for another 0.25 mile, finally stopt at the Hoffmann Shingle Mill, which was wrecked. A fine growth of redwood, some 200 feet in height, was mowed down, and covered to the extent of 10 acres or more with from 30 to 60 feet of debris. The trees were from 3 to 10 feet in diameter. The main canyon was filled with earth and rock for an average width of 80 yards and a length of 400 yards. The entire area of the slide was about 25 acres. The difference in altitude between the point where the slide started and the shingle mill, where it stopt, is 500 feet. According to Mr. G. A. Waring, the slide material has a depth of 300 feet and is composed of soil, clay, and shale. Mr. E. P. Carey, who examined and photographed this interesting earth-avalanche, states that it originated in rock that broke away in pieces from the steeply

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**Santa Cruz Mountains--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		☑				inclined slope at the head of the gulch, leaving a large theater-like space, the bare, light-colored rock walls of which were in sharp contrast with the surrounding green vegetation. The movement was faster in the center or deepest part of the gorge than on the margins. The rock was in general piled up higher along both sides than in the center, and many pieces became entangled in the standing or uprooted trees. A steep-walled tributary to the southeast of the main gulch supplied rock material to the main avalanche, and the 2 streams joined much as confluent glaciers do. The material involved in the avalanche showed every gradation from powder to angular pieces 30 feet or more in diameter. The surface was uneven throughout. Near the mill a man was killed by a tree that fell as the avalanche was advancing.
		☑	A	1906	Lawson and others, 1908, p. 267.	On Deer Creek a large landslide started from near Grizzly Rock and slid westward, but changed its direction 60° or more farther down toward the creek. The mill in the creek bottom below the slide was partly buried, and one man was killed. It is 500 feet from the mill in the gulch to the top, at the point where the slide started. The slide covered about 25 acres of ground, and destroyed a lot of virgin timber from 3 to 10 feet in diameter. The slide material, which is 300 feet deep, is composed of soil, clay, and shale.
75		☑	A	1906	Lawson and others, 1908, p. 268.	A small landslide had moved across the road (at 44, map No. 22), which 20 men spent one and a half days clearing away.
76		☑	B	1906	Lawson and others, 1908, p. 389.	A similar [to loc. 85] earth-avalanche was caused by the earthquake on the ranch of Judge Welch, not far from Long Bridge and within 2 miles of Saratoga. Mr. Herre reports that here the soil on the north-west side of a small creek coming down from the Castle Rock Ridge, was shaken down for perhaps 0.5 mile, tho not continuously. In places the slide material filled up the creek-bed and totally changed the contour. It destroyed the road to the ranches farther up the canyon, and wrecked some bridges. Along the upper part of the area affected, a vineyard was destroyed; while farther down the canyon a heavy forest growth, consisting mostly of redwood, oak, alder, and laurel, was obliterated. This slide lies in the path of the San Andreas fault.
77		●	C	1906	Lawson and others, 1908, p. 262.	Congress Springs * * * The car tracks on the curve near the path to the spring had been thrown over toward the bank for about 20 feet of the curve, a 4-inch displacement resulting.
78		●	C	1906	Lawson and others, 1908, p. 109.	Following the Stevens Creek road on down toward Congress Springs, several landslides were noted, mostly small ones due to caving in of the banks of the creek. Just west of the springs the road was badly broken, twisted, and shoved up in places, the downthrow being first on one side and then on the other. In some places along the bank the west side projected 2 inches farther than the other, while the fence showed an offset of 2 feet. The large stone bridge across the creek appeared intact, but west of it a large patch of ground had slipped down 2 feet.
79		☑	B	1906	Lawson and others, 1908, p. 262.	On the Azule Springs road * * * Near the place where five roads fork, one mile north of Azule Springs on the road running southeast from the forks, there was a 6-foot drop on the road caused by a section sinking in a solid piece on a long slope, without much disturbance in its vicinity.
		☑	C	1906	Jordan, 1907, p. 69.	[Picture caption] Rift Across Road near Azul Springs, Santa Clara County.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains--Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
80			C	1906	Lawson and others, 1908, p. 262.	On the Stevens Creek road, just after leaving the Saratoga road * * * a crack 2 inches wide showed a downthrow of 2 inches on the west side. * * * at the next turn, 0.5 mile southeast of Stevens Creek * * * a large area of ground, extending for 150 feet, had been torn up in a direction of N. 3° W., and a slide formed which almost blocked the road.
	■		B	1906	Lawson and others, 1908, p. 261.	At the southeast corner of the same grant [San Antonio] * * * . The road in front of the house [Sellinger's] was cracked, but probably on account of the steep slope below the road. South of the house, across Stevens Creek, there was a landslide 100 feet in width on the steep face of a bluff.
	◀		B	1906	Lawson and others, 1908, p. 262.	Only one more effect of the shock was noted in this vicinity; namely, the bridge over Stevens Creek, on the road running due east and west from West Side, was rendered unsafe for horses by being shoved a foot out of place.
81	■		A	1906	Lawson and others, 1908, p. 262.	On the northeast side of the creek, 0.25 mile south of the place where a road turns northeast from the Stevens Creek road to go up Monte Bello ridge, there was a large landslide about 0.5 mile long and terraced from the top of the mountain.
82	●		C	1906	Lawson and others, 1908, p. 389.	There were numerous slides along Stevens Creek, due chiefly to the caving of the creek banks.
	■		C	1906	Lawson and others, 1908, p. 262.	The short road which runs northwest along Stevens Creek for a couple of miles beyond the junction with the cross-road which connects with the Monte Bello ridge showed an exposure of serpentine with cracks running along it N. 3° W. The cracks at the widest point measured about one foot. In the serpentine area the ground was badly broken up, and in one place it was covered with 3 feet of water. (Observation made April 22-23.) [Some of these cracks may have been fault ruptures.] Following the road northwest beyond the terminus shown in the map, many cracks were seen, due to big landslides. Fallen trees have rendered the road impassable; boulders and dead trees still fell occasionally; even while the observer was there a large tree fell not 10 feet from him, loosening rocks and soil.
	■					Just south of the two houses near the southern end of the cross-road leading toward the Monte Bello road from the Stevens Creek road, a break ran due east and west; it was 2 inches wide with a downthrow of 0.25 inch on the west side. * * * Another crack 4 inches wide was found in the road above the house.
83	■		C	1906	Lawson and others, 1908, p. 264.	(F. Lane.)--Along the ridge road southwest of Stevens Creek, separating Santa Clara and Santa Cruz Counties, there were some cracks due to landslides. Sandstone blocks, some of them 6 feet in diameter, had rolled down the hills toward the creek.
	■		C	1906	Lawson and others, 1908, p. 389.	Along the ridge road southwest of Stevens Creek, sandstone blocks, some of them 6 feet in diameter, rolled down the hills toward the creek.
84	■		C	1906	Lawson and others, 1908, p. 389.	Mr. Herre further reports a large slide on the Mindego Ranch, 20 miles southwest of Palo Alto. Here, on the north side of Alpine Creek, a tract of some 50 acres sank at the time of the earthquake, with little or no apparent forward movement. The tract sloped to the south and west, and formed part of a great, open hill pasture, with trees and underbrush about the lower or creek side. The creek-bed itself is filled with a growth of Douglas spruces and other trees. The land, which before the earthquake was steeply inclined,

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains--Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
						is now comparatively level, the eastern and northern part having sunk perhaps 100 feet, while that on the west has sunk but 10 or 15 feet. The surface of the sunken tract was greatly seamed and cracked, and part of it was flooded, owing to the springs uncovered; but otherwise it was unchanged in appearance. There was no piling up of earth, nor sliding of one portion over another. A fence crossed the tract, and the posts on it sank so that but a few inches protruded above the surface; while some Douglas spruces also sank several feet into the earth. A number of cattle were on the land at the time of the earthquake, but were uninjured. It was a work of great difficulty to remove them, block and tackle being necessary. The creek-bed was apparently not affected, nor were the trees in it disturbed. There was no apparent movement of the earth into the canyon, but the whole mass seems simply to have been dropt from a steep slope to a nearly uniform level, surrounded by the high, blank, almost perpendicular walls of earth and rock from which it had been sundered.
85	☑	C		1906	Lawson and others, 1908, p. 388.	* * * on the ranch of Andrew Stengel, an earth-avalanche is reported * * * on a small tributary of Alpine Creek, and about 4 miles southwest of the San Andreas fault at the point where the latter crosses Black Mountain into the head of Stevens Creek Canyon. The creek here is in a narrow, steep-walled canyon in the bituminous shale of the Monterey series. The soil on the canyon side was very shallow, and at the time of the earthquake it was shaken down into the bottom of the canyon, leaving the walls absolutely bare in places for a hundred yards at a stretch. The slide extends for 0.25 mile on both sides of the canyon.
86	☑ ☑	B		1906	Lawson and others, 1908, p. 273.	Four miles from the town of Pescadero, on the east side of a bridge over Pescadero Creek, the ground had sunk 2 inches and the aperture filled by the land sliding. A mile nearer the town, the road had dropt 5 feet, but had been filled by a big slide. A house at this point was quite intact, but the chicken-house near it was carried down and partly buried by the landslide. On Eues Creek, near its junction with Pescadero Creek, a hillside had started to slide and apparently needed only to become rain-soaked to continue the slipping.
87	☑	B		1906	Lawson and others, 1908, p. 273.	A small landslip, 0.25 mile up the east side of the short creek which flows into Gazos, just west of the fork of the road which continues northwestward to Little Butano Creek, showed a 2-foot vertical displacement at the top, and the land had shoved into the road below. This slide measured 150 feet from its top to the road, and its width at the road was 100 feet.
88	☐	C		1906	Lawson and others, 1908, p. 273.	Near a house on the level creek bed of Little Butano Creek, 4 cracks averaging 3 inches in width and about 20 feet in length ran N. 33° E. The only crack noticed along the trail toward the coast was 1 mile northwest of the place where Little Butano Creek turns from southwest to northwest, and was about the same length, but ran N. 3° W.
89	●	C		1906	Lawson and others, 1908, p. 273.	(G.A. Waring.)--On Butano Creek there were slight cracks in the road, and the streams were muddy. * * * the banks beside the road showed traces of caving, there were only slight cracks, the longest one being in the middle of the road above the creek, running N. 67° E. for a distance of about 50 feet.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
90		C		1906	Lawson and others, 1908, p. 273.	A 1-inch crack at the first fork of the road a mile from the town of Pescadero extended north and south for about 50 feet, * * * and water oozed out of level ground near by.
91		C		1906	Lawson and others, 1908, p. 272.	In the town of Pescadero * * * . Cracks were visible in the streets. * * * Cracks in the road also appeared, and dust spurted up. * * * Going eastward from Pescadero, a small crack 30 feet long, with an east and west strike, was observed. In an orchard near by there were several cracks, the widest one measuring 8 inches, with a vertical displacement of 1 foot.
	C		1906	Carey, 1906, p. 297.	Near Pescadero natural illuminating gas is reported to have escaped from fissures made in the ground, but during subsequent shocks the amount that escaped steadily decreased.
	C		1868	Holden, 1898, p. 79.	1868, October 21, Santa Cruz Mountains, near Pescadero. * * * large pieces of rock rolled down the mountains. It is said that the waters of Pescadero Creek became muddy in a moment, and that the surface was covered with bubbles, which burst with a slight report and a small flame when a match was applied to them.

92		C		1906	Lawson and others, 1908, p. 272.	About 2 miles east of the town [Pescadero], on the north bank of Pescadero Creek, a landslide in the shape of a half-moon, its axis lying N. 23° W., had slipped down toward the bed of the stream. The greatest vertical displacement at the top of the slide was 15 feet; the distance from its apex to the road about 85 feet; and the span from end to end along the road about 220 feet. No solid rock was exposed by the slide. The road had dropt 6 feet at the south end, and 8 feet at the north. Only a few cracks appeared on the surface of the part which had slipped. The creek lying directly below the road had apparently received very little soil from the landslide.
93		C		1906	Lawson and others, 1908, p. 266.	* * * at San Gregorio * * * Cracks from 12 to 18 inches wide appeared in the cultivated bottom-land * * * .
	C		1906	San Jose Mercury, 1906a.	Chief Engineer Rogers and party came down from up the coast Wednesday. He reported that at San Gregorio, San Mateo county, a few miles beyond Pescadero, he saw fissures in the earth from a few inches to fifteen feet in width from which a little sand and water was being forced out.
94		A		1906	Lawson and others, 1908, p. 266, map 22.	* * * a couple of miles farther east [of San Gregorio], the creek was dammed up to a depth of 6 feet by a slide from its southeast bank (at 32, map No. 22) * * * .
95		C		1906	Lawson and others, 1908, p. 273.	On the Pomponio Creek road * * * . A big slide above the last house forced the observer to leave the road and take the trail, which rejoins the road a half mile farther on.
96		A		1906	Lawson and others, 1908, p. 266, map 22.	Miss L. E. Bell reports that near Bellville a small alkali flat was raised about 3 feet. There was a landslide into the road for a distance of 300 feet, the height of the slide being 100 feet (34, map No. 22).
97		B		1906	Lawson and others, 1908, p. 266.	Near the Weeks ranch house, between La Honda and the summit of the ridge on the road leading to Redwood, an inconspicuous crack was noticed running east. It was about 2 inches wide, with no vertical movement evident. The north side of the crack, however, had moved

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		☑				fully 3 feet eastward. The crack simply marks a big slide which has been slipping for years, and which descended 3 feet during the earthquake.
98	☑	☑	C	1906	Lawson and others, 1908, p. 264.	Farther west up the road which loops toward Langley Hill, a big crack running east and west, caused by a slide, showed a drop of 8 inches on the north side; and from here on down to the Alpine road the road was badly cut up with slides, but was not impassable. On the steep grade of Langley Hill a slide had moved 30 feet.
99	☑	☑	C	1906	Lawson and others, 1908, p. 264.	Following the Alpine road up Corde Madera Creek, cracks were common on the outside or filled portion of the road, and these were generally parallel with the embankment. The steep southern slope of the ridge just north of the Alpine road, along its lower course, was favorable to landslips. At many places huge masses of rock had been thrown down from these steep bluffs into the road, completely blocking it up. On the south side of the creek the slopes were not favorable to landslips, but there were several of them; and at one point, about a mile from the summit of the ridge where this road enters the Page Mill road, one slide carried away the entire roadbed for a distance of about 300 feet.
	☑	☑	C	1906	Lawson and others, 1908, p. 389.	At many places on the south side of Corte Madera Creek, huge masses of rock had been thrown down from the steep bluffs into the road, completely blocking it. About a mile from the summit of the ridge, where the Alpine road enters the Page Mill road, a slide carried away the entire roadbed for a distance of about 300 feet.
	☑	☑	C	1906	Lawson and others, 1908, p. 106.	<i>Road from Judge Allen's southward.</i> --Between 3 and 4 miles southeast of Portola, many cracks were visible extending in all directions. Several showed an uplift on the east or northeast side, which is also the downhill side. Some cracks were from 4 to 5 inches wide, and had a vertical throw of nearly a foot. In other places the downhill side had been thrust upward, and pieces of the crust shoved as much as 4 inches over the uphill side. Near the top of the ridge, just before reaching the point where the trail branches off, a 4-inch crack running S. 63° E. showed a 4-inch upthrow on the northeast (downhill) side. Southwest of the ridge and about 100 feet below the trail, an old landslide dating back to some time within the past year, covers about 2 acres. Around this slide the ground appeared to have been much cracked recently.
100	☑	☑	C	1906	Lawson and others, 1908, p. 389.	Many other earth-avalanches of minor importance were caused by the earthquake in various parts of the Santa Cruz Mountains. At Hidden Villa, 2 miles northwest of Black Mountain, large blocks of rock are reported to have rolled down the slopes.
101	☑	☑	C	1906	Lawson and others, 1908, p. 108.	<i>Page Mill road.</i> --In following the Page Mill road up Corde Madera Creek [now named Matadero Creek] from Mayfield, the first noticeable trace of the earthquake was a crack crossing the road due east and west, its width varying from 0.5 to 1 inch. Wagon-tracks showed a lateral displacement of 1 inch, the north side of the crack having moved west, relatively to its south side. This crack was traced a short distance into the fields beside the road, where it disappeared. Several smaller cross-cracks intersected it at intervals. There was no apparent vertical displacement. About 100 yards farther south were 3 smaller cracks varying from 0.25 to 0.75 inch in width. One ran N. 53° W., and another N. 23° W. The latter, being only 8 feet from a culvert crossing under the road, appears to have been deflected by this from a course running more nearly east. Here again was no evidence of vertical throw. Going on up toward the Alpine road from this point, more and more cracks were found, running approximately east and west, with the exception of several

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**Santa Cruz Mountains--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		☐				north and south ones where the road ran closely parallel to the stream. Less than a mile from the first crack, groups of cracks were accompanied by small slides of dirt from the hill to the west of the road, and farther on from the bluff to the east of it. The cracks ran nearly parallel with the axis of the branch valley lying northeast and southwest. Farther up the road, large cracks began to appear among smaller ones running parallel. The first of these was 2.5 inches across and ran S. 13° E., with a downthrow of 1 inch on the east side, and could be traced from 50 to 100 feet on either side of the road. For a mile farther up the road, the cracks became so numerous and complicated that it was impossible to map any individual ones. They intersected and ran in all directions, and were all of varying widths, the largest seen measuring 8 inches across. The size of this crack, however, was probably partly due to its position on the side of a hill. The larger cracks could be traced for several hundred feet. In some places crushing had taken place, and the layer of macadam on the road had been humped up and broken. In this same area are many small landslides, some large enough to cover the road; one has occurred since the earthquake. [Some of these cracks may have been fault ruptures, see McLaughlin, 1974.]
102		☐	C	1906	Lawson and others, 1908, p. 389.	On Purissima [sic] Creek [unclear whether in Santa Clara County or on a different creek of the same name in San Mateo County] a slide filled the road for a length of about 100 feet; another, between 0.25 mile and 0.5 mile long, dammed the creek to a depth of 25 or 30 feet.
103		☐	A	1906	Lawson and others, 1908, p. 264, map 22.	On the road from Clarita Vineyard to the Allen place (at 18, map No. 22), several small cracks 0.25 to 0.5 inch across ran east and west; numerous cracks intersected (near 18, map No. 22) in various directions, while some large ones running parallel to the contour lines were probably due to earth slipping. [Some of these cracks may have been fault ruptures, see McLaughlin, 1974.]
104		☐	C	1906	Lawson and others, 1908, p. 265.	On the Bear Creek road, southwest of Woodside, there were many cracks caused by landslips down steep banks.
105		☐	C	1906	Lawson and others, 1908, p. 266.	Small cracks appeared in the ground at Lobitos, and a small slide occurred in the road 0.25 mile up the stream.
106		☐	C	1906	Lawson and others, 1908, p. 266.	* * * a crack east of the road below Purisima, due to a landslip, extended for about 1,000 feet nearly north and south; and an earth-slide on the side of a hill a mile or more farther south was about 100 yards long and 80 feet across.
107		☐	A	1906	Lawson and others, 1908, p. 265, map 22.	Following the trail from King's Mountain House down Purisima Creek, a large slide on the northeast side of the creek had filled the road to a width of about 100 feet (at 23, map No. 22). The buildings at Hatch's Mill, just below (24, map No. 22) were not damaged, but a little farther down several cracks were found, one 8 inches wide and running S. 23° E.
108		☐	A	1906	Lawson and others, 1908, p. 265, map 22.	On the northeast side of the creek, just below Borden's Mill, a big slide had dammed the creek to a depth of 25 or 30 feet (at 25, map No. 22). The slide was between 0.25 and 0.5 mile long. The buildings at the mill showed no damage, but a bridge just above the mill was crushed by a slide from the south side of the creek.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains--Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
109		OH	A	1906	Lawson and others, 1908, p. 266, map 22.	* * * the bridge over Pilarcitos Creek, north of the town of Half Moon Bay * * * (at 30, map No. 22) * * * was badly cracked, as were the approaches at both ends. Just south of the bridge, several small cracks in the low ground west of the road permitted water to spout up, bringing sand with it.
110	20	■	A	1906	Lawson and others, 1908, p. 395, plate 132A.	<p>One * * * [flow landslide] was formed in the hills bordering the terrace at Half Moon Bay, immediately south of Frenchman Creek, 1.5 miles north of the town, and a mile from the sea, at an elevation of 100 feet. It is pictured in plate 132A. At this place the earth caved away in a crescent-shaped area on a slope of only 18°, and flowed out in two long arms so as to leave a hole 4 feet deep, surrounded by vertical walls of unaffected soil. The flow occurred at a fairly high point on a gently undulating incline. The discharged earth was divided by a mound, at a point 150 feet below the summit of the arc, and followed two courses which were determined by gullies on both sides. Much of the debris over-flowed the central mound at the same time, and inundated the barley fields to a depth of 2 to 4 feet, for 100 feet farther. On both sides of the central mound the caving away continued to the same depth. In the left-hand fork it stopt within a few feet, and the flow did not extend very far beyond. In the right-hand fork a cut 100 feet long and 50 feet wide was made, the earth flowing down from it 250 feet farther over the grain field, as shown in plate 132A. Thus the whole length of the slide was 500 feet. The width of the main hole was on the average about 100 feet, and the length, as already mentioned, 150 feet not including the arms.</p> <p>In this hollow in the hillsides many dry blocks of sod carrying growing grain--usually in an upright position--were left stranded 4 feet below the surface of the hill by the removal of the subsoil. The fence that crost this area was broken and carried away and partly buried. Where the caving ceased in the right fork, a ridge of debris was piled up across the mouth of the hole, much higher than the stream of loose material that flowed farther. Similar ridges were heapt up across the path of the flow, where the breaking away of the hill stopt in the other arm and at the upper end of the central mound.</p> <p>The south or right arm of the flow extended down the hill at an angle gradually decreasing from 18° to less than 5°. Large parts of the fence were carried on its surface for 300 feet.</p> <p>Plate 132A gives a detailed view of the lower extremity of the right arm. The stream came to an abrupt stop, like a quickly cooled lava flow, and preserved a face 1 to 2 feet in height above the grain field. The surface of the flow consisted largely of blocks of sod, usually almost upright, which were carried down from the hole without much moistening, or transformation into material capable of flowing. The bulk of the flow was a moist aggregate of earth fragments possessing something of their previous form and grading into mud, which assumed a semi-fluid consistency underneath. The bottom of the hole, and the flow itself, remained too muddy to walk on for weeks after the earthquake, and the field below the lower end of the large arm was left marshy, tho it had not been so before. It is to be noted that several fairly heavy rains followed the earthquake after an interval of several days, and before these earth-flows were visited; but these were not sufficient to account for the amount of moisture observed. The chief effect of the water was in the ground at a depth of 3 or 4 feet below the surface. It rendered the soil sufficiently fluid to enable it to flow down the gentle slope, probably partly oozing from under the surface crust and partly transporting the sod with it. Most of the surface was carried down with the main flow, the stranded surface blocks that remained in the cavity being accountable for as fragments from the broken edges subsequently giving way and being carried only a short distance as the upper end of the flow came to rest. In this way, probably, the walls were trimmed, for the cut in general was left remarkably clean.</p>

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
111		■	C	1906	Lawson and others, 1908, p. 396, plate 132B, plate 133A.	<p>Another flow of similar character [see locs. 110, 112, 113, 114 and 125] took place 3 miles north-northwest of the town of Half Moon Bay, on the creek next west of Frenchman Creek. It is shown in plates 132B and 133A. On the morning of the earthquake an acre of the gently sloping alluvial floor of a broad, short valley tributary to the main creek on the east caved and flowed out, leaving an excavation 10 feet deep, where before it had been almost level and where there had been no stream channel. In this case, the water already gathered in this basin-like valley, which here had had no means of prompt escape, was an important aid in the formation of the flow * * *. The presence of a large amount of water and the forcible movement during the earthquake shock resulted in the loosening and undermining of the ground and its transportation as a fluent mass. The angle of slope was about 5°. The flow carried out thousands of tons of earth in this manner and spread it over about 2 acres of meadow land, to an average depth of 1.15 to 3 feet.</p> <p>Plate 132B gives a view of this earth-flow, showing the pit from which it was derived. Covering much of the surface of the flow and the floor of the hole are to be seen blocks of sod which have been carried right side up as if the material had moved <i>en masse</i>. The amount of water in evidence shows clearly how the earth was softened and enabled to move. The picture was taken two weeks after the earthquake. At that time water was still seeping up from underground, and out of the lower portions of the broken walls, while the ground near the surface of the valley was quite dry. The water had formed two definite rivulets thru the debris, at an elevation above the surrounding meadow, and was running in continuous streams, fast cutting a channel for itself and removing the soft material. Considerable water was dammed back in the hole by a 4-foot ridge of debris piled across the mouth of the hole, as in the case of the previously described earth-flow [loc. 110]. This mound of earth, along the line where the stream left the caved-in area and flowed over the preexisting slope, was probably piled up at the last by the remnants of the flow gliding down and heaping themselves up as a barrier at the mouth of the hole.</p> <p>The cavity, about an acre in extent, has 10-foot walls which gradually decrease in height lower down the valley, the bottom of the hole being more nearly level than the valley-floor. Plate 133A shows part of this flow in detail.</p> <p>Some of the great blocks of sod around the edges have not been removed, altho the material from underneath has gone. Concentric cracks not visible in the pictures extend around the edge of the hole and for 50 feet above its upper end, showing that the area affected is broader than appears at first sight, and that the work is not yet all accomplished. The material of the valley-bottom is a coarse, arkose earth, derived from decomposing granite, and containing many rock fragments.</p> <p>A flood of earth covers about 2 acres of the meadow. Water was present in this earth-flow in greater amount than in any other that was examined. The nature of the material may be judged of by the abrupt face of the stream where it stopt. The edge makes a steep angle with the meadow and rises to an average height of 2 feet above it. Yet the fact that this mass of earth was able to move more than 300 feet after it left the lower end of the hole, and spread into an even and thin layer over a wide extent of nearly level meadow, shows that it was fairly soft. It was moved on a basal layer of semi-fluid mud and sand, with the aid of the weight of the overlying and partly disintegrated earth.</p>
	21A					
	21B					
112		■	C	1906	Lawson and others, 1908, p. 252.	<p>About 4 miles east of Half Moon Bay, just off the south edge of the San Mateo sheet, there was another large earth-slide similar to the two [earth-flows, locs. 110 and 111] already mentioned.</p>

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
113	1	B		1906	Lawson and others, 1908, p. 397.	<p>The largest of the earth-flows seen occurred in the canyon south of the house of Mr. Nunez, 2.5 miles east-northeast of the town of Half Moon Bay, at an elevation of about 500 feet. It originated in a manner similar to the others [locs. 110, 111, 112, and 114], but in a canyon along which there is a distinct but ordinarily dry stream channel. A long, irregular hole from 4 to 7 feet deep was excavated near the head of the valley, and a great volume of earth flowed down its curving course for 0.25 mile, as far as the Nunez house, and there stopt, being in part diverted into the main creek to which the valley is there tributary. According to the testimony of witnesses the flow reached the end of the 0.25 mile in 0.5 hour after the earthquake shock. It was seen gliding slowly down and engulfing the orchard just back of the house. According to observers on the Nunez ranch, the earth-flow was not accompanied by any water; but two weeks later, when examined by the writer, it preserved every evidence of having been muddy. Especially was this true at the bottom, where great masses of mud still had the consistency of jelly. It is probable that there was no flowing water on the surface of this or other earth-flows at the time of their formation, and that the presence of water in the flow was not evident to the casual observer because of the comparative dryness of the material on its upper surface.</p> <p>The slope of the canyon down which the moving body of land crawled is about 25° near the head and decreases to 15° farther down. The flow filled this to a width of 100 feet on the average, and to a depth varying from 10 to 20 feet. The inertia of the mass is illustrated by the fact that in the early stage of the flow the earth was piled 20 feet higher on the hill, on the inside of the big curve made by the canyon, not far below the pit, than it was when the flow came to rest. The marks at this elevation were probably made very soon after the main mass was discharged from the cavity, before it had spread very widely. The central portion of this earth-flow is pictured in plate 131B, where it appears as a ridge many feet high rising above the tall grass on the hillside, on the right of the picture. The pressure of the material at the head of the flow, as it started, was so great that the earth bulged up over the sides in places, in such a way as to force upward great blocks of sod and turn them on edge or completely over, away from the rim of the hole.</p> <p>The flow assumed the form of two lateral ridges and a central depression, or channel. The ridge on the west or inner side of the curve was considerably the higher. The form was due partly to the concavity of the valley; but chiefly, it is thought, to the tendency of the more fluid material to follow the deepest possible path along the gully under the center of the flow. Thus the drier material was retarded at the sides. Subsequent to the first starting of the flow, a stream of semi-fluid mud and sand continued to run down the central channel, covering its sides with a coating of mud and leaving flowage striations on it. This channel and its markings are exhibited in plate 131B. Two weeks after the earthquake, when the photograph was taken, water was running in this channel and had cut down into it several feet deeper. Its bottom, however, was still from 5 to 10 feet higher than the bottom of the underlying pre-existent water course, where water had not flowed before at this time of the year. The man in the picture is standing at the bottom of the gully. To the left of him, the hammer and note-book mark the top of one of the parts of the lateral ridge which is here divided into several hummocks. To the right is the other and higher lateral ridge. The foreground was formerly covered by a dense thicket of willow trees. These willows have been completely buried, except at the sides where some dead branches protrude. A fence that crost the canyon was torn away for 100 feet, and not a trace of it could be found. The fence shown in the picture is one newly built in its place.</p>

plate 131B

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**Santa Cruz Mountains--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
114	22	☑	B	1906	Lawson and others, 1908, p. 397, plate 133B..	Two other smaller earth-flows occurred just over the hill westward from the last one described [loc. 113]. They are shown in plate 133B, the canyon on the left being the one occupied by the Nunez flow. One of these 2 earth-flows, that at the right of the picture, started near the top of the ridge in a depression in the slope, formed a hole 75 feet long and 40 feet wide, and coursed down a narrow runnel having a gradient of 25° to the bottom of the hill, a distance of 600 feet. Enough earth issued to fill up the rather deep ditch in the gully clear to the bottom of the hill and to bury the grain field on both sides to a depth of 1 to 2 feet. In this case, as in the preceding one, there were formed lateral ridges higher than the center, so as to leave a groove between. Down this channel there flowed softer material, which lined the sides of the lateral ridges with a smooth coat of mud and left conspicuous flow-age marks. The flow thus raised a ditch for itself above the level of the slope. The earth-flow probably assumed this form by leaving behind, at the sides, the material least capable of flowing, and by concentrating its most liquid parts along the deep central line. The other earth-flow was near by, on the convex face of the knoll in the center of the picture. A similar cavity was produced, from which the contents were spread out broadly. It is a good example of the starting of a gully, as there was no depression before. One branch of this earth-flow came straight down the hill and slightly toward the canyon on the left; the other branch came down toward the gully in which the first-mentioned of these two earth-flows occurred. Thus drainage lines were started which ultimately may separate the central hill from the ridge on the right, of which it is now a continuation. The left arm of the flow on the hill may develop a channel, as explained below, which will cause the drainage from this hill, which is now toward the foreground, to pass into the canyon on the left.
115		☑	C	1906	Lawson and others, 1908, p. 252, plate 124C, plate 126B.	From Half Moon Bay to San Mateo, there were several large slides of different character from those already mentioned [earth-flows]. These resulted from the slipping of large masses of rock, many of the fragments in one of the slides being over 20 feet in diameter. (See plates 124C and 126B.)
		☑	C	1906	Lawson and others, 1908, p. 389.	Near Half Moon Bay considerable masses of granite were dislodged on a steep slope. (Plate 124C.) On the road along Pilarcitos Creek, an earth-avalanche brought down big blocks of sandstone upon the road. (Plate 126B.) [See also loc. 121.]
116		☐	C	1906	Lawson and others, 1908, p. 253.	Just southeast of the house [on Cahill's ridge] is a depression in the ridge, across which furrows and cracks formed similar to those along the main fault-line, but not extending more than several hundred feet. These cracks do not seem to have been landslide cracks, for they are on top of the ridge and on a flat piece of ground. [See also loc. 120.]
117		☑	B	1906	Lawson and others, 1908, p. 253.	A house on the northwest side of Half Moon Bay road, 2,000 feet southwest of the dam [through Crystal Springs Lakes], was thrown from its foundations, while some 200 feet northwest of this house there was a slide in the canyon.
118		☐	B	1906	Taber, 1906, p. 308, fig. 7.	A striking evidence of [fault] displacement is shown in the earth dam that divides the Crystal Springs Lake. This dam is about 500 feet in length, and the road from San Mateo to Half Moon Bay runs along its crest. The accompanying sketch (Fig. 7) [See fig. 7 at end of tables] shows the position and direction of the cracks that were formed in the dam. The larger cracks [clearly secondary] are about 6 inches wide and are parallel with the dam. Smaller intersecting cracks were formed near the northeast end of the dam along

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**Santa Cruz Mountains--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						<p>the probable line of the fault, and the road was offset about 6 feet at this point. The fences on both sides of the road were broken in a number of places, and the unbroken boards were bent and arched so as to give a serpentine appearance to the fences. The wires of a telephone line crossing the dam sag in great loops.</p> <p>It seems probable that the total [fault] displacement is greater than the amount that may be directly measured at any place along the line of the fracture, for there is evidence of drag in the soil for a considerable distance on both sides. Water-pipes at a distance of several hundred feet from the fault-line have been pulled apart, telescoped, or bent in the direction of the movement, and fences formerly straight have been bent into a slight curve for a distance of 200 or 300 yards from the fracture.</p>
119	☑	C		1906	Lawson and others, 1908, p. 398.	There were examples of such slips [landslides] along the coast hills north San Pedro Point, near the road halfway between San Bruno and San Andreas Lake, near the road from Belmont to Crystal Springs Lake, 0.5 mile southeast of the San Mateo Alms House, and in many other places on the San Francisco Peninsula. In some places bare ridges had their lines of symmetry broken into little knolls and irregularities by these slips, a common occurrence in the hills of soft sand formations in the northern part of the San Francisco Peninsula.
	☑					
	☐	C		1906	Lawson and others, 1908, p. 246.	Thru the hills west of Belmont no cracks nor big landslides were found, but there were small landslides along the road leading from Belmont to Crystal Springs Lake.
120		C		1906	Lawson and others, 1908, p. 253.	Another peculiar phenomenon was observed upon Cahill's Ridge, less than 1 mile northwest of the cracks mentioned [loc. 116]. In an area of limestone, a small patch some 30 feet in diameter was torn up as tho it had been plowed and harrowed, and no large pieces of sod were left intact. Around this in various places were cracks of a few inches in width, with one or two over a foot wide. There was a slight downthrow on the uphill side to be noticed in some of these cracks, which eliminated the possibility that they were cracks preparatory to landsliding.
	☒					
121	☑	C		1906	Lawson and others, 1908, p. 265.	Following the road along Pilarcitos Creek toward Half Moon Bay, many cracks and slides were found on the ocean side of the ridge, but few on the east side. All of these seemed due to slipping of the earth. At one place there had been such a large slide [see also loc. 115] that big blocks of sandstone had fallen down into the road. Here and there along the road big cracks had opened, parallel with the road and the creek where the slope is very steep, and promising to make the road impassable by landslides, should a heavy rain come.
	☐					
122	☑	C		1906	Lawson and others, 1908, p. 252.	On the south face of Scarper Peak, and on the southwest face of Ox Hill, there were several landslides both large and small.
	☑					
123	☑	C		1906	Lawson and others, 1908, p. 252.	South of Montara Point, in the low foot-hills north of Half Moon Bay, there were two large low-angle landslides or earth-flows. One of these landslides was on the low foot-hills facing the ocean; the other on the northeast bank of Frenchman's Creek [loc. 110], several miles northeast of Half Moon Bay.

HISTORIC GROUND FAILURES IN NORTHERN CALIFORNIA TRIGGERED BY EARTHQUAKES

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**Santa Cruz Mountains--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
124		☐	C	1906	Lawson and others, 1908, p. 252.	On the southwest face of Montara Mountain, nearly all of which is visible from the road, no landslides of any size were observed.
125		☐	C	1906	Lawson and others, 1908, p. 253.	On Sawyer's Ridge, about 9 miles north of the region described on Cahill's Ridge [locs. 116, 120], there were cracks several hundred feet long almost at the top of the ridge. These were parallel to the line of the main fault, which is a mile to the east, and there was a marked downthrow of from 2 to 3 inches on the southwest side, which in this case was the uphill side.
126		☑	C	1906	Lawson and others, 1908, p. 390.	There were also several such slides [small earth-avalanches] on the granite slopes of Montara Mountain, farther north in the San Francisco Peninsula.
127		☑	C	1906	Lawson and others, 1908, p. 252.	South from the Devil's Slide to the first small coast valley, there were landslides along the cliffs. The rock in this vicinity is massive granite, but the landslides showed that the rock had disintegrated for a considerable distance below the surface and the slides were in this decomposed rock. Wherever the railway bed [Ocean Shore Railway] was filled or built out with this material, there was more or less sliding and settling, caused by the earthquake.
128		☑	C	1906	Lawson and others, 1908, p. 252.	Just north of the point known as Devil's Slide, there was a landslide of the whole face of the west end of Montara Mountain. It started at about 800 feet above the sea, and swept down carrying many hundred feet of roadbed along with it. The material that slid was sandstone and granite, but it seemed to be much weathered and softened in places, so that it was loose ground.
		☑	C	1906	Lawson and others, 1908, p. 387.	One earth-avalanche to the north of the Devil's Slide started about 800 feet above the shore and swept the face of the cliff, carrying away several hundred feet of roadbed. The slide occurred near the contact of sandstones reposing on granite, and both kinds of rock were involved. Smaller earth-avalanches occurred farther south on the sea-cliffs.
129			C	1906	Lawson and others, 1908, p. 252.	From San Pedro Point southward for about 1.5 miles, the cliffs rise to heights of from 400 to 800 feet. The railway company had cut a bench for its roadbed several hundred feet above the ocean. This roadbed, being largely in solid rock, was for the most part not much injured; but in some places it was obliterated by rock slides that came from above.
		☑				
130		☑	C	1906	Lawson and others, 1908, p. 387.	To the south of Mussel Rock there were several small earth-avalanches along the cliffs, and numerous cracks were formed near the brink of the cliffs which will in future doubtless lead to further falls from the cliff-face. Near San Pedro Point there was a large movement of the earth on the face of the high cliff.
		☑				
131			C	1906	Lawson and others, 1908, p. 251.	In the valley of Laguna Salada, the Ocean Shore Railroad had a temporary trestle erected for making a fill in the valley up to required grade. This trestle was twisted and thrown out of line, and the earth sank along the newly filled roadbed. * * *
		☑				Along the base of the cliffs south of Laguna Salada, there were several small slides, some from the face of the hills and others in the newly graded roadbed. There were many small cracks along

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**Santa Cruz Mountains—Continued*

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
						the tops of the cliff, parallel to its edge, showing that the face of the bluff was shattered, and that more earth might slide. One big rock pinnacle, which had been left above the roadbed as a landmark, and which had seemed a little dangerous before, was shaken down.
132	23	☑	C	1906	Lawson and others, 1908, p. 387, plate 129C, plate 129D.	South of the Golden Gate, the most notable earth-avalanches were along the sea-cliffs between the city and Mussel Rock. This cliff has a length of about 6 miles and ranges in height from about 100 feet up to 700 feet, and is cut almost wholly in the strata of the Merced (Pliocene) series, which are inclined at angles varying from 15° to 75°. The rocks are for the most part rather soft and incoherent, tho there are numerous well-cemented and indurated beds in the series. This cliff converges on the fault at a small angle, and intersects it at its south end near Mussel Rock. The cliff was severely shaken and great quantities of earth and rock were caused to fall or slip down. The great earth-slump at Mussel Rock (Plate 129C, D) was also notably accelerated.
			C	1906	Lawson and others, 1908, p. 241.	All along this line of cliffs [between Lake Merced and Mussel Rock], and for a short undetermined distance inland, the rock masses were cracked, broken, and traversed by narrow fissures. These effects grow more and more numerous and of greater and greater magnitude until, a short distance north of Mussel Rock, the fault is reached. * * * All along the faces of these cliffs, much material fell or slid down to the beach.
		☑				
24			C	1906	Lawson and others, 1908, p. 250.	Along the coast from Mussel Rock to Lake Merced * * * . Along the face of these cliffs the Ocean Shore Railway had started a grade at an elevation of about 300 feet above the tide level. Along this bluff a large amount of earth slid down the slopes at the time of the shock. This caving of the banks was due to the nature of the soil, the proximity to the fault-zone, and the disturbance of natural slopes due to the railroad terrace near the top. In places this slope toward the ocean was brought about to the angle of the repose of this material and the roadbed was entirely destroyed for a distance of 3 miles.
		☑				
		☑	C	1906	Lawson and others, 1908, p. 250.	Near Mussel Rock part of the roadbed slid for about 500 feet and on the hillside above the road there was a long crack which was the beginning of a slide that might have taken a large part of the hill.
		☑	C	1958	Coffman, 1973, p. 179.	1958. December 11. * * * A minor landslide occurred on State Highway 1, west of Daly City. Magnitude 4.7.
		☑	A	1957	Coffman, 1973, p. 178.	1957. March 22 and 23. * * * State Highway 1, near Mussel Rock, was blocked by landslides; highway pavement was cracked extensively. * * * a large reinforced concrete reservoir cracked.
133		☑	B	1906	Lawson and others, 1908, p. 250.	There were several large landslides on both the southwest and northeast sides of the [Wood's] gulch, and at the ocean the amount of dirt that had fallen was very large.
			A	1906	Lawson and others, 1908, p. 250.	On April 25, the writer was on the edge of the cliffs near Wood's Gulch. About 3 P.M. of that day there was a shock with an intensity estimated to be between VI and VII. At that time the cliffs shook like so much gelatine, and it was necessary to hold on to prevent falling. On the north side of the canyon, hundreds of tons of earth fell even with this light shock.
		☑				

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**Santa Cruz Mountains--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						<p>Along the top of the cliffs large cracks were formed to a distance of several hundred feet from the edge. Many of these cracks were a foot or even as much as 3 feet in width, and small scarps were often present, 4 or 5 feet high and 20 or 30 yards long. The general tendency was for everything to slide into the ocean, but this was not always true. Miniature scarps of more than 6 feet were seen with a downthrow upon the northeast or inland side. The Merced beds, as a whole, were badly shaken, and broke up all along the coast section.</p>
	☑	C		1906	Townley and Allen, 1939, p. 135.	1906 April 25. 3:15 p.m. * * * Landslides along the cliffs on the coast.
	☑	B		1957	Bonilla, 1959 p. 34.	Landslides occurred principally in two places: along the sea cliff between Mussel Rock and Alemany Boulevard, and along the shores of Lake Merced. [See loc. 232.]
	✱	B		1957	Bonilla, 1959, p. 35.	Cracks resulting from lurching or settlement of artificial fill occurred principally along the highways but some occurred in residential streets and in stony artificial embankments on the west shore of Lake Merced. Most of the cracks along the highways were on the downhill side, were straight, and either paralleled the center line or trended diagonally toward it. Some, however, were arcuate in plan. In two places in Westlake Palisades cracks were associated with small settlements of the street, sidewalk, and lawns. Small vertical movements occurred along some of these cracks and only horizontal separation in others. Cracks due to lurching or settlement of fills were seen along the coast highway north of Mussel Rock; along Chinese Cemetery Road [loc. 134?]; along Junipero Serra Boulevard at the intersection with the cemetery road; in Westlake; and southeast of the intersection of Skyline Boulevard and Westmoor Avenue.
	☑					Cracks from landsliding occurred near the tops of the scarps of old or new landslides. These cracks were typically arcuate in plan, commonly showed small vertical movements, and in most places were on the downhill side of highways. This type of crack was prominent along the coast highway and along the cemetery road.
						Along several of the northeast-trending streets and one northwest-trending street in Westlake Palisades the sidewalks and pavement were arched. The arching may have been caused by compression resulting directly from earthquake waves or by some secondary effect, such as downslope movement of the pavement and sidewalks. * * *
	☐					Another unusual type of crack was observed in the shoulder of the coast highway just south of Woods Gulch. Here the ground was irregularly fragmented as though an explosion had been set off beneath it (photo 1).
134		C		1906	Lawson and others, 1908, p. 250.	On the east edge of the hills west of the Chinese Cemetery and 9-mile house, a line of cracks extends for a distance of about 1,000 yards. These cracks are more than a foot wide in places, and there is an apparent downthrow on the northeast; in one place there is a long line of crushed earth, such as occurs along the main fault-line. Inspection showed that these cracks were caused by a slight landslide. The line of crumbled earth was due to the earth above it on the hillside sliding slightly, and the crumbling represented a line of buckling of the crust.
	☑					These cracks are upon the top of a hill, at an elevation of about 400 feet; their general direction is about N. 40° W., and parallel to the San Andreas fault, and the line of hills here has the same general trend.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

Santa Cruz Mountains--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
135	25	☐	B	1906	Lawson and others, 1908, p. 392, 393 and 394.	<p><i>Mount Olivet Cemetery</i> (A. C. Lawson). -- Perhaps the best illustration of an earth-flow caused by a sudden accession of water to the incoherent materials of a slope, in consequence of the earthquake shock, is that which occurred in the upper part of Mount Olivet Cemetery, near Colma, 9 miles south of San Francisco. The locality is at the base of the San Bruno scarp, and about 2.75 miles northeast of the San Andreas fault at Mussel Rock. The steep slope of the scarp is underlain by hard sandstone of the Franciscan series, with but a thin veneer of soil, or none at all. At the base of the scarp is the gentle slope of Merced Valley, underlain here by Pleistocene and recent sands. The sands, partly eolian, lap up on the lower flanks of the scarp, and mantle the trace of the auxiliary fault which follows its base. The sands thus vary in thickness from a feather edge to an unknown thickness, which it is believed may be as much as a few hundred feet at no great distance from the base of the scarp. * * * At the moment of the earthquake there was a sudden outgush of sand and water at a point at the upper end of the cemetery, close to the base of the scarp and quite near, if not immediately upon, the line of the buried fault-trace. This stream of sand and water, admixed with the loam of the slope, flowed rapidly down the course of a shallow arroyo on a grade of about 1:25 with a depth of from 13 feet in its upper part to about 3 feet in its lower. The front of the stream stopt abruptly at a point just beyond the roadway about half a mile from the origin. The flow was so rapid that it carried away many small trees; a wind-mill was wrecked and the heavy concrete blocks which served for its foundation were swept down, with other debris. One of the pumping stations of the cemetery was demolished by it, and 2 horses were carried off their feet, and were extricated afterwards with difficulty. (See plates 130A, B and 131A.)</p> <p>According to Mr. M. Jensen, the superintendent of the cemetery, the entire flow had been accomplished within 3 minutes from the time of the shock, and he was at its source within 20 minutes after it occurred. The height of the flow within a few hundred feet of its source was attested by the mud upon the trunks of some eucalyptus trees near its margin. This mud extended up to 13 feet above the bottom of the arroyo. This, however, doubtless indicates the height of the front of the stream as it past this point. As the flow advanced, its surface near its source rapidly dropt; and by the time the front had reached the roadway the stream was probably no deeper at its source than at its terminus. Indeed, it seems to have been somewhat less, as there was a marked tendency for the sand to pile up at the front by reason of the negative acceleration at the front due to loss of water. After the moving mass had come to rest and partially dried out, it was found that it had left a streak of muddy sand on the bottom of the arroyo averaging 100 feet wide and about 3 feet thick. Taking the length of the flow as 900 yards, this gives the total volume of the compacted wet sand as 89,100 cubic yards. The cavity in the slope caused by the evacuation of this sand and loam was not measured, but was estimated to have a width of 150 yards, a length of 300 yards in the direction of the flow, and an average depth of 2 yards. On this estimate, its volume would be about 90,000 cubic yards, which agrees quite closely with the estimated volume of the material ejected.</p> <p>* * * There was no disturbance of the soil on either side of the cavity, even in its immediate vicinity. On the shoulder to the southeast, where the trace of the auxiliary fault passes over practically bare rock, no evidence of movement was detected on critical examination.</p>

plate 130A
plate 130B
plate 131A

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**Santa Cruz Mountains--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
	■	B		1906	Lawson and others, 1908, p. 249 and 250.	Northeast of Mount Olivet Cemetery there was an earth-flow in the sandy soil at the base of the San Bruno Mountains. The angle at which the materials slid was hardly more than 10 degrees. The sand and water forming this slide came out of a hole several hundred feet long and 150 feet wide, flowed down the hill several hundred yards toward the cemetery, carried away a pile of lumber, and knocked the power-house from its foundations. The front of the mud-flow piled up in a bank when it reached the nearly level ground, and dammed up the mass behind it. The earth was harder several weeks later than it must have been at the time of the flow, but it was still slushy and there was still a little water flowing along the path of the earth-flow, coming from a small spring where the slide originated.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
136		A	1906	Lawson and others, 1908, p. 249, plate 96A.	In front of the Holy Cross railway station (plate 96A) the tracks of the main line of the Southern Pacific were slightly bent, but the lighter rails of a side track near by were much more disturbed. Around the station the ground had settled and there were a number of cracks, from 4 to 6 inches wide, but these were probably due to the fact that this ground had been filled in to get the required grade for tracks and the station.	
		A	1906	Lawson and others, 1908, p. 243.	<i>Effect on certain street railways</i> (T. Mallally).-- There does not seem to have been any actual shortening of the length of the street railways of the United Railroads of San Francisco; but the rails in one location traveled about 3 feet in a northerly [southerly?] direction. This location was in the valley and was marsh land, beginning at a point about 100 yards north of Holy Cross Cemetery, where the rails parted, and ending about 1,000 yards north [south?] of Holy Cross, where the rails buckled up in the air. We had to cut out about 3 feet at this point, and add 3 feet where it parted at the other end. Of course there was a decided movement of the rails all along, in a lateral direction, which left the tracks out of alinement, but was not enough to prevent operation of cars. This condition would indicate that the fill in the marsh land moved in a northerly [southerly?] direction about 3 feet, but that the actual distance along our line has not been appreciably changed.
	A	1906	Lawson and others, 1908, p. 249.	One hundred feet west of the Southern Pacific Railroad track is the electric line of the United Railroads between San Mateo and San Francisco. This roadbed was also filled in considerably for the required grade, and was not as well settled as the Southern Pacific tracks, so it suffered more severely. West of the Holy Cross Cemetery, the rails were distorted and pulled apart 3 or 4 inches at the joints, due mainly to the dropping of the roadbed. Poles were out of true, but no wires were seen broken from tension or the swaying of the poles.	
		B	1906,	Lawson and others, 1908, p. 250.	On the west bank of a creek, near and parallel to the line of the railroad southwest of Holy Cross Cemetery, there was a crack several hundred feet long. This was along the bank near the creek bed and was an incipient landslide.
	B	1906	Lawson and others, 1908, p. 249.	North of Holy Cross Station, by a little lake west of the cemetery, there was a large landslide along the roadbed of the Southern Pacific Railway. For about 300 feet the bed caved and in one place the west track was left suspended in the air. West of the railroad there were large cracks in the newly filled grounds of the Woodlawn Cemetery.	
137		C	1906	Lawson and others, 1908, p. 247, plate 97D.	The track of the electric tramway line, just south of Baden, shows evidence of intense disturbance. (See Plate 97D.) The roadbed which was built up nearly all the way here was cracked parallel to the rails. One crack varied from 2 inches to a foot in width, and extended about 1,000 feet along the filled-in roadbed. For this distance the double tracks were twisted back and forth in a zig-zag fashion, and up and down to some extent. One rail was bent 2 feet horizontally and 10 inches vertically. Not a single rail in this 1,000 feet remained straight or in place, but in no case were the rails detached from the ties. Most of the poles supporting the electric wires were thrown out of line. The ties were shoved back and forth and from side to side, leaving clean, bare places where they had slid about. [See also loc. 141.] The tracks of the Southern Pacific Railway line, which are parallel to the electric road in the vicinity of Baden Station, were slightly disturbed but not so badly that trains could not run over them. The Southern Pacific roadbed is much better ballasted than the electric	

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**San Francisco Bay, Santa Clara Valley, and east bay hills--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						line, because it is older and has become more firmly packed, which is the reason that it was not disturbed like that of the electric line. This disturbed portion of the electric line continues about 200 feet north of a road by the Baden Station, until a cut is reached where filling up was no longer necessary. The cracks were thus confined to the filled ground.
				B	1906	Lawson and others, 1908, p. 248.
						The electric-car line that runs to South San Francisco turns a right angle at Baden, from northwest to northeast. The rails northwest and those northeast of the turn were both badly bent. On the northeast branch the rails were bent into a U-shape, the base of the U being to the northwest with a side thrust of about 2.5 feet. The rails on the northwest end of the line were bent into a V, with the base of the V pointing northeast, the lateral displacement being about 1.5 feet. These are about 60-lb. rails, and at the V-shaped bend mentioned the rails were broken in three places.
				C	1906	Duryea and others, 1907, p. 252.
						Of the three, long, riveted-iron, pipe lines leading from storage reservoirs into San Francisco, the middle one, 36 in. in diameter, leading from San Andreas Reservoir, was fractured at one point only. This was at Baden, where the pipe crossed a piece of marsh land on a wooden trestle.
				B	1906	Lawson and others, 1908, p. 248.
						Just east of the station at Baden, where a creek crosses the county road, there were cracks in the filled soil * * * .
				C	1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 18.
						Near Baden the line had been telescoped 42 inches, shearing off an 8-inch gate valve. The [University Mound] reservoir itself was undamaged, yet its three days' supply was rendered useless by the breaks in the cast-iron distributing mains. [See also loc. 140.]
138				B	1906	Lawson and others, 1908, p. 248.
						North of San Bruno Point, at the Southern Pacific tunnel along the bay shore cut-off, no damage was done, except for the sliding and settling of the debris in the newly filled area.
139				C	1906	Lawson and others, 1908, p. 248.
						The buckling of the tracks of the South San Francisco car line between the town [South San Francisco] and San Bruno Point * * * is significant of the contrast in the intensity of the shock at the two places. The rails are bent and broken in a number of places, where the track crosses the marsh between the two places. The difference of intensity is striking when it is taken into consideration how close they are together.
140				A	1906	Schussler, 1906, p. 31.
						One feature of the destruction of the bridge and pipe across the San Bruno marsh was that some of the pipe was thrown to the west and some to the east as much as four or five feet. * * * We re-established by careful survey, the straight line and grade of pipe, and found that neither the original straight line of the piles nor the grade of their tops had been disturbed by the earthquake.
				A	1906	Duryea and others, 1907, p. 252.
						* * * [The break in the 44-in. Crystal Springs pipeline] was the most extensive which occurred at any point about the Bay, save those immediately on the fault line * * * . This was at the crossing of the San Bruno Marsh, where, for a distance of about 2 000 ft., the pipe was supported upon trestle bents resting on a pile foundation. The pipe was pulled apart at a number of places, and nearly all of it was thrown entirely off the supports on either side.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
141	26	☒	A	1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 18.	In company with Herman Schussler, chief engineer of the Spring Valley Water Company, the writer made a detailed examination of the principal conduits and reservoirs. On the San Bruno marsh the 44-inch line to the University Mound reservoir had been thrown off the trestle for a distance of 1,300 feet; and, while the pipe was readily repaired, the trestle had to be rebuilt, as many of the timbers had rotted.
		☒	A	1906	Derleth, 1906b, p. 551.	The Crystal Springs conduit * * * is ruptured in a number of places, but mainly where it crosses the marshes. The worst destruction has occurred in a distance of about 1,600 ft., where the pipe crosses a marsh between San Bruno and South San Francisco. In this place the pipe rests upon a wooden floor, supported by pile bents. These piles on the average penetrate the mud to a depth of about 40 ft. * * * the pipe was alternately thrown from one side to the other of the trestle floor and its box covering was generally smashed.
		☒	A	1906	Lawson and others, 1908, p. 248.	From South San Francisco to San Bruno, there is a line of big steel water-mains, supported on a trestle frame, where it crosses the marsh. This line did not break, but was bent and twisted into S-shaped figures.
		☒	C	1906	<i>San Jose Mercury</i> , 1906b.	San Bruno. The approaches to the bridges between San Bruno and South City were sunken, making the bridges difficult of passage.
		☒	B	1906	Lawson and others, 1908, p. 247. plate 97C	Near San Bruno, where the county road crosses a small stream, there were numerous cracks in the ground from 3 to 10 inches wide, parallel to the line of the road, which is N. 25° W. The road at this place was built 8 feet above the mud flats, so that these cracks are accounted for by the settling of the fill. * * * Plate 97C illustrates the effect of the shock upon the track of the electric railway on the marsh west of San Bruno.
		☒	C	1906	Lawson and others, 1908, p. 251.	Similar things [settlement] happened to newly filled roadbeds along the west edge of the Santa Clara Valley, near Baden and San Bruno.
142		☒	C	1906	<i>The Chicago Record-Herald</i> , 1906a.	Train Is Shaken Up. I was on a Southern Pacific train twenty miles from San Francisco when the shock came. * * * Farther on two great fissures appeared on each side of the track where the earth had opened. A little further we saw that the Santa Fe tracks, next to ours, had sunk out of sight where there was a deep fill. [The train continued to San Francisco.]
		☒	C	1906	Lawson and others, 1908, p. 246.	At San Mateo Point, which is on the shore of San Francisco Bay, east of the town * * * alluvial flats around the point showed some small cracks, and there was a slight sinking of the ground near the bay.
		☒	B	1906	San Francisco Bay Conservation and Development Commission, 1975, p. 17.	11. Voting on Permit Application No. 9-75. Application of the City of San Mateo to rebuild an existing dike * * *. The dike is located along a mile stretch of the Bay shoreline between Coyote Point Regional Park and San Mateo Creek, in the City of San Mateo, San Mateo County. Robert M. Davidson [should be Robert G. Bezzant], Director of Public Works for the City of San Mateo, summarized the application and exhibits. He said the dike was constructed before the turn of the century, suffered a failure in the 1906 earthquake, was rebuilt about 1911, has been raised a few times as it settled into the mud, and after World War II certain sections were replaced to protect housing behind the dike. [The minutes of the Board of Trustees of the City of San Mateo between ca. fall 1910 and April 17, 1911, confirm the

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						construction of dikes for mosquito abatement, 3,150 feet long between Burlingame Avenue and Coyote Point and 7,000 feet long from Coyote Point south to San Mateo Creek. However, these minutes do not mention preexisting dikes and hence do not confirm a dike failure in 1906.]
143		B		1906	Lawson and others, 1908, p. 259.	(F. Lane.)--South of Menlo Park and east of the Meyer Place on the west side of San Francisquito Creek, a crack about 1.5 inches wide ran for 20 feet along the edge of the county road parallel to and just above the creek, showing a half-inch vertical displacement, the lower side lying next to the creek. This crack appears to be due to the starting [sic] of the filled ground of which the road is partly made. * * * Water-pipes along the road leading from the reservoir toward Menlo Park had been pulled apart.
	C		1906	Hyde, 1906c, p. 767.	PIPES DESTROYED BY UNEQUAL SETTLEMENT.--Wherever filled ground existed, settlement in greater or less degree took place as the result of the temblor. * * * Southward, in the vicinity of Palo Alto, where the effects of the earthquake were very pronounced, it is interesting to observe that the long 12-in. cast-iron pipe, known as the Searsville line, supplying the Leland Stanford, Jr., University, was broken in three places and in addition received many smaller cracks, principally along the bottom.
144		B		1906	Schussler, 1906, p. 32.	Neither the Sunol filter beds, on the Alameda Creek System, nor the Sunol Aqueduct and 36-inch pipe line, on the east side of the bay, nor the four submarine [under San Francisco Bay] pipe lines were injured; only a slip-joint, on one of the two 16-inch shore connections, was pulled apart several inches, on the east side of the bay * * * .
	A		1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 116.	(See the maps, Pls. LVI and LVII.) Some subaqueous pipe lines crossing the bay seem not to have been injured.
145		C		1906	Lawson and others, 1908, p. 259.	People reported new holes formed in the slough near Cooley's Landing, but their statements were not verified.
146		A		1906	Lawson and others, 1908, p. 260.	In one case a wind-mill (at 6, map No. 22), which had been in use for years to pump water from the well, was no longer found necessary, but the artesian water was muddy.
147		B		1906	Lawson and others, 1908, p. 408 and p. 261.	At the Ynigo Ranch, 3 miles northeast of Mountain View Station, there was an artesian well which had, before the shock, flowed slightly or not at all, and a wind-mill was used to raise the water. After the shock, it was found that the casing had been shoved up 2 feet, damaging the pump. The flow of water was increased, and black sand was brought up. Another well at this ranch was unaffected. Along the Jagel Landing road, 2 artesian wells had increased pressure after the shock. An old artesian well filled with stones had begun to flow for the first time in several years.
148		C		1906	Salinas Daily Index, 1906b.	On Alviso slough two rows of trees in an orchard had parted off and slid into the slough.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
	⊙	✱	C	1906	Taber, 1906, p. 315; also in Jordan, 1907, p. 279.	A well near Alviso, at the head of the bay, formerly required a wind-mill to pump the water. At the time of the earthquake the casing was driven 2 feet out of the ground, wrecking the pump, and since that time the well has been flowing under a heavy pressure. In some of the lowlands small cracks were formed, out of which water issued, bringing up mud and sand.
	✱		C	1906	Ransome, 1906, p. 294.	[Railroad grade subsidence of several feet] is reported from Alviso, a town at the south end of San Francisco Bay.
149	⊙	⊙	A	1906	Weatherbe, 1906, p. 402.	* * * some rather remarkable demonstrations of the earthquake have occurred along the levee paths following the Coyote river north from the bridge on the road from Milpitas to Alviso. * * * At the locality mentioned large fissures, as much as eight feet wide and of nearly equal depth, have been opened and as partial filling ensued immediately, they must have been of much greater depth when first formed. In some places the road has been completely precipitated into the creek and at a point about half a mile below the bridge both the banks and the bed of the stream, including a heavy growth of willows, have been cut by a series of parallel cracks and the trees and banks thrown into the stream, thus forming a partial dam. All of these cracks are roughly parallel with the stream * * *. Simultaneously with the above phenomena, dozens of small geysers or spouting craters were formed along the creek and in the adjacent fields. The mouths of these varied in diameter from three inches to about 15 in., though the actual orifices probably do not exceed four or five inches in diameter. Mud and water were spouted to a height of over twenty feet, and continued to flow for several days. On some of the miniature craters incrustations of salt were deposited. The bridge above-mentioned was shifted on its concrete supports, the two ends moving in opposite directions, and throughout the same locality rows of trees in the orchards are said to have been twisted and staggered out of shape.
27A	⊙		C	1906	Lawson and others, 1908, p. 282.	Cracks like those which were observed in the ground on the Milpitas-Alviso road reappeared on both sides of the Coyote River at intervals all the way to San Jose. Altho they occur in a general north-south direction, it seems probable that their origin was due to the unstable condition of the alluvial deposits which underlie the valley.
	⊙	⊙	B	1906	Lawson and others, 1908, p. 281, plate 140B.	From 1,500 to 2,000 feet west of the bridge over Coyote Creek, cracks cross the road in front of the Boot ranch-house, and several of them occur in the road leading to that house. (Plate 140B.) Some of these cracks are about 6 inches wide and have a general bearing of N. 43° W. Immediately after the earthquake, water flowed from some of them and brought up sand, which was heaped up about 6 inches high. The water ceased to flow after the second day.
27B	✱	⊙				Near the dwelling house on the Boot place, the ground settled 11 inches on the east side of the crack. The fissures past under the corner of the dwelling house and the building was partly thrown from its foundation. The cellar beneath it was filled with water to a depth of from 2 to 3 feet. There is a capped artesian well in the yard of this house, and about this well is a pool of water 12 feet across. The west side of the pool was lifted 1 foot higher than the east side, and fish were thrown out of the pool. A hundred feet east the fissures past under the barn, and the ground settled on the west side. Water flowed from cracks in the yard and piled up sand 6 inches high on both sides.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		◀ ✕				<p>People living near Coyote Creek state that the water rose between 2 and 3 feet immediately after the earthquake; and up to April 26 the water in this stream had not returned to its normal level. At the bridge over Coyote Creek, on the Alviso-Milpitas road, the concrete abutments were thrust inward toward each other about 3 feet. A pile driven in the middle of the stream, which had been cut off below the water-level, was lifted about 2 feet and now rises above the water.</p> <p>About 150 feet north of this bridge the banks of the stream cracked, the fissures running parallel with the channel and the land on the creek side sliding toward the stream. (Plate 140A.) West of the stream, in an adjoining field, water rising thru cracks built up many craterlets of sand. (Plate 143A.) Residents of the vicinity state that the water rose 3 or 4 inches above the tops of these craterlets while they were being formed, and that it ceased to flow toward the end of the second day after the earthquake.</p> <p>In the road running northward along the west side of Coyote Creek from the bridge, many large cracks opened. Five hundred feet north of the bridge the cracks were 2.5 feet wide and 3 feet deep when the place was visited April 26. Farther north the cracks were very abundant, mostly parallel with the road, and some were 4 feet deep and 3 feet wide. A quarter of a mile north of the bridge, the whole road was shoved eastward into the channel of the creek, and with it a large number of willows and cottonwood trees that grew along the banks. Just south of this place the road was broken up badly for a distance of 300 feet. One of the largest cracks in the road was 5 feet wide, 6 feet deep, and more than 100 feet in length. The bearing of the fissures at this place was N. 23° W. For the most part the principal features were approximately parallel with Coyote Creek.</p>
28	○				<p>plate 140A</p> <p>plate 143A</p>	
		◀				
		◀	C	1868	Lawson and others, 1908, p. 446.	Where the Milpitas road crosses Coyote River, the banks were shaken together and the river-bed filled up.
		◀ ○	C	1868	Lawson and others, 1908, p. 444.	<i>Milpitas.</i> --Along Coyote Creek the ground was cracked from Boot's ranch to the San Francisco Bay, the cracks being on the bay side and following the winding of the creek. As in 1906 much water was ejected from the cracks, and Coyote Creek rose. (W. Bellou.)
		◀	B	1906	Lawson and others, 1908, p. 280.	Of the two bridges over Coyote Creek, the northern one suffered some damage by displacement of end supports. It was unsafe to travel over at the time of the visit. The southern bridge [loc. 154] was found intact, the end supports showing signs of but small movement.
		○	C	1906	Carey, 1906, p. 297.	Near Milpitas along the Coyote Creek artesian water gushed out of cracks and holes in the ground, making temporary fountains several feet high, bringing up silt and forming cones about the outlet, as shown in photograph. Similar outpourings of water are reported from the Salinas valley. In some cases artesian wells stopped flowing, but in general the water level was raised, so that many ordinary wells overflowed. The water in most cases was more or less muddy.
150		◀ ✕ ○	B	1906	Lawson and others, 1908, p. 281.	At Mrs. North Whitcomb's ranch, on the south side of the Alviso-Milpitas road, between Coyote Creek and Milpitas, the prune orchard was cracked and the ground shifted at several places. The ranch-house, of concrete with a wooden upper story, was cracked across the northwest corner and settled slightly on the northwest side. In the back yard were fissures 1 foot wide, running about N. 13° W., with a downthrow of 1 foot on the east side. Some of the prune trees in the orchard are 2 feet out of alignment, and some as much as 6 feet. The lateral displacement here shows a relative movement of the south side toward the east. Considerable sand was brought up by water flowing from the cracks in this orchard.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
151	○	C		1868	Lawson and others, 1908, p. 444.	Cracks in the vicinity of Milpitas flowed artesian water for 48 hours after the shock. (Mr. Durkee.)
	◁	C		1906	Jordan, 1907, p. 66.	[Picture caption] Slump in Soft Ground, Milpitas.
	○	C		1906	San Jose Herald, 1906b.	The district between Milpitas and Alviso is seamed with immense fissures from which water is pouring. The country is being rapidly inundated. The road between Milpitas and Alviso is beneath water in many places, making passage impossible. The bridge over the creek is down. Sections of land varying from small plots to entire fields have sunk to depths of six inches to five feet.
	◁					
	✱					
152	■	C		1906	Lawson and others, 1908, p. 282.	Milpitas-San Jose Road (G. F. Zoffman).--About 0.5 mile south of Milpitas, on the Milpitas-San Jose road, cracks were formed across the road. They did not, however, appear to have any definite direction, and were so small that no lateral movement was discernible.
	■	C		1906	The Evening Post, 1906a.	The roads skirting the bay were slightly injured in places by fissures, but no serious faulting of the underlying rock was observed. * * *
	✱					From San Jose to Alviso the road is lowered in places by the shocks, and the front of the principal hotel at Alviso has sunk at least ten feet.
153	○	C		1868	Lawson and others, 1908, p. 444.	I was told at the time that the water spurted up in the streets of San Jose, and out in the road between Milpitas and San Jose, to the height of several feet.
154	●	A		1906	Lawson and others, 1908, p. 282.	On the north side of the bridge which crosses Coyote River, on the San Jose-Milpitas road, some cracks were found but they were evidently caused by the sliding of the banks. The bridge was not damaged.
155	⊙	B		1906	Lawson and others, 1908, p. 286.	(M. Connell).--On the farm of Mr. Fox, 3 miles north of San Jose, the water pipe of an artesian well was broken off 60 feet below the surface and carried by the heave of the land in a northwesterly direction 4 feet from its original position.
156	←□→	C		1906	Lawson and others, 1908, p. 282.	Alum Rock Road (G. F. Zoffman).-- * * * No cracks were found between Coyote Creek and the mountains * * * .
157	□	C		1906	Jordan, 1907, p. 188.	San José's water works, like that of Santa Rosa, was not injured; its sewers also were left intact, showing that there was no unequal displacement of the ground.
	□	C		1906	Lawson and others, 1908, p. 285.	(E. C. Jones).--There was only one broken gas main in San Jose, caused by the high wall of the building falling over; the bricks penetrated thru the soft earth to the main and broke it.
158	⊙	C		1906	Lawson and others, 1908, p. 284.	Water and mud in many instances are reported as having spurted from the artesian wells, but in a few days they resumed their normal condition. * * *
	✱					Data were obtained of the directions in which the chimneys fell thruout the town. After the data were collected and tabulated as shown below [2710 chimneys], it became evident that chimneys usually fell with the slant of the roofs.

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region—Continued**San Francisco Bay, Santa Clara Valley, and east bay hills--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
			C	1865	Holden, 1898, p. 67.	1865. October 8. The streams at McCartysville and Los Gatos have risen greatly since the earthquake, tapping the sources of the artesian wells in the Santa Clara Valley, many of which have ceased to run since the earthquake.
159			B	1906	Lawson and others, 1908, p. 286.	Just northwest of the 12-mile house, where the county road crosses to the Fisher ranch, there were cracks from 2 to 6 inches wide in the coarse gravelly bottom of the Coyote River. There was evidence of water having been ejected from these cracks, as there were heaps of clean, fine material surrounding small orifices. It was said at the ranch-house that muddy water came out of these openings following the shock.
160			C	1906	Lawson and others, 1908, p. 283.	Along the road down Penetencia Creek, a considerable amount of debris had slid into the road, in many places obstructing all travel except for pedestrians; but no evidence of cracks could be found.
161			C	1906	Lawson and others, 1908, p. 282.	Between this place [Calaveras Valley] and the head of Alum Rock Canyon, the residents stated that cracks appeared across the road in several places; but altho this was in the proximity of the Calaveras Valley fault-line, which passes thru this region, it was not possible to verify their statements.
162			C	1906	Duryea and others, 1907, p. 258.	Between Niles and San José, on the Southern Pacific, there was at one point a displacement of 3 ft. horizontal, but the vertical displacement was only 6 in.
163			C	1868	Lawson and others, 1908, p. 444.	On the mountain above the old Mission, just above a place called Peacock Springs, a great crack in the earth appeared, which looked as if the lower part of the mountain had parted and split down. Many times I have crossed the bridge which was built over the crack, and stooped and thrown rocks down to see if I could tell how deep it was. (Mrs. N. Ainsworth.)
164			B	1906	Lawson and others, 1908, p. 304.	According to the track-boss, the railroad track suffered no displacements anywhere between Niles and Irvington.
165			A	1906	Lawson and others, 1908, p. 306.	While at Niles, a visit was made to one of the new tunnels of the Western Pacific Railway, which is about 1 mile east of Niles in the Niles Canyon. The tunnel had penetrated about 130 feet into the hillside, but had not yet passed thru anything but a sandy clay. During the previous winter the walls at the portal, and also on the inside, had stood without timbering. Since the earthquake it had been impossible to break out more than 4 feet of ground ahead of the timber sets without caving taking place. There had been an apparent movement in the soil which had removed its consistency and made it incoherent. The amount of water present in the tunnel was perceptibly changed. The foreman said that there was more water since the shock than there had been even in the wettest part of the winter.
	G	1933	Coffman, 1973, p. 169.	1933. May 16. Niles Canyon * * * Landslide * * * .

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
166			B	1906	Lawson and others, 1908, p. 309, plate 141A.	At the Alviso ranch, a little over a mile north of the town [Livermore], the top of a small hill was broken up at the time of the earthquake. The breaking of the ground did not consist of fissuring along a line, but was in the nature of an uplift of a limited area. There were 3 fairly well marked concentric rings where the ground had broken, the inside ring in each case being forced higher than the outside ring. The effect was similar to that obtained by placing three plates of different sizes within each other. * * * Mr. Still reports that where the ground was deformed in concentric ridges, as described by Mr. Matthes and Mr. Crandall, there was an alkaline spring years ago. [A somewhat similar phenomenon was seen on Cahill's ridge (locs. 116, 120) in San Mateo County.]
			B	1906	Lawson and others, 1908, p. 308, plate 141A.	An interesting feature appears 0.25 mile north of Meyn's ranch, west of the road leading north from Livermore, about 2 miles north of that place. It is on the summit of a smoothly rounded hill, sloping gently down to an even, peaty meadow traversed by the arroyo of Cayetana Creek. * * * The summit of the hill in question was found crowned by a series of concentric deformations, rising stepwise above one another. A number of nearly concentric cracks were found extending northward into a sort of panhandle, along each of which an upward movement of the soil had apparently taken place. The uplift along the 2 principal cracks was found to be 19 and 16 inches, respectively. Along the minor cracks the vertical displacement amounted to an inch or two only. The surface of each step or bench was found to slope inward, and in some places the edge even appeared to have curled inward.
167			B	1906	Lawson and others, 1908, p. 309.	<i>Santa Rita</i> , 3 miles east of Dublin (F. E. Matthes).--A small, flat levee along the east bank of Tassajara Creek, immediately north of the main road, showed several somewhat crescentic cracks along which the ground had slipt down and toward the creek from 1 to 3 inches. These cracks extended farther south, according to local settlers, and crost the road; but this was no longer traceable at the time of the visit.
168			C	1861	Holden, 1898, p. 58.	1861. July 4?; 16h. 11m. * * * in the San Ramon Valley * * * . It opened a large fissure in the earth, and a new spring of water.
			C	1861	Coffman, 1973, p. 157.	1861. July 3. Contra Costa and Alameda Counties. Severe * * * . In San Ramon Valley a fissure opened, and a new spring of water appeared.
169			C	1906	Lawson and others, 1908, p. 280.	The track suffered a slight shifting in several places north of the village [Newark]. Cracks opened in the ground in the vicinity of 2 small watercourses, but on a less extensive scale than that noted at Alvarado [loc. 170]. Some of them crost the railroad track. In every case they emitted the same bluish sand (with the water) that had been found near the Alameda Sugar Mill. In one place, 1.5 miles northeast of the village, considerable water was still left standing in shallow ponds. According to neighboring ranchmen, these ponds had not existed prior to the earthquake.
			C	1906	<i>Oakland Tribune</i> , 1906a.	Newark, April 18.--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 in what might be termed a dry district.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
	○		C	1906	<i>The Bulletin</i> , 1906.	Fissure created by earthquake near Newark becomes running water, and pipe wells become gushers spouting twelve feet.
	□					One of the most peculiar freaks of the great temblor of last Wednesday morning is a fissure in the earth a short distance from Newark, several feet wide and about a mile and a half long, running with an excellent quality of water.
	⊙					This river was first noted by the crew of one of the Southern Pacific Company's trains coming up from San Jose, and investigation discloses that many of the old pipe wells in the vicinity have suddenly gushed forth, in some instances the water spouting from eight to twelve feet into the air.
170			B	1906	Lawson and others, 1908, p. 305.	The [Alameda Sugar] mill stands on flat, alluvial ground 100 feet north of Alameda Creek. Along the banks of the latter 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, notably the fire-engine house, which moved bodily, concrete foundation and all, 2 feet south toward the creek. A small railroad trestle southwest of the mill moved 4 inches south on both of its abutments, probably owing to slumping of loose ground on the north side of the creek. A 2-inch water-pipe, laid under the ground some 60 feet north of the creek and almost parallel with the same, shows indications of having been submitted first to tension, causing rupture at one of the joints, then to sudden compression, causing it to be jammed together with violence.
	○					Cracks in the ground may be found as far as 250 feet from the creek. They were nearly all closed at the time of the visit (May 7), but 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 of the superintendent, 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. The fence in front of the house shows that the ground there has been raised into a low hump. The sewer pipe leading west to the creek was detached from the house by a space of 22 inches. * * *
	⊙					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 crushed in several places.
	⊙					* * * A few cracks opened across the streets [of Alvarado], but these had been filled on the date of the visit.
	○		C	1868	Lawson and others, 1908, p. 443.	<i>Alvarado</i> . * * * The ground opened in several places and water issued.
	✱		B	1906	Duryea and others, 1907, p. 254.	At Alvarado, near the pumping station, the 30-in. riveted-iron force main conducting the water to Oakland crosses the Alameda Creek on a short bridge. * * * In this pipe was placed a 24-in. stop-gate resting on a concrete foundation. The piles under the pipe were not deeply placed; and the shake operated to settle them irregularly, some going down as much as 6 in.
	✱		B	1906	Hyde, 1906c, p. 766.	ALVARADO FORCE MAIN.-- * * * The earthquake threw this pipe out of alignment into a decidedly sinuous location for a distance of about one-half mile. The flanges of the gate valve were broken by the unequal settlement of the trestles carrying the pipe and the concrete pier on which the valve rests.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		✱		B 1906	Derleth, 1906a, p. 503.	The Alvarado force main, a riveted pipe, was wrenched in two places. Three hundred feet from the pumps the pipe snapped, and a quarter of a mile further on toward the city, in which distance the pipe lies upon piling, the flange of a large gate valve was broken by the settling of the piles.
		✱ ✱		B 1906	Duryea and others, 1907, p. 249 and p. 250.	[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.
171		○		B 1868	Lawson and others, 1908, p. 443.	The ground opened from 6 inches to 2 feet, and water with sand was ejected to a height of from 1 to 3 feet. North of the village [Hayward] a ridge of ground 3 feet wide was raised 2 feet. * * * On the hills there were several new springs.
		○ ✱		B 1868	Lawson and others, 1908, p. 442.	The crack below Haywards Hotel was 12 inches wide. It ejected water and white sand. A fence which traversed a hill from north to south was crost by the crack, and had the ends of the boards loosened from the posts. Gradually these boards lapt over one another, until within a couple of weeks they overlapt several inches, the progress of the overlapping being noted from time to time by a pencil mark. The "cap" board of the fence was also archt up in consequence of this movement. Large waves were set up in the soil. The house was moved southward, while a neighbor's was tipt northward. (D. S. Malley.)
		○		C 1868	Lawson and others, 1908, p. 442.	On B Street the ground opened about 2 inches, and water and sand were forced from the opening. Some springs were closed, while others were opened or made to flow more freely.
		○		C 1868	Lawson and others, 1908, p. 435.	In the vicinity of Haywards it is reported that there were two branch cracks from the main one [fault?], trending off into the hills. Water and sand were ejected from the crack in one place.
172		☐		C 1838	Wood, Allen, and Heck, 1939, p. 3.	1838, late in June. * * * VIII at least. * * * Landslide at San Leandro.
		☐ ☐		C 1868	Halley, 1876, p. 263.	The bed of the San Leandro creek, which had been dry for several months, is now coursed by a stream of water six feet wide and one foot deep. Back of San Leandro, in the mountains, there are numerous fissures in the earth, from which came clouds of dust, and from some have come great volumes of water which flows into the San Leandro Creek.
		☐ ☐		B 1868	Halley, 1876, p. 267.	A Mr. Davis, who resides on a farm near San Leandro, informs the <i>Bulletin</i> that the workmen on his farm at the time the shock occurred, observed that the ground was disturbed and thrown about with a rapid and violent rotary motion, which continued several seconds. A creek running through the farm, and which was nearly dry, rose instantly to the depth of about three feet, and several deep gulches were formed in the plain.
173		✱		B 1906	Lawson and others, 1908, p. 304.	* * * at Mills College * * * In the made ground there was a drop of from 1 foot to several feet.
				C 1906	<i>Alameda Daily Argus</i> , 1906.	[At Alameda] * * * damaged tracks in the marsh. One of the new tracks of the Oakland Traction Company across Webster St. sunk about four feet and the rails are twisted, blocking traffic.

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
174	☒	C		1906	Derleth, 1906a, p. 503.	The [water] distribution system of East Oakland seems to be practically unaffected, but in West Oakland, upon filled ground, some of the smaller pipes and some of the service connections have been broken, but the damage is, relatively speaking, slight.
	◀	C		1906	<i>Alameda Daily Argus</i> , 1906.	Bay Farm Island shows many crevices and cracks on the surface.
		C		1906	<i>The Evening Post</i> , 1906b.	Railroads are inactive, and wires are useless. Railroad tracks across the marsh are twisted. * * * More than 600 feet of the track of the Oakland Transit Company sank nearly four feet.
	☒	B		1906	Duryea and others, 1907, p. 254.	One 12-in. cast-iron pipe near the water front in East Oakland was drawn apart at the joint, and one or two breakages occurred on a long line of 8-in. pipe leading to the Southern Pacific Railroad Broad-Gauge Pier.
	◀	B		1868	Holden, 1898, p. 76 and 77.	1868. October 21; IX. Oakland. * * * The draw of the railroad bridge was thrown twelve inches out of line.
	☒	B		1906	<i>Oakland Enquirer</i> , 1906.	The magnesite works at the foot of Ninth avenue in East Oakland have sunk several feet and now the ground on which they stood is under water. The sinking is probably due to the violent earthquake of Wednesday morning. The land on which the works stand is very unsubstantial, being simply built up by the process of dredging.
	☒	C		1906	<i>Leslie's Weekly</i> , 1906a.	[Picture caption] Frame structure which was cracked and wrenched and which sank for several feet into the yawning ground.
	◀	B		1868	Halley, 1876, p. 266.	The drawbridge on the line of the S. F. and O. R. R. was thrown out of place about eight inches, and as the locomotive and nearly all the cars were at San Antonio, no train left Oakland at 8 o'clock.
175		A		1906	Derleth, 1906a, p. 503.	The earthquake did not produce, relatively speaking, much destruction to these [Oakland, Alameda, and Berkeley water systems] works. Breaks in the pipe lines invariably were found upon soft ground, or where the pipe lines passed from soft and yielding to more rigid foundation. * * * The 24-in. steel pipe crossing the Twelfth St. dam at Lake Merritt was also snapped from the settling of the flood gates, but the 37 1/2-in. pipe running parallel and slightly to the east, across the same soft foundation bed was only slightly deformed.
	☒	A		1906	Lawson and others, 1908, p. 302.	On the Twelfth Street dam, a cast-iron pipe was broken and displaced over a foot; while the high pressure steel pipe paralleling it was practically undisturbed.
		A		1906	<i>Oakland Tribune</i> , 1906b.	Menaced by Water. The tide at the time of the earthquake was at its lowest, and at the time of writing it has turned and running into Lake Merritt. What will happen when the lake is filled and the backing of the water pressures with great force on this portion of the dam is something that can not be foretold. The rock foundation of the dam at this point is cracked and broken and gives indications of giving away at any time. REPAIRS DAMAGE Secretary Hanson of the Contra Costa Water Company was early on the scene and with a force of men began at once to repair the water main so that the people of the city could have water for the protection of their homes in case of fire. It is not expected that water will be turned on before this afternoon The great main has sunken with the street and broken in two and parted for the space of several inches and the pipe will have to be uncovered and a new length put in or the pipe drawn together.
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TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		●				Along the west shore of Lake Merritt the bank has been cracked and broken and caved off into the lake, showing the force of the shake at the water level.
176		✱	C	1906	Duryea and others, 1907, p. 254.	A 24-in. riveted pipe lying in a street leading across a tide marsh in Oakland was pulled apart 5 in. and displaced 8 in. laterally by the settling of the entire street.
	✱	✱	C	1906	Rickard, 1906a, p. 271.	* * * the lower alluvial flats of Oakland and Berkeley were seriously disturbed * * * .
	✱	✱	B	1868	Wood, M.W., 1883, p. 665.	October 21, 1868. [Oakland] Portions of the wharves were carried away in some instances, while walls were cracked in almost every house * * * .
177		✱	A	1906	Bronson, 1959, p. 185.	Southampton Shoals Lighthouse in northern San Francisco Bay sits firmly on piles that were tilted eleven degrees off vertical during the quake and never righted.
178		✱	C	1906	<i>Salinas Daily Index</i> , 1906c.	The Santa Fe's Condition. Santa Fe officials report that their line at Point Richmond had suffered greatly from the temblor. * * * A landslide choked tunnel No. 2 near Point Richmond but this was cleared by 6 o'clock. * * *
	✱	✱				All water mains in Richmond and Point Richmond were broken.
179		✱	B	1906	Lawson and others, 1908, p. 391, plate 128A, plate 128B.	<i>San Pablo earth-slump.</i> --At the time of the earthquake a landslide occurred on Mills' ranch, which is about 4 miles east of San Pablo. The slide is interesting from the fact that a previous geological mapping of the region indicated that the point where it occurred was on the line of a fault extending in a northerly and southerly direction through the Sobrante Hills. The slide was examined by Mr. E. S. Larsen, who describes it as follows:
	✱	✱				There are many other landslides in this vicinity, showing that the country is subject to such slides. In this particular case, one of the Castro boys informed me that the main part of this slide began during the winter rains, and had fallen a foot or more during these rains. The balance of the fall occurred the morning of the earthquake. The slide is on the east slope of a steep hillside and extends from the top of the hill nearly to the bottom, about 400 feet on the slope. The width is about 1,500 feet. At the northeast corner the scarp is greatest, reaching perhaps 50 feet. It gradually decreases, and is very slight for the southwest 700 feet. On this southwest 700 feet the only evidence of a slide is the crack near the top of the hill. The north 800 feet of ground shows every evidence of sliding. The dry ground is much cracked, and these cracks extend up and down the hill near the scarp and along the hill where the ground has been piled up. In some places there is a network of cracks. On the south side of the main slide the ground has piled up about 10 feet. This extends along nearly all of the south side, and this tendency to pile up to the south is shown in other places. Moreover, the north side shows that the ground has pulled away toward the south. The above shows that the movement was not directly down the hill, but was more to the south. The formation is sandstones and shales, with considerable soft surface soil.
						The same slide was subsequently visited by Mr. F. E. Matthes, and the following descriptive note is by him. (See figs. 68 and 69.) [See figs. 68 and 69 at end of tables.]

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						<p>The slip occurred east of a high ridge at the southern end of the Sobrante Hills. It covers the northeast half of an area whose terraced nature is indicative of a former landslide of much larger dimensions. The accompanying sketches show the general outlines, and a cross-section of the slide. It will be noticed that 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. The lower slopes were not materially changed, and but little debris fell into the stream-bed.</p> <p>A steep scarp has been produced east of the crest of the ridge. The downsip along this scarp does not exceed 50 feet, and decreases both to north and south. Along the north edge there has been a marked movement down and southward, the scarp there averaging 10 feet. Along the south side, on the other hand, the loosened mass had advanced over the old surface, presenting a bulging and cracked frontal scarp some 6 feet high. It appears from this that the movement took place, not along the line of greatest declivity, but in a direction somewhat more southward, as indicated by the arrow. The 2 hummocks probably existed before the slip occurred, but judging by their greatly cracked and rent surfaces, it seems likely that their height has been slightly increased. The main crack, which extends southward from the upper scarp, continues along the hillside in irregular zig-zags for some 300 feet south of the slide. (See plate 128A, B.)</p>
180			B	1906	Lawson and others, 1908, p. 310.	On a hillside above Peach Tree Spring, on the west side of Mount Diablo and very near the contact of the Knoxville shales and the Franciscan, a crack opened in the ground about 30 feet long, in a north and south direction, gaping 4.5 inches.
			C	1965	Coffman, 1973, p. 182.	1965. September 10. * * * Minor rockslides were observed at Mount Diablo * * * .
181			A	1906	Salinas Daily Index, 1906c.	The big bridge at Middle River between Point Richmond and Stockton sank three feet and was shoved out of line.
182			B	1906	New York Tribune, 1906.	Stocton, Cal., April 18, -- * * * The Santa Fe bridge, over the San Joaquin River, settled several inches. [See also loc. 254.]
			B	1906	The Evening Post, 1906d.	Santa Fe Bridge Over the San Joaquin Settles. Stocton, Cal., April 18.-- A sharp earthquake shock was felt here at 5:15 o'clock this morning. The Santa Fe bridge over the San Joaquin River settled several inches.
183			C	1906	Lawson and others, 1908, p. 195.	At Point Reyes Light-house * * * . One of the light-house keepers stated that after the shock he lookt from the window of his room, which commanded a portion of the sea near the beach, and saw the water "boiling," but there was no change of the nature of a wave.
184			C	1906	Lawson and others, 1908, p. 75.	About 6 miles farther south, at the head of Pine Gulch Creek, another road crosses the range, and in following this a group of cracks was seen. A short distance west of the divide, and about a mile in a direct line from the fault-trace, is a fault-sag trending northwest-southeast. On each side of it a crack was seen, the eastern crack being the wider and showing a small throw to the southwest. This crack was traced for about 0.75 mile and found to curve thru an arc of nearly 90° from southeast to southwest. At its southwest end, or at

TABLE 6.—*Specific descriptions of ground failures in the San Francisco Bay counties region--Continued**San Francisco Bay, Santa Clara Valley, and east bay hills--Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
					plate 52A plate 53A	<p>least the southwestern limit of tracing, it is on a ridge, and it there expands into, or else is replaced by, a group of cracks diverging fan-wise. On each member of the group faulting took place, the downthrow being toward the northwest except in the case of two apparently short cracks with downthrow to the southeast. On four of these cracks the throw was greater than 1 foot, and at one place it was about 5 feet. Each crack was associated with a preexistent bluff or scarp, indicating that earlier movements have occurred at the same place. The field in which the principal phenomena occur is cultivated with the exception of the steeper scarps, whose faces retain a bushy growth. (See plates 52A and 53A.)</p> <p>A tract lying between this locality and the coast, and extending several miles in each direction, exhibits a peculiar topography intermediate in type between that of the Rift and that commonly associated with landslides. Near the coast are a number of basins with ponds or lakes of much larger size than those along the Rift, and in association with these are seen a number of sags similar to the fault sags of the Rift. On several lines which were thought from the physiography to represent partings between dislocated blocks, earthquake cracks were seen, and on one of these near the coast there was a vertical displacement of 3 feet, the downthrow being to the southwest.</p>
		■	B	1906	Schlocker and Bonilla, 1963, p. 31.	<p>Vertical movement of as much as 5 feet, which Gilbert (in Lawson and others, 1908, p. 75) ascribed to faulting, occurred at locality 3 south of Mud Lake. The authors accompanied by Alan Galloway and Don Tocher, were able to positively identify locality 3 as the one that Gilbert described (op. cit., 1908, p. 75). This movement was probably caused by landsliding rather than faulting. Very large landslides are prominent just west of the locality, and study of aerial photographs reveals that an irregular scarp formed by a landslide joins the fractures described by Gilbert (1908). Moreover, the stream valley down hill from the site has been blocked by the landslide movement, causing ponding of the valley and deposition of sediments.</p>
185		■	C	1906	Lawson and others, 1908, p. 195.	<p><i>Seven Lakes.</i>-- * * * There were a few landslides, and a number of cracks already mentioned (page 75) [loc. 262] testified to movements of large blocks of ground; but I think these were due to a peculiarly sensitive condition of the country rather than to the violence of the shock.</p>
186		■	B	1906	Lawson and others, 1908, p. 192.	<p>Daniel Bondietti lives 3.5 miles north from the head of the [Bolinas] lagoon, and his buildings are about 20 rods east of the main crack. His house was shifted 3 feet toward the fault and his barn moved in the same direction.</p>
187		■	B	1906	Lawson and others, 1908, p. 198.	<p>Back of the Steele place, near the north end of the [Bolinas] lagoon, the hillside started [sic] eastward toward the lagoon, bulged upward, and cracked into several fissures from 30 to 100 feet long and from 5 to 18 inches wide. * * * The two bluffs along the stage road from the head of the lagoon to the town also broke and fell from 40 to 60 feet, completely blocking the stage road along the lagoon beach.</p>
55		■	C	1906	Lawson and others, 1908, plate 49B.	<p>[Picture caption] Cracks made by earthquake in tidal mud near head of Bolinas Lagoon. G.K.G.</p>
56		■	C	1906	Lawson and others, 1908, plate 52B.	<p>[Picture caption] Earthquake cracks in Bolinas at edge of an earthquake sag. G.K.G.</p>

TABLE 6.—Specific descriptions of ground failures in the San Francisco Bay counties region—Continued

San Francisco Bay, Santa Clara Valley, and east bay hills--Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation	
		◀		B	1906	Gilbert, G. K., (from USGS Library Archives).	[Picture caption] Gilbert collection #2895. California earthquake. House one mile northwest of Bolinas. Stands on alluvial fan of Bolinas Creek. Was moved southward on fan. In the foreground is a secondary crack. Marin County, California. n.d.
188		■		C	1906	Lawson and others, 1908, p. 198.	The great ocean bluffs along the south and west of the entrance to Bolinas Lagoon, some 165 feet high, crumbled and fell, crashing down upon the ocean beach and reducing the slope of the bluff to half its former angle.
		■		C	1906	Lawson and others, 1908, p. 387.	On the sea-cliffs on the north side of Bolinas Bay and west of the town of Bolinas, there was a very general crumbling and fall of the sea-cliff upon the beach.
		■		C	1906	Weatherbe, 1906, p. 402.	* * * the mouth of Bolinas bay * * * the high cliffs -- about 150 ft. -- at the end of the peninsula have crumbled and fallen down, carrying small trees with them.
189	57	●		B	1906	Lawson and others, 1908, p. 198.	Along the main street of Bolinas stand most of the houses * * * . Of these about two-thirds were heaved, slid, tipped, and shattered into uninhabitable condition. * * * Along the bay shore were 7 buildings. Of these 6 went over or down. At the Flagg Staff Inn the tipping of the house has thrown it so far east into the bay that one may sit along the upper edge of the parlor floor and fish in 4 feet of water along the opposite edge of the same room.
		●		B	1906	Weatherbe, 1906, p. 402.	At the village of Bolinas, the soil has slipped down easterly toward the lagoon and on the east side of the road, which runs north and south, the buildings are entirely demolished, while those farther up the hill on the west side are not so badly affected.
190		■		C	1906	Lawson and others, 1908, p. 77.	On the steep southern face of Mount Tamalpais a number of rocks were loosened and rolled down the slope, some of them being large enough to cut swaths thru the thicket which were visible for months afterward.
191		▬		A	1906	Lawson and others, 1908, p. 207.	At the building occupied by Mr. George D. Shearer, 306-310 Fourth Street, on level land near the depot, there is a crack running north and south * * * .
		▬		A	1906	Lawson and others, 1908, p. 207.	A crack one block long, north and south, in low land near the station is reported.
		▬		A	1906	Lawson and others, 1908, p. 208.	A crack was formed in the ground 100 feet long, running north and south. The greatest damage was half a block north of the depot.
192		▬		B	1906	Lawson and others, 1908, p. 208.	At Scheutzen Park, 1.5 miles east-southeast of San Rafael, on land 7 feet above sea-level * * * water-pipes were broken, and there were many small fissures in the neighboring ground, running north and south.
		✖		B	1906	Letter by William Hancock, 1906 earthquake collec- tion; California Historical Society Library, San Francisco.	[William Hancock was living in Sausalito and working in San Francisco After the earthquake he went down to the ferry in Sausalito.] The asphalt pavement in front of the ferry was all broken up and in one place sunk down, and the sea frontage looked as though it was about to fall into the water; long lines of cracks parallel to the sea edge.

TABLE 7.—*Specific descriptions of ground failures in San Francisco City and County*

Location number is assigned to each reported ground-failure site. Corresponding numbers are found on plate 3. Figure number refers to figure in this report showing damage described under "Quotation" column. Failure type is indicated by the following symbols. Corresponding symbols are found on plate 3.

▣ Hillside landslides including rotational slumps, block glides, debris avalanches, and rockfalls	○ Sand boils
● Streambank landslides including rotational slumps and soil falls	□ Absence of ground failure noted
◁ Lateral spread	✕ Miscellaneous effects
✕ Ground settlement	✕ Cracks in streets and pipeline breaks
▣ Ground cracks not clearly associated with landslides, lateral spreads, settlement or primary fault movements	◁□→ Arrows showing extent of area affected. Symbol shows failure type

Accuracy with which failure sites can be located is given as follows: A, a site that can be accurately relocated; B, a site that can be relocated to within a few kilometers and probably could be located more accurately with further investigation; C, a site where the information is insufficient to allow precise location. Plate numbers in the "Reference" column refer to plates in the original source material.

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
193	31	✕	C	1906	Lawson and others, 1908, p. 233.	[foot of Market ground failure zone] In spots the streets sank bodily, certainly as much as 2 feet, probably more. Accompanying this depression, concrete basement floors were broken and arched, as if to compensate for it. The surface of the ground was deformed into waves and small open fissures were formed, especially close to the wharves. Buildings on the water side, along East Street, generally slumped seaward, in some cases as much as 2 feet. The damage was greatest close to the water's edge, growing less as the solid land was approached, gradually at first, then more rapidly. These phenomena seem to suggest that the materials used in filling were shaken together so as to occupy less space with the accompanying development of waves, fissures, and structural damage.
		◁				
		◁	A	1906	Hyde, 1906b, p. 739.	[Picture caption] The first picture shows the distortion of car tracks and the line of the local fault in East St. at its junction with Pacific St., along the water front. This territory is within the area of made land on the marshes of the old harbor front.
		◁	A	1906	Jordan, 1907, p. 125.	[Picture caption] Fig. 12--Rupture of Car Tracks and Pavement on East Street, Corner of Pacific Street.
		◁	A	1906	Derleth, 1906b, p. 553.	Fig. 14 shows destruction of car rails and street surface, corner East and Pacific Sts., near the Ferry Building.
		◁	C	1906	Jordan, 1907, p. 98.	It is a general observation that the earthquake waves transmitted by the softer and less coherent materials and formations appeared to be much more destructive than waves which traversed the hard and more elastic rocks and other sound deposits. The billow-like effects that appeared in the streets of San Francisco near the Ferry house are most excellent examples of deformations in soft, incoherent materials. The sliding and rolling effects observed on some of the sand dunes and especially along the hillside at the northern end of Van Ness Avenue may be cited as allied phenomena. [loc. 221]

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation																											
	A			1906	Lawson and others, 1908, p. 143.	Editor's note: A part of the following quoted table was deleted, as it was not pertinent to the discussion.																											
						Table 6.--Elevations of bench-marks before and after the earthquake																											
						<table><tr><th rowspan="2">LOCALITY</th><th rowspan="2">CHARACTER OF BENCH-MARK</th><th rowspan="2">B.M.</th><th colspan="3">ELEVATIONS</th></tr><tr><th>AFTER EARTHQUAKE COAST AND GEODETIC SURVEY 1906-1907 (Meters)</th><th>BEFORE EARTHQUAKE COAST AND GEODETIC SURVEY 1877-1905 (Meters)</th><th>NEW-OLD COAST AND GEODETIC SURVEY (Mm.)</th></tr><tr><td>Cal. and Mont- gomery Sts.</td><td>Water table of Parrott Bldg.</td><td>41</td><td>5.1488</td><td>5.0173</td><td>+131.5</td></tr><tr><td>East and Mission Sts.</td><td>Iron pillar of brick bldg.</td><td>43</td><td>2.4828</td><td>2.8523</td><td>-369.5</td></tr><tr><td>Folsom between Main and Beale Sts.</td><td>Granite post set in brick wall.</td><td>44</td><td>5.4835</td><td>5.5516</td><td>- 68.1</td></tr></table>	LOCALITY	CHARACTER OF BENCH-MARK	B.M.	ELEVATIONS			AFTER EARTHQUAKE COAST AND GEODETIC SURVEY 1906-1907 (Meters)	BEFORE EARTHQUAKE COAST AND GEODETIC SURVEY 1877-1905 (Meters)	NEW-OLD COAST AND GEODETIC SURVEY (Mm.)	Cal. and Mont- gomery Sts.	Water table of Parrott Bldg.	41	5.1488	5.0173	+131.5	East and Mission Sts.	Iron pillar of brick bldg.	43	2.4828	2.8523	-369.5	Folsom between Main and Beale Sts.	Granite post set in brick wall.	44	5.4835	5.5516	- 68.1
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	B			1906	Himmelwright, 1906, p. 19.	[Picture caption] EARTHQUAKE EFFECT. A fissure on East Street near the water front. Note the settlement of the street surface as shown by the exposed curb at the right hand side. In this locality the ground was "made," or artificially filled in.																											
	C			1906	Seattle Post- Intelligencer, 1906b.	Water Front Suffered Less. * * * North of the ferry things were not so good, but still they were better than anyone expected. Broadway wharf No. 1 was badly listed, and will have to be rebuilt, while Broadway No. 2 collapsed completely. The Union street wharf was blown up by the military authorities to save other property.																											
	A			1906	Hall, 1906, p. 32.	Here are, in general terms, the leading facts of earthquake effect within the area which we may designate as the city's principal soft spot, even though it is not the largest area of marsh and mud flat which has been filled over and built upon. Beginning on the east and west streets at the north limit of the area of disturbance, we find the uppermost evidence on Pacific street at about the corner of Front, then on Jackson street at about the inter- section of Battery; next on Washington street at the intersection of Battery; next on Clay near the intersection of Sansome; then on Sacramento, also at the intersection of Sansome; on California it is doubtful whether the disturbance at Sansome is due to general subsi- dence or only to subsidence toward a foundation excavation; on Pine street the upper limit of pronounced street disturbance is about 100 feet above Battery, on Market the line is very distinct at about the foot of Bush street. On Mission a sharp line of subsidence across the street about 100 feet before First, on Howard and in the line of Fremont to the east thereof the line is again plainly marked by a crack and subsidence below it; and finally, on the line of Folsom, about seventy feet below Beale, a line of subsidence is very distinctly marked diagonally across the street exactly at the location and in the direction of the foot of the old hard ground and edge of the former mud flat. Plating these points on the map it is found that they either lie within or outline very nearly the limit of the former soft spot in the lower portion of the principal business part of the city. Below this bounding line the streets are nearly all waved, there being depressions of from six inches to as much as four feet in one																											

Location No.	Figure No.	Failure type	Accumulation	Year of earthquake	Reference	Quotation
						<p>or two places and two or three feet at quite a number of points. While it cannot be said that the whole street area within this zone has sunk, a considerable portion of it has, and near the water front most of it has sunk from six to twelve inches, with several areas of greater depression.</p> <p>Davis street from Vallejo to California street, presents perhaps the extreme case, there being distinct depressions of from one to three feet at every street crossing or within every block, but it is apparent that some of this is due to slip of the street filling into building foundation areas, consequent upon failure of retaining walls and poor foundations of the buildings themselves.</p> <p>The area of about eighty feet frontage which has sunk to a maximum of about eighteen inches in front of the Market-street Ferry building and the depression of somewhat greater area and to a maximum depth of about three feet, at the northwest corner of the same building, are the extreme cases of subsidence along the main waterfront. Contrasted with the very heavy masonry Ferry building founded on piles and concrete, which has not sunk at all, these subsidences will illustrate the point that it is only the soft mud and loose filling thereon which has been disturbed by the earthquake. There are places on the north and south streets where the whole street appears to have been thrown a few inches toward the bay, and at East street, which is the water-front street, there is much evidence of similar movement to about six to eighteen inches where the pavement has been shoved against wharves, piers and other water-front structures and caused to buckle up.</p> <p>Street and water-front railway rails are in a number of places buckled up six inches to two feet or are thrown as much as six inches out of line. Throughout the filled area above street-corner silt basins have been tripped out of plumb and bulged into sidewalk areas, and sewer manholes in street intersections are in several places canted up, showing sewer disturbance beneath; while granite curbs for 100 feet or more in length were tripped up by unequal movement of street pavements and the underlying ground and thrown out bodily on their sides upon the pavement or sidewalk.</p> <p>The Market-street Railway track, carried on a prism of concrete founded on piles for its length within this area, did not sink with the street on each side of it and is yet nearly on its original grade except at one point, where it has sunk apparently about four inches for several hundred feet.</p> <p>It is noticeable that streets have sunk least or not at all in front of the newer deep-piled foundations for adjacent buildings--Market street in front of the Hotel Terminus and in front of the Buckley building, for instance--and this indicates that a part of the street movements is due to settlements into cellar and foundation excavations on failure of their retaining walls.</p> <p>A curious revelation is noticed on the west side of Davis street, between Broadway and Pacific street. Here in 1857 was the water-front wharf. When the street was filled in it is evident that all the piles were not removed. The street pavement, which is basalt blocks, has sunk six inches or more for the full length of the frontage, and the position of the pile heads for about half the length is marked by their punching the pavement up in little pyramids, and for the other half length the position of the pile bents with caps on is shown by the pavement sinking on either side of the caps, leaving ridges of paving blocks over them. Evidences of old structures beneath the surface and filling are brought out in a similar way at a number of points.</p>
						<p>All of the made ground between the Market St. water front and the region of Montgomery St. has been decidedly moved and deformed. Wave-like effects are common along lower Market St. and the water front. Wave-like depressions and crests amounting to four and five feet are found throughout this region. The same observations can be made in many other localities of the city, where soft ground is met.</p>
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TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
194			A	1906	Derleth, 1906a, p. 503.	The earthquake destruction was most marked on soft and sandy soil and upon made ground. The Ferry building, at the foot of Market St. is decidedly damaged. Its tower must be taken down. Bad cracks are found running horizontally between the windows on the second story. This building rests upon excellent foundations, but it is supported upon material which seems to have acted like a viscous fluid. The building has been unharmed by fire, and with the exception of the tower can be repaired.
	☒					
			A	1906	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 135.	The Union Ferry Building [on piles] (Pl. XLVI, A), with the exception of its high tower, was little injured, and the level of its floors was not perceptibly changed. At the same time, the streets at its front, which rested simply on the made soil, were rolled into waves 3 or 4 feet in height.
	☒					
			A	1906	Himmelwright, 1906, p. 226.	UNION FERRY BUILDING. * * * The street surface at the N. W. corner settled 2', cracking the asphalt pavement and carrying down a large section of the sidewalk.
195			C	1906	Duryea and others, 1907, p. 319.	On Market Street, near the Ferry House, the cable tracks resting upon piles moved very little in comparison with the collapse of the street surface on both sides of the car tracks.
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			A	1906	Jordan, 1907, p. 123.	[Picture caption] Fig. 11--Street Surface in Front of the Ferry Tower, Showing Undulations and Cracks in the Asphalt Pavement.
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			A	1906	Derleth, 1906b, p. 552.	[Picture caption] Fig. 15.--Crack in Pavement in Front of Ferry Building. Figs. 14 and 15. Views of Street Deformations, San Francisco Earthquake.
			B	1906	Lawson and others, 1908, p. 236.	* * * the cable-car system on lower Market Street. On account of the constant tendency of the whole district to subside from year to year, as the filling material became more closely compacted, these conduits were constructed upon piling to secure permanence of grade. On both sides of them the street sank in places as much as 2 feet, and the pavement was broken, fissured, and thrown into waves. These tracks did not escape entirely, but for several days, before street repairs were made, they constituted a narrow raised path along the center of the street.
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			C	1906	Hyde, 1906b, p. 739.	The most important wave-like distortions were observed on lower Market and Mission Sts., and on East St. [loc. 193] along the present water front.
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			C	1906	Rickard, 1906a, p. 271.	In San Francisco the street-car tracks on Market street retained their alignment fairly well, but the roadway was depressed fully four feet. Market Street is paved with cobbles; where there was an asphalt pavement in the lower parts of the town below Montgomery street, the roadway was buckled so as to make tents, and in other spots there were depressions several feet below the normal level.
	◀					
			C	1906	Leslie's Weekly, 1906b.	[Picture caption] Mark of the Earthquake's force on East street.
	◀					
			C	1906	Los Angeles Daily Times, 1906a.	[Picture caption] The procession to the San Francisco Ferry. Railroad tracks torn by earthquake.
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			C	1906	The Evening Post, 1906c.	Down on the harbor front, the earth seems to have sunk from six to eight inches, and great cracks appear in the streets. Car tracks were twisted into all shapes * * * .

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
196		✱	A	1906	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 76, plate 25A.	AETNA (YOUNG, OR COMMISSARY) BUILDING. The steel-frame structure at the corner of Spear and Market streets, * * * rests upon piles, and suffered relatively small damage from the earthquake. Pl. XXV, A, shows the corner of the building and the subsidence of the street at this point. * * * There was a vault under the Market street sidewalk, immediately behind the wall at the curb line. The basement floor in this vault was of concrete and had a total thickness of 7 or 8 inches. The earthquake caused the earth to bulge up in the portion of the basement under the sidewalk, rupturing the concrete floor and turning it up on its edge, so that where there had previously been a clear headroom of 7 1/2 feet the highest point of the bulge was within 3 1/2 feet of the beams carrying the sidewalk.
		✱	A	1906	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 31 and 32.	The five-story AETNA Building * * * was built on piles. * * * The basement floor, which was of concrete 7 or 8 inches thick, was pushed up under the sidewalk, reducing the headroom at this point from 8 feet to 3 1/2 feet, approximately. This bulging was probably caused by settling (Pl. XXV, A), as the foundation piling did not extend under the sidewalk. [Pl. 25A shows sidewalk did not subside; adjacent street did.]
		✱	A	1906	Himmelwright, 1906, p. 81 and 84.	YOUNG or SELLER BUILDING. S.W. Cor. Spear and Market Streets. * * * Levels on the water table show that the N. E. and S. W. corners are 3" and 6" lower respectively than the N. W. corner. These facts would indicate that the foundations had moved sufficiently to tilt the entire building to the east. From marks on the curb of the sidewalk, it is also apparent that the surface of the ground settled considerably around the N. E. corner.
		✱	B	1906	Leslie's Weekly, 1906c.	[Picture caption] Surface of Market Street sunk by the earthquake five feet below the curb level.
197		✱	A	1906	Lawson and others, 1908, p. 244.	Appraiser's Building.-- * * * The northwest corner is 0.909 foot = 10.908 inches above the southwest corner. The northeast corner is 0.909 foot + 0.054 = 0.963 foot = 11.556 inches above the southwest corner. The southeast corner is 0.080 foot = 0.96 inch above the southwest corner. The rod was held on top of the water-table at each of the four corners, and the sights were nearly equal in length. The south side of the building is about 11.23 inches lower than the north side. [Because no immediately pre-earthquake measurements are available, it is not certain that all settlement occurred during the earthquake.]
		✱	A	1906	Lawson and others, 1908, p. 236.	Buildings erected upon good foundations withstood the ordeal well, even when the streets around them were deprest and fissured. The Appraisers' Building furnishes a good illustration of this; it is substantially built of brick upon a piling foundation, at the corner of Washington and Sansome Streets, and still stands without significant damage. The levels of its foundation walls were not disturbed.
198		◀	B	1868	Huber, 1930, p. 266.	The shock was principally felt on "made ground" and the flats where the foundation is known to be unreliable at all times. Eastward of Montgomery Street, toward the Bay, there are a number of buildings injured, while some are utterly ruined. Along the old water line of the Bay, running just back of Macondray's old place on the corner of Pine and Sansome Streets, and thence diagonally north-eastward toward the corner of Front and Jackson Streets, something like a slide occurred and buildings suffered severely from the slipping of the made-ground foundations on the old mud bottom of the Bay. This effect is more marked at some points than others; at the old Railroad Hotel on Clay Street, below Sansome, it is more marked than elsewhere.
		◀	B	1868	Huber, 1930, p. 268.	* * * photographs of * * * the rear of the Railroad House, on Clay Street, between Battery and Front, as they appeared after the shock.

TABLE 7.—*Specific descriptions of ground failures in San Francisco City and County—Continued*

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
199		✱	A	1868	Lawson and others, 1908, p. 436.	On Pine Street, near Battery, the cobbles on the south side of the street sank away from the curbstones to the depth of 1 foot in some places; and the asphalt sidewalk on the north side was twisted and torn out of all shape, and its connection with the curb-stone severed.
200		✱	A	1868	Lawson and others, 1908, p. 436.	In many places the made land settled. At the junction of Market and Front Streets, the ground sank for a foot or two, and there was evidence that the tide had risen in the adjoining lot at the same time, for a pond of water collected and remained until low tide.
201		EO	A	1868	Lawson and others, 1908, p. 437.	At the corner of First and Market Streets, the ground opened in a fissure several inches wide. At other places the ground opened and water was forced above the surface.
		✱	A	1906	Himmelwright, 1906, p. 86 and 89.	CROCKER ESTATE BUILDING. S. E. Cor. Mission and First Streets. * * * The levels on the water table show that the N. W. corner and the N. E. corner are 1/2" and 1 1/2" lower, respectively, than the S. E. corner of the building.
202		□	A	1868	Lawson and others, 1908, p. 437.	At Fremont and Mission Streets the ground opened in many places. The general course of damage in the city was along the irregular line of the "made land," or low alluvial soil, where it met the hard or rocky base beneath it. Along the line of the old shore of Yerba Buena Cove, we found the damage to brick buildings much the largest.
		□	A	1906	Lawson and others, 1908, p. 437, plate 146.	The floor of the Pacific foundry was raised about 2 feet in places. The center of Mission Street (opposite Fremont Street) exposed an opening from 8 to 10 inches wide; and openings of the ground were also plainly to be seen on Fremont Street, in the same vicinity. Outside of the immediate district described above, damage to the rest of the city was very meager. * * * the region of greatest agitation was confined to the low portions of the city, or the vicinity of some old creek bed or swamp.
		✱	B	1868	Huber, 1930, p. 267.	The shop of Mr. Garratt, brass founder, near the corner of Mission and Fremont Streets, has been raised to its original position. It was found to have been lowered about eight inches by the recent earthquake.
		✱	A	1906	Himmelwright, 1906, p. 86.	SCOTT BUILDING. S. W. Cor. Fremont and Mission Streets. * * * The S. W. corner of the building is badly racked and cracked by the earthquake.
		✱	B	1865	Huber, 1930, p. 264.	Stoddard's warehouse on Beale Street is said to have been thrown out of place several inches as though it had been lifted up and set down again, while the south side of the building appears to have settled considerably. After the shock, the water rushed into the cellar, or basement, but whether from a disarrangement of the water pipes, or from any fissure in the earth which might have opened, was not known.
		⊗	A	1838	Louderback, 1947, p. 52.	Mr. Spear informed me that during the earthquake of June, '38, before mentioned, a large sand-hill standing in the vicinity of what is now Fremont street, between Howard and Folsom, and between which and the bay at high tide there was a space of about twenty feet, permitting a free passage along the shore to Rincon Point (the coves of which were then much resorted to for picnics and mussel parties), was moved bodily close to the water, so as to obstruct the passage along the shore. After that no one could pass there at high tide, and we were compelled to go around back of the sand-hill, and wade through loose sand to reach that point, a much more laborious walk.
203			A	1906	Duryea and others, 1907, p. 288.	The Folger [sic] Building, on Howard Street, was of brick exterior and wood interior, and was left standing after the earthquake, the fire not having reached it. As was generally the case in buildings of any

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		✱				description, the chimneys suffered and a small portion of the parapet wall, but otherwise the building was not damaged; and yet, at this very site, the street in front of the building had settled about 2 ft.
		✱	A	1906	Himmelwright, 1906, p. 28.	FOLGER BUILDING. S. W. Cor. Howard and Spear Streets. * * * The street level settled about 2 ft. at the northeast corner of the building, but there are no earthquake cracks visible in the walls at this point.
204		✱	A	1906	Hyde, 1906a, p. 705.	The bascule bridge recently erected by the Southern Pacific Company across the San Francisco River, so-called, at the foot of Channel St., near the water front, was seriously crippled by the settlement, to the extent of 4 in., of the east corner of the south abutment.
205			C	1906	Lawson and others, 1908, p. 236, 237, and 238, map 17.	<p>[South of Market zone.] High intensity was developed thruout a small elongate district having a width of about two blocks, which extends from near the corner of Eighth and Mission Streets to the vicinity of Fourth and Brannan Streets; from this point the boundaries are irregular and very sinuous, leading to the water-front at about the crossings of Third Street with Berry and Channel Streets. A glance at the geological Map, No. 17, shows that the regularly bounded portion of this district corresponds very closely with the area of a former tide-marsh, drained and flooded by one or two small tidal streams. The former shore line of Mission Bay was just north of Brannan Street, between Fourth and Fifth Streets, so that the irregular seaward portion of the district lies outside the old shore.</p> <p>This is one of two localities in the city, the other being a "made" land tract along the former course of Mission Creek [loc. 214], in which destructive effects of great magnitude were conspicuously developed. Only in very close proximity to the fault was greater violence manifested. For blocks the land surface, paved streets, and building plots alike, were thrown into wave forms, trending east and west about parallel to the length of the area. The amplitude and wave-length of these earth billows, and the distances to which they extend, are indefinite and irregular. The fissuring and slumping, and the buckling of block and asphalt pavements into little anticlines and synclines (arches and hollows), accompanied by small open cracks in the earth, characterize the land surface. This slumping movement or flow took place in the direction of the length of the area, and its amount was greatest near the center, or channel, where the street lines were shifted eastward out of their former straight courses, by amounts varying from 3 to 6 feet. A satisfactory photograph of this phenomenon was not obtainable, owing to the quick convergence of parallel lines in perspective, but to the observer in the field it was a very striking result of the shock.</p> <p>The greater part of the district was occupied by wooden dwellings and shops, with a small percentage of mediocre brick buildings and a few of substantial construction. The fire swept the area clear. Not even heaps of debris remained to cover the ground, most of the destructive effects being obliterated, along with the structures in which they were developed. Enough remained, however. Foundation walls and sidewalk pavements were broken and flexed; sharp little anticlines were produced in the street by the arching of block paving, as on Russ Street between Folsom and Howard Streets (plate 88C); granite curbing was broken and thrust up into an inverted V, as on Moss Street, between Folsom and Howard Streets (plate 88D); there were fissuring and slumping in the block pavement, as along Columbia Street between Folsom and Harrison Streets (plate 89A), and sharp flexures of the paved streets and car tracks, as on Sixth Street just south of Howard Street [loc. 209]. These effects point simply and clearly to the great magnitude of the intensity thruout the greater part of this old swampy district.</p>
					plate 88C	
					plate 88D	
33					plate 89A	

TABLE 7.—*Specific descriptions of ground failures in San Francisco City and County—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
					plate 89B	<p>Attention has already been directed to the slumping or flow movement to the east along the long axis of the area.</p> <p>The heavily ballasted car-tracks on Bryant Street, at the crossing with Fourth Street, were sharply flexed laterally, tho bounded by block paving. (Plate 89B.) This was at the eastern end of the district where the marsh formerly bent to the south around the flanks of Rincon Hill, a mass of firm sandstone rising from the floor of Mission Valley. No similar sharp flexures were encountered along east-west streets in the western or central portion of the district, tho lateral displacement and flat, sinuous curvings of the street lines were common enough; notably on Harrison Street between Fifth and Sixth Streets, and on Folsom Street between Fourth and Seventh Streets. Both these streets cut across the direction of the flow movement at a small angle. These phenomena are easy to understand if, as seems certain, Rincon Hill served as a solid buttress against which the flow to the east was arrested, causing sharp crumpling of the surface near the buttress, with less disturbance farther away. This was combined with a slight tendency to flow southward in the southeastern part of the district.</p>
					plate 89C	<p>The shaking caused the materials used in filling to settle together and occupy less space, so that the surface over the whole district was lowered by amounts varying from a few inches to 3 feet or more. This is clearly seen in the change of street levels along the margin of the solid ground, where the car rails are bent downward in little monoclines. Occasionally a structure with a relatively good foundation remains at its former level, with the whole neighborhood deprest about it. Such a case is exemplified on Sixth Street, a little south of Howard Street [loc. 209], near the margin of the area. (Plate 89C.) The flow movement is thought to be due simply to the action of gravity, the loose, water-soaked material being compacted into less volume by the shaking. Besides this sinking of the district, and its flow movement, mention has been made of the deformation of its surface into irregular waves, trending approximately east and west parallel with the length of the district. Along the streets running approximately north and south, at right angles to the elongation of the area, car rails were bent abruptly to the side, or raised in arches, and sharp anticlines were formed in the block pavements. Large square concrete slabs, used for sidewalk paving, were thrust one over the other; and in one or two cases a slab entirely covered an adjoining one. These phenomena indicate shortening by compression in the north-south direction. On the other hand, however, a stretching of the surface is shown by fissures in the paving; by places where wedge-like blocks were deprest below the general level; and by the rails of car tracks which were pulled apart in amounts varying from 8 to 12 inches. Owing to the relatively great and very variable structural strength of paved streets and heavily ballasted car tracks, these phenomena are not developed regularly nor frequently enough to afford a satisfactory test of the hypothesis that they are directly associated with the wave forms into which the surface of this district was thrown. Besides owing perhaps to the varying rigidity of the materials which make up the surface of the streets and building plots, the wave forms themselves, tho generally prevalent, are not persistent in their extension. The compression and distension effects, however, are believed to be due to the same cause as that which generated the wave forms; for there is no evidence of any true shortening, or lengthening, of the north-south dimension of this district, nor is there any probability of this having occurred.</p> <p>In addition, then, to the flow movement and the settling together of the loose materials causing depression, there was some sort of rhythmic movement in this loose earth which produced wave forms in the surface, with places of compression and places of stretching. It probably was this movement which was most effective in producing structural damage. It is not believed that these surface waves were traveling waves "frozen" as the shock subsided. If they had been of that character, the ground surface should be more broken than it</p>

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
						<p>appeared to be; for in relatively rigid materials such waves must develop open fissures along the crests, which would close with crushing in the troughs. It must be noted, without any attempt at explanation, that the destructive effects of great magnitude which have been described above, are practically confined to the "made" land which occupies the old marsh site.</p> <p>Southeast of Brannan Street, where formerly lay Mission Bay, such effects are of less magnitude, in general; are less regular in their occurrence and are, on the whole, less prevalent.</p>
	◀	B		1906	<i>San Francisco Chronicle</i> , 1906c.	The Fourth and Sixth street sewers were also greatly damaged, some of them showing a vertical and horizontal movement of as much as five or six feet, and portions will have to be reconstructed.
	✱	A		1868	Lawson and others, 1908, p. 437.	At the corner of Fourth and Bryant Streets, walls were cracked and damaged; Fourth Street near Bryant opened in places and at the crossing of Harrison and Fourth the railroad track settled about 8 inches, the planks between the rails rising about 10 inches.
	✱	A		1906	Himmelwright, 1906, p. 175 and 179.	CALIFORNIA CASKET CO.'S BUILDING. Mission Street, between Fifth and Sixth Streets. * * * The levels on the water table indicate that the northwest corner is about 1/2" lower than the northeast corner.
	✱	C		1906	Hall, 1906, p. 32.	<p>It would be tedious in these articles which the writer is endeavoring to keep within readable limits to catalogue too many dry and hard facts made about hard and soft land, so he does not undertake to trace in detail the outline of the Mission bay and estuary, salt marsh and fresh swamp areas, as these have now again been made evident by the street subsidence and other movements caused by our king shake. The region is a large one. To go slowly step by step around it as we did in the case preceeding [foot of Market area, loc. 193], on foot, as it were, would take too long; so we move rapidly over most of it as in an auto, and, commencing on Townsend street, near the Southern Pacific Railroad yards, we notice a disturbance near Cook street, another in Brannan, near Ritch; another near Harrison and Fourth; another near Folsom and Fifth, and another near Howard and Sixth. We find that by these we may outline on the map the old salt marsh limit as far as the greater impress of the earthquake's heel, which is found in the neighborhood of the new Postoffice.</p> <p>MISSION AND SEVENTH STREET DISTURBANCE.</p> <p>It looks pretty bad on Mission street at and near Seventh, to see the whole street disturbed for about 700 feet in length, to see that this disturbance extended far down Seventh street, and that an area of the adjacent land had sunk.</p> <p>As an American one cannot but feel glad that the new Postoffice building escaped, though barely, being in this area of depression. As a San Franciscan who knew this spot fifty years ago, who saw it a marsh with a little stream running through it, who saw hunters wearing gum boots tramping about shooting jacksnipe in that very area, who later saw it drained for market gardening, and still later saw it filled to a depth of ten or fifteen feet with sand dumped off a bank from side dump cars, and then saw it occupied by light wooden houses for a score and a half of years, it seems entirely natural that a real earnest earthquake should make it settle and move just as it has settled and moved. It never had an inducement to get down to a good bearing before. Now it has been shaken to where it will probably stay, and San Francisco will be the better for it.</p> <p>In the block south and west of the Postoffice this old John Sullivan marsh formerly headed. Its course was toward the east, joining an area of salt marsh which bordered Mision bay. * * * The facts now are that under the earthquake influence the filling over this marshy area has settled at a number of places and to depths of from a few inches to three or three and one-half feet. One of the most pronounced settlements is the one referred to on Mission and Seventh where the</p>

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						subsidence has reached a maximum of about three and one-half feet, as judged by the floor of the Postoffice building and the movement toward the bay, as judged by the street railway track and alignment of the trolley line support poles, has extended for 300 to 600 feet in the length of Mission street, reached a maximum of about five feet at a point 175 feet south and west of Seventh. Platting the limits of this disturbance on the map, they are seen to coincide as near as can be measured with the outline of the old Sullivan marsh as shown by the Coast Survey map of 1857, and as the writer distinctly remembers it to have been.
206		✱	A	1906	Duryea and others, 1907, p. 265.	* * * a number of brick warehouses on the north side of the Southern Pacific Railroad, between Fourth and Sixth Streets, * * * their settlement during the earthquake, with respect to the railroad right of way, just south of them, being about 2 feet.
207		✱	A	1906	Hyde, 1906b, p. 740.	On Fifth St., between Folsom and Harrison Sts., the brick sewer settled with the adjacent land, its crown was destroyed and the channel had become filled with sand which blocked up the sewage to a dangerous extent.
208		✱	A	1906	Lawson and others, 1908, p. 245.	<i>Mint.</i> -- * * * The southwest corner is the lowest, being 0.498 foot = 5.976 inches (mean) below the northwest corner. * * * The deformation indicated by the above measurements can not be wholly referred to the earthquake, since it is quite probable that the structures had settled somewhat before that event. It appears, however, to be desirable to put the measurements on record for future reference.
209		✱	B	1906	Hyde, 1906b, p. 738.	[Picture caption] Settlement on Sixth Street. * * * just south of Howard St. The amount of the drop at the lamp post * * * was fully 2 ft. The sidewalk north of this point and the street at the junction of Howard appears to have settled but very little.
		✱	B	1906	Derleth, 1906b, p. 553.	Fig. 13 shows a drop in Howard St. Where the men are standing a sidewalk on foundations has remained in place. [Picture caption, p. 551] STREET SUNKEN; SIDEWALK IN PLACE BECAUSE ON FOUNDATIONS.
		▣	B	1868 1865	Lawson and others, 1908, p. 438.	A small crevice opened, as in 1865, on Howard Street beyond Sixth Street.
		▣	C	1868 1865	Holden, 1898, p. 76.	1868. October 21; IX. * * * As in 1865, a small crevasse was opened on Howard Street, beyond Sixth.
		▣	C	1868	<i>Sunday Record-Herald</i> , 1906.	Twain Tells Humors of 1868 Earthquake. * * * A crack a hundred feet long gaped open six inches wide in the middle of one street and then shut together again with such force as to ridge up the meeting earth like a slender grave.
		✱	C	1906	Lawson and others, 1908, plate 89C.	[Picture caption] Sixth Street, near Howard. Once occupied by marsh. Street dropt nearly 3 feet. Sidewalk held up by piling foundation of a building. H. O. W.
210	35A 35B 35C		A	1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 97 and 98, plate 62, plate 63, plate 64.	The steel-frame and granite post-office building (Pls. XLII, B; XLIII; XLIV) was carried on isolated grillage foundations, each column having its own footing. The diagonals of the building ran nearly north and south and east and west, the south corner being at Seventh and Mission streets. To the south and west of Mission street was an elongated, narrow, curved area in which the earthquake damage was very severe [see loc. 205]. It was commonly reported that this area, which was

TABLE 7.—*Specific descriptions of ground failures in San Francisco City and County—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						not far from the south corner of the post-office building, was a stream bed or ravine that had been filled within the recollection of the older inhabitants of San Francisco. * * * Mr. Roberts, who is evidently a cool and accurate observer, seemed of the opinion that the material under the building was a natural deposit, and not an artificial fill. But toward the south it was not of a nature to inspire confidence in its carrying power at the depth shown on the foundation plans. He accordingly obtained authority to lower the footings wherever the material at the depth shown on the plans seemed unreliable, so that the footings of the south half of the building were lowered--some of them, as I remember his statements, to a depth of 20 feet or more below the basement-floor level. At any rate, he carried them to a point where the material, in his judgement, was sufficiently hard and compact. All this underlying material is very sandy; but at considerable depths, I understand, gravel appears, and the combination is almost as hard as hardpan.
✱	A			1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 44, plate 43B.	The ground at the corner of Seventh and Mission streets settled about 5 feet (Pl. XLIII, B). The floor of the [Post Office] building was slightly cracked at that point, and Mr. Roberts stated that there was a settling of about 1 3/4 inches.
✱	A			1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 99, plate 43B.	The street went down about 4 or 5 feet at this point [Mission St. in front of the Post Office] as a result of the earthquake (Pl. XLIII, B).
◀	A			1906	Lawson and others, 1908, p. 238.	The new United States Post-office building, (plate 94B), at the corner of Seventh and Mission Streets, was just on the margin of the district [see loc. 205]. It is a steel and granite structure, resting upon a foundation of piling driven to a considerable depth * * *. At its southwest corner, the streets are deformed into great waves, some with an amplitude of at least 3 feet, causing fissures and sharp compressional arches in the pavement and sidewalks. Some of the granite flanking structures, which did not rest upon the pile foundation of the building, shared this undulatory movement.
✱	A			1906	Lawson and others, 1908, p. 244.	<i>New Post-office.</i> -- * * * The southwest corner is the lowest and is the only one that settled materially, being about 0.393 foot = 4.72 inches lower. The outer walls have cracks in many places. This is a fairly good showing for a bad foundation. [Because no immediately pre-earthquake measurements are available, it is not certain that all settlement occurred during the earthquake.]
◀	A			1906	Lawson and others, 1908, plate 94B.	[Picture caption] San Francisco Post-office, Mission and Seventh Streets. Near corner of building is on edge of old marsh. Ground over marsh sank and lurched.
◀	A			1906	Hyde, 1906b, p. 737.	[Picture caption] At the corner of Mission and Seventh Sts. The ground is a loose fill and settled considerably, while Mission St. has apparently been thrown to the southeast at this point at least 2 ft.
◀	A			1906	Jordan, 1907, p. 154.	[Picture caption] Fig. 27--General Postoffice, Southwest Corner, Showing Severe Distortion and Subsidence of the Sidewalk and Street Levels.
◀	A			1906	Davidson, 1906, p. 181.	* * * on the "filled" in land near the new Post Office, the building, piled upon a clay foundation, suffered but little, while the street in front, made upon twenty-three feet of sand over a marsh, sank two feet and slid out from the building about one and one-half feet.
	A			1906	Duryea and others, 1907, p. 288, plate 38.	The Post Office Building * * * was on piles * * * and the earthquake wave motion moved through this forest foundation, following and developing lines of least resistance, with consequent promiscuous racking all over the building. At the four corners the cracks were most pronounced * * *.

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		✱ ◀	A	1906	Himmelwright, 1906, p. 192.	UNITED STATES POST OFFICE. N. W. Cor. Seventh and Mission Streets. * * * At the southwest corner, the ground settled about 2 ft. at the building line and about 5 ft. at the curb, the entire surface from the building line moving out about 5 ft. to the south. This distorted the sidewalk and steps of the two entrances, there being cracks in the joints of the cement sidewalk slabs 8" wide. It was necessary to place two temporary wooden steps of about 8" rise from the sidewalk in its settled position to that portion of the steps which remain approximately at the original height.
		✱ ◀	A	1906	Himmelwright, 1906, p. 193.	[Picture caption] UNITED STATES POST OFFICE. Northeast Corner of Seventh and Mission Streets. At the curb in front of the building, on the right-hand side, the ground settled 5 feet and moved to the east away from the building about 6 feet. At the building line, the ground settled about 2 feet, causing the displacement of the granite coping, steps, etc., at the sidewalk level, as shown. The sidewalk was originally a straight grade on the right-hand side where the sag is now shown. The northwest corner of the building was badly racked by the earthquake, and temporary shores were in position when the photograph was taken. This building was only slightly damaged by the fire.
		✱ ◀	A	1906	Hyde, 1906a, p. 701.	United States Post Office.-- * * * The effect of the earthquake throughout this vicinity has been most marked. Streets in this neighborhood have settled very considerably and the sidewalk has also seriously sunk. Mission St., at the corner of 7th, has been thrown bodily southward to the extent of at least two feet. It is evident that the building itself settled slightly, inasmuch as serious cracks were developed on the granite facing at the southwest, northwest, and the northeast corners, and these cracks presumably extend into the brickwork.
			A	1906	Derleth, 1906a, p. 503.	The magnificent Post Office building, corner of Mission and Seventh Sts., rests upon sand, and under one end of it at one time ran an old creek bed. This building rests upon piles and heavy concrete walls, but has been badly cracked due to the severe convulsion of the ground. It has been unharmed by the fire, but will need extensive repairs.
211		◀	B	1906	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 99, plate 62B.	* * * there was a partially erected steel frame (Pl. XLII, B) on the southwest side of Seventh street, near the post-office. Before the earthquake all the columns were plumb and in true alignment. As a result of the shock there was a lateral shifting of the column bases--the relative movement being almost 2 feet in some places--at the cellar-floor level. The basement walls of the incomplete building were also shifted horizontally; at the east corner, where the walls had met at a right angle, they had been ruptured by a vertical crack and moved laterally in such a way that the angle between them was reduced to about 75° * * * .
212		✱	C	1906	<i>Los Angeles Herald</i> , 1906.	[Picture caption] This remarkable photograph shows how Mission street, San Francisco, sunk away from the curb to a depth of five feet. The postoffice is located one block north, where the ground was upheaved to a height of several feet. In this area of "made" ground houses were completely overturned and in several instances sank for considerable distance below the level of the street.
		◀ ✱	A	1865	Lawson and others, 1908, p. 449.	On the marshy lands in the vicinity of Howard and Seventh Streets the ground was heaved in some places and sank in others. Lamp-posts were thrown out of perpendicular, gas-pipes were broken, etc.
		◀ ◻	B	1865	Holden, 1898, p. 66.	1865. October 8; IX; * * * On the marshy lands in the vicinity of Howard and Seventh streets, lamp posts, water pipes and gas pipes were broken and thrown out of position. The ground on Howard Street, from Seventh north to Ninth, cracked open, leaving a fissure nearly an inch wide.

TABLE 7.—*Specific descriptions of ground failures in San Francisco City and County—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
213		☒	C	1906	Lawson and others, 1908, p. 229.	The blocks between the old tide-marsh area, extending east from near the Post-office [loc. 205], and the former course of Mission Creek [loc. 214], give evidence in the form of cracked foundation walls, broken concrete cellar floors, etc., of intensity values high in Grade C.
214			A	1906	Lawson and others, 1908, p. 238 and 239.	[Mission Creek zone] As stated briefly above, a similar district [loc. 205] of high intensity occurs in an area of made land along the lower portion of the former course of Mission Creek. This district varies in width from 1 to 2 blocks, extending from near the corner of Ninth and Brannan Streets westward for about 3 blocks, then southward for about 2 blocks more; and finally, westward some 4 blocks more to a point on Nineteenth Street just east of Dolores Street. Mission Creek was formerly a sinuous tidal stream, with narrow fringes of salt marsh about its banks. Near its mouth the stream wound around a rocky point where the serpentine hills of the Potrero rose abruptly from its southern bank. Here along its margin, is found the most sudden transition from high to low intensity that is anywhere encountered in the city. Along Dore Street, a narrow alley running from Bryant Street to Brannan Street, between Ninth and Tenth Streets, the street pavement was broken into a series of waves. The photographs, plate 89D, looking along Dore Street from Bryant toward Brannan Street; plate 90A, looking from Brannan Street in the reverse direction; and plate 90B, showing in detail the trough of one of these waves, with the fissuring of the pavement near the farther crest, indicate more clearly than words the great intensity manifested here. Less than 2 blocks south on the hill slopes, more than 50 percent of the chimneys were left standing, and no serious structural damage was noted. No comment seems needed to establish clearly the fact that the change in the character of the ground, this being the only variable factor, is in some way the cause of the change in the degree of intensity.
38A						
38B						
38C						
		◀			plate 89D plate 90A plate 90B	
39A						
39B						
40D		◀			plate 91A	On Ninth Street, east of Dore Street, between Bryant and Brannan Streets, the block pavement was badly damaged by fissuring, slumping, and the formation of surface waves. Frame dwellings were thrown from their underpinning, and a few collapsed. Plate 91A shows a wave trough near Bryant Street, with the resulting disturbance of the pavement. The dwellings immediately in the trough have dropt from their foundation posts. In Plate 91B, looking along Ninth Street from near Brannan Street, is shown the depression and fissuring of the street and its slumping or flow westward toward the former channel of a short branch of Mission Creek, which occupied the present location of Dore Street. Streets, curbing, car tracks, etc., are deflected from 6 to 8 feet from their former positions. The frame dwellings were not destroyed, but a careful examination of the picture will show that most of them are badly injured. Many were left in a dangerous condition by the shock.
40A					plate 91B	
40B						
40C						
41		◀				On Tenth Street, between Bryant and Brannan Streets, less violence was noted and the slumping of flow eastward (toward the channel of the little branch of Mission Creek) is scarcely noticeable.
		◀				
			C	1906	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 26.	As in districts outside of San Francisco, the greatest damage was done to those structures having insufficient foundations built on soft alluvium or filled ground. The settling of the ground in the mud flats along San Francisco Bay and of the filled ground in old water courses was accompanied with great destruction. It was in such ground that the greatest number of breaks occurred in the cast-iron gas and water mains and the sewers. The breaks in the sewers were not so evident as those in the gas and water mains, for the reason that the latter were under pressure and breaks in them resulted in breaks in the streets themselves. The most noticeable destruction resulting from the settling of soft or filled ground occurred in Howard [now South Van Ness] and Shotwell streets between Seventeenth and Eighteenth streets [loc. 215], Bryant street between Ninth and

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
					plate 6A	and Tenth streets, Dore street between Bryant and Brannan streets (Pl. VI, A), and at the corner of Seventh and Mission streets [loc. 210]. The settling was greatest in Howard, Dore, and Bryant streets, being in Dore street at least 5 feet.
		✱				
			A	1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 8, plate 5, plate 6B.	The filled districts of San Francisco afford several examples, and two of these are illustrated by Pls. V and VI, B. The view shown in Pl. V is northwestward on Ninth street, near Brannan. Before the earthquake the car tracks and curb line were straight and approximately level, and this condition was not disturbed on the relatively firm ground shown in the distance. In the nearer part of the view the street crosses a tract of made ground created by filling a valley tributary to a narrow tidal inlet called Mission Creek. The descent of this valley was southwestward, and the made ground flowed in that direction, carrying street and buildings with it. In taking the photograph reproduced in Pl. VI, B, the camera stood on ground made by the filling of Mission Lagoon, an expansion of Mission Creek, and was pointed northward, commanding a portion of Howard street [loc. 215]. The made ground here flowed northeastward and the buckling of street-car tracks was caused by its motion. Where the same earth flow crossed Valencia street [loc. 216] the horizontal movement amounted to 6 feet.
404		◀				
43		◀				
		◀	B	1906	<i>San Jose Mercury</i> , 1906c.	[Picture caption] Twelfth [17th ?] and Mission Streets. The sidewalk was torn open here. [See also loc. 217.]
		◀	A	1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 9, plate 6A.	Another example of the effect on the filled-in land in this part of the city is shown in Pl. VI, A, a view of Dore street between Bryant and Brannan streets. The settling of the soft ground caused the street to drop at least 5 feet at this place.
		✱	A	1906	Gilbert, Humphrey, Sewell, and Soule, 1907, plate 56.	MAP OF SAN FRANCISCO SHOWING BURNED DISTRICT; [This map also shows "Principal earthquake breaks in streets." The locations of these breaks have been plotted on Plate 3.]
		◀	B	1906	Hyde, 1906b, p. 739.	The most important local settlements and transverse movements occurred in the vicinity of the Valencia Hotel between 18th and 19th Sts., on Valencia St. [loc. 216], on Howard St. between 17th and 18th [loc. 215]; on 14th, between Mission and Howard [loc. 214]; on Folsom, at the corner of 17th [loc. 215]; on Mission, at the corner of 7th [loc. 210], and on Van Ness Ave., between Vallejo and Green Sts. [loc. 221].
215		✱	A	1906	Hyde, 1906b, p. 740.	On Howard St., at the corner of 17th St., very complete destruction of the brick sewer, as well as most other pipes and conduits in the ground, was caused by the extensive settlements in this region. On Valencia St., near 18th St. [loc. 216], similar ruptures were produced.
44			A	1906	Lawson and others, 1908, p. 239, plate 92B, plate 93A, plate 90C.	Again, along the creek bed from Folsom Street, between Seventeenth and Eighteenth Streets, to the vicinity of Valencia Street at Eighteenth, great destruction was conspicuously prevalent. * * * The south side of Howard Street, between Seventeenth and Eighteenth Streets * * *. As in other places, the streets were deprest, fissured, and thrown into waves. Car rails were arched and bent laterally in a violent fashion.
45		◀				
43						
46		◀	A	1906	Lawson and others, 1908, plate 90C.	[Picture caption] Eighteenth Street, just east of Shotwell. Fissuring and depression of pavement. H. O. W.
47		◀				
		◀	A	1906	Derleth, 1906b, p. 554.	Fig. 20 shows a street view, taken April 25, at the corner of Howard and Seventeenth Sts., where the ground was much distorted. The car tracks are twisted out of shape, the brick sewer is broken and the water and gas pipes are wrenched and snapped.

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
				B 1906	Himmelwright, 1906, p. 18.	<p>[Picture caption] RESIDENCES. Howard Street near Seventeenth Street. The upper view shows two buildings that have been tilted badly out of plumb by the earthquake. The rear portions of the buildings settled about 10 feet. The telegraph poles are approximately plumb. Note the building on the right, the corner of which has broken into the side of the tilted one.</p> <p>The lower view shows Howard Street, looking west. The front of the two buildings shown in the upper view are approximately in the centre. One building near the left-hand side has tilted away from the street line until it almost disappears.</p>
216	48A 48B		A	1906	Hyde, 1906b, p. 739.	<p>The most important and interesting case of settlement and throwing out of alignment of streets in San Francisco, due to the vibrations of the temblor, was that of Valencia St., between 18th and 19th Sts., in the Old Mission district. At this point there was formerly a tidal stream, known as Mission Creek, whose existence had long since ceased owing to the fact that its course had been filled in and the land so reclaimed had become thickly built up. The earthquake caused a settlement of from 6 to 8 ft. for a distance of from 150 to 200 ft. along this street, and at the same time shifted the entire street, with adjacent lands, eastward through a maximum distance of 9 to 10 ft. This change in alignment and grade could, of course, mean nothing less than the entire destruction of all water and gas mains, electric lighting and telephone conduits, sewers, cable conduits, railroad tracks, etc. The breakage of these important lines, especially to the water mains, was of greatest significance. In this case the destruction of the water pipes, of which a 28-in. and a 16-in. were found in this street at this point, meant the cutting off of a large part of the water supply of the portion of the city which was soon to be in flames.</p>
		A	1906	Lawson and others, 1908, p. 239, plate 93B.	<p>At Eighteenth and Valencia Streets there was a serious break in the water-pipe. Here, on both sides of the street, the ground sank about 6 feet, causing the roadway to arch in a very noticeable way. Ten-inch car rails were bowed up into arches from 24 to 30 inches in height. The Valencia Street Hotel collapsed so that occupants of the fourth story could step out into the street. Casualties in this district can never be known accurately, owing to the immediate onset of the fire, and the complete devastation it produced.</p>
		C	1906	Duryea and others, 1907, p. 214.	<p>In filled-in tidal areas, marsh-lands and swamps there was considerable movement in a number of places (the greatest near 16th St. [18th St.?] and Valencia St., where the settlement was 5 ft. and the lateral movement 6 ft.) and in all such disturbed areas the sewers were destroyed.</p>
		A	1906	Schussler, 1906, p. 43.	<p>APPENDIX D. The following are extracts from the report of City Engineer Woodward on the breaks in the San Francisco sewer system caused by the earthquake as published in the "San Francisco Chronicle" of June 17, 1906: * * * "On Valencia street, between Eighteenth and Nineteenth streets, there was a lateral movement to the east, with a maximum of six feet and a subsidence with a maximum of five feet. This occurred in made ground over the old Willows marsh, one of the tributaries of Mission creek."</p>
			B	1906	Derleth, 1906b, p. 551.	<p>The Valencia Hotel, it will be remembered, was situated on Valencia St., near 18th, on filled ground, where once ran the old Mission or Islais Creek. The Valencia Hotel and other cheap brick and frame buildings in that region from Valencia to Howard Sts. very generally collapsed. Many lives were lost in the Valencia Hotel.</p>
		B	1906	Derleth, 1906c, p. 581.	<p>[Figure caption] STREET SUBSIDENCE IN SAN FRANCISCO. VIEW ON VALENCIA ST., NEAR 18TH ST., OPPOSITE SITE OF VALENCIA HOTEL. (It was at this place that street water mains were broken. The street dropped about 4 ft. and moved eastward about 6 ft. at the maximum point.</p>

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
	✱	B		1906	<i>San Francisco Chronicle</i> , 1906a.	[Picture caption] Ruins of the Valencia Street Hotel, showing the depression in the street. This is the best photograph of the effect of the earthquake itself yet published.
	✱	B		1906	<i>Los Angeles Daily Times</i> , 1906b.	[Picture caption] Valencia Hotel, San Francisco, in which forty people were killed.
	✱	B		1906	<i>Los Angeles Daily Times</i> , 1906b.	[Picture caption] San Francisco Flats Sunk One Story Into the Ground by Earthquake. Great Fissures in Street. photo by H. C. Carr. On the corner next the Valencia was a new set of three story flats, just completed, and most of the flats not yet occupied. As though someone had struck it on top with a giant hammer, the entire building had sunk one story into the ground; you could walk right in at the second story.
	◀	A		1906	<i>The Evening Wisconsin</i> , 1906.	BIG CREVASSE IN STREET. At Eighteenth and Valencia there is a crevasse in the street six feet wide and entire sidewalks are torn up. The street car tracks are badly twisted all through the southern section of the city and traffic is at a standstill.
	✱	A		1906	Schussler, 1906, p. 30.	* * * the College Hill Reservoir * * * had been emptied of its contents 11,400,000 gallons, which it contained at 7 A. M. April 18, by its main arterial pipe, 22-inch diameter, and its companion pipe, 16-inch diameter, both on Valencia street, having both been torn off and destroyed between Eighteenth and Nineteenth streets by the sinking of Valencia street of from one to five feet.
	✱	A		1906	Hall, 1906, p. 32.	VALENCIA STREET SUBSIDENCE. A number of lesser footmarks of our earthquake are to be seen in the street between Seventeenth and Eighteenth and east and south of Mission. These all coincide with the irregular limits of our indicated specially soft spots in the former salt marsh area, and we follow them around until we come to another pronounced case of subsidence and slip, which is noticeable in Valencia street between Eighteenth and Nineteenth, in Mission between Seventeenth and Eighteenth and in Howard from Seventeenth and Eighteenth. Valencia street shows subsidence of one to five and a half feet and slip of one to six feet for 450 feet in length; Mission shows very slight subsidence and slip of only about one foot for about 400 feet in length, while Howard shows a subsidence of two to three feet for over 500 feet in length and a maximum slip of about four feet. The limits of the movement, platted on the map, exactly outline the ravine in which was formerly headed, between Mission and Valencia, "The Willows," a San Francisco place of resort. The whole area was in those days moist land, with a little stream in it for a part of each year, and which has been filled upon between hard hillsides. Being soft beneath and on a down-grade in the line of greatest earthquake vibration, the temblor found in it an easy mark for a pronounced demonstration. Again, at its head between Valencia and Guerrero a side ravine came down from the south. The slip across Nineteenth street of about six and a half feet, as shown by bowing of the line of curbing, outlines the branch of the old depression, which was filled on a steep gradient and quite naturally slid easily. [See loc. 217.]
	✱	A		1906	Rickard, 1906b, p. 287.	Valencia Street has sunk 8 to 10 feet * * * . Down 18th street also, from Valencia to Howard [now South Van Ness], the ground has sunk on the north side along the center of the cobble-paved roadway and there is a crack 12 to 15 inches wide along the line of rupture. Neighboring houses show the effects of disturbance. Evidence of a similar kind is obtainable elsewhere in this vicinity and it is noteworthy that the belt of deranged buildings and dislocated roadways follows exactly the line of the filling over the old creek.
	✱	A		1906	Schussler, 1906, p. 35.	One of the most serious breaks in the main pipe lines was caused by the earthquake shaking and settling down, by from one to five feet, the region between Eighteenth and Nineteenth streets, on Valencia street. Here an old swamp had been loosely filled in, many years ago, by any and all kinds of material and rubbish obtainable, the fill being twenty feet or more in depth.

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
217	50		A	1906	Lawson and others, 1908, p. 239, plate 94A.	On land made by filling in, "The Willows," a marshy tract formerly extending up the Eighteenth Street Valley from Mission Lagoon, near the corner of Nineteenth and Guerrero Streets, there was observed a considerable slumping or flow movement of the surface. The photograph (plate 94A) shows the Youth's Directory, a charitable institution for boys, where the street and building were moved northward and slightly eastward, toward the former channel and downstream, fully 6 feet.
218			B	1906	Lawson and others, 1908, p. 240, plate 90D.	Near the corner of Waller and Portola Streets, not far north of the head of Market Street, is a locality, less than a block in extent, where houses were shifted slightly on their foundations; their upper stories were moved farther eastward (downhill) than the foundations * * *. Here a thin layer of sand reposes upon the slopes of a little upland valley between the low serpentine hills to the east and the high chert hills to the west. The effects are such as would be produced by a shaking downhill of this thin sand layer, with the structures which rest upon it.
219			B	1906	Jordan, 1907, p. 123.	STREET AND SURFACE DEFORMATIONS Great distortion of the surface was best observed in the streets, and was found on the filled areas and in some places, on the sand dunes. The best localities for observation were: * * * (5), Van Ness Avenue at Eddy Street; [Complete quotation under note 3 table 3.]
220			A	1906	<i>The Argonaut</i> , 1906.	[Picture caption] Point at corner of Van Ness and Pacific Avenues, San Francisco where the fire broke out again, leading to the destruction of North Beach. [Picture shows a crack in the sidewalk with some subsidence.]
221	52		A	1906	Lawson and others, 1908, p. 231.	At the corner of Vallejo Street and Van Ness Avenue, fissures were formed in the asphalt paving, sidewalk pavements were thrust over the curbing, and water-mains and sewers were broken. Buildings were thrown out of the vertical, and foundations and lower story walls were shifted and crushed. The walls about the foundation of one brick building were actually deformed into undulations with much consequent cracking. This building was so badly damaged that it had to be taken down. Surrounding this corner is a small ovoid district, about 2 blocks in extent, in which the intensity was clearly of grade B. This was once a sharp ravine and had been filled to a depth of 40 feet in order to provide a suitable grade for streets and buildings. The filling was shaken together and moved slightly downhill.
		B	1906	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 118, plate 56.	At one point on Van Ness avenue (see B, Pl. LVI), where I happened to see the mains uncovered, a heavy water pipe, apparently about 20 inches in diameter, had been broken into pieces not more than 2 feet long. The total length of the break, however, was not more than 40 or 50 feet, so far as I could judge from what I saw uncovered.
		B	1906	Schussler, 1906, p. 43.	APPENDIX D. The following are extracts from the report of City Engineer Woodward on the breaks in the San Francisco sewer system caused by the earthquake as published in the "San Francisco Chronicle" of June 17, 1906 [p. 34]: "The vicinity of Van Ness avenue and Vallejo street is one of the prominent points of interest. It was found that Van Ness avenue had been more or less affected from a point 150 feet south of Vallejo street to Union street, the greatest subsidence being two feet at the crossing of Vallejo street. There was also subsidence of Vallejo street for 150 feet on each side of Van Ness avenue. There was a lateral movement to the north on Van Ness avenue of about three feet on Vallejo street, decreasing to

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						about one foot at Green street, the ground and buildings upon it having been moved bodily so that now the buildings encroach upon the neighboring lots or upon the street. As a result of the subsidence and lateral movement the sewers extending east, south and west of the crossing of Van Ness avenue and Vallejo street were broken for about 150 feet. The scene of the disturbance was an old fill of about forty feet which had been made years ago in the ravine leading to the northwest to the lagoon formerly called Washerwoman's bay." [All of the information relevant to ground failure occurrences in the Chronicle report is contained in this extract by Schussler.]
		B	1906	<i>Oakland Tribune</i> , 1906c.	* * * VAN NESS AVENUE. In no portion of San Francisco is the vagaries of the temblor registered as on Van Ness avenue. Down towards the bay the houses facing on this beautiful boulevard have been twisted like corkscrews, and the pavement is filled with gaps several feet wide and many feet deep.
		B	1906	<i>Leslie's Weekly</i> , 1906e.	[Picture caption] A mark of the earthquake in Van Ness Avenue.
222	53		A	1906	Lawson and others, 1908, p. 232, plate 88B.	A portion of Union Street, between Pierce and Steiner Streets, not more than a quarter of a block in length, where a filling had been made to equalize the street grade, was shaken down into the adjacent building lot on the north. The north sidewalk was shifted about 10 feet to the north, and deprest about 10 feet below its original level. The south sidewalk was deprest a few inches and shifted to the north from 2 to 3 feet. The paving and the cable conduit suffered more severe damage than at any other point in the city. * * * The phenomena have no general significance, however, despite their striking character, being merely a sliding of unconsolidated material not supported on the sides.
			C	1906	<i>Oakland Tribune</i> , 1906c.	Near Union Street the bitumen has been converted into a series of waves. Closer to the military reservation the effect of the shake upon the earth is even more apparent. Several grades were distinctly changed.
223			A	1906	Gilbert, Humphrey, Sewell, and Soule, 1907, p. 27.	The group of buildings comprising the plant of the San Francisco Gas and Electric Light Company, built on the soft ground along San Francisco Bay just west of Fort Mason, was badly shaken, and none of the buildings escaped damage. * * * The ground settled very considerably under the vibrations of the earthquake, and further destruction was caused by the unequal settling of the building.
224			B	1868	Lawson and others, 1908, p. 438.	On the beach at the foot of Webster Street, below high-water mark, a fissure opened, extending lengthwise with the water.
225			C	1868	Lawson and others, 1908, p. 438.	A large fissure was made in the high bank near Fort Point and the shock was felt severely at the Fort.
226			A	1906	Lawson and others, 1908, p. 232.	On Fulton Street, between Twelfth and Thirteenth Avenues, there was much slumping of the street-filling down into the Park adjacent; and exactly the same sort of damage occurred on H Street, between Ninth and Fourteenth Avenues. * * * They were especially susceptible to damage from earthquake shock, being practically loose earth embankments.
		C	1906	Lawson and others, 1908, p. 233.	All driveways in the western part of Golden Gate Park showed scattered narrow fissures.

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
		■	C	1906	Fallows, 1906, p. 313.	[Picture caption] CRACK IN THE EARTH. This photograph shows a crack in the earth in Golden Gate Park, San Francisco, caused by the earthquake.
227		●	B	1906	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 30.	At the bottom of Strawberry Hill is a bridge crossing over Stow Lake. This bridge is made of concrete, and showed no signs of cracking, although the banks of the lake slipped into the water.
228		■	A	1906	Lawson and others, 1908, p. 232 and 233.	Strawberry Hill, in Golden Gate Park, is a chert knob rising abruptly in the sand wastes. * * * The whole periphery of the hilltop was broken into a series of concentric blocks or steps, and the outer ones moved down the hill from 2 to 3 feet. The artificial stone work was badly cracked and dislodged. These phenomena indicated that the material used in grading the upper slopes had settled somewhat, with consequent rupture of the surface and wrecking of the building.
		■	A	1906	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 29 and 30.	The most interesting structure in Golden Gate Park is the cyclorama (Pl. XXIII, A), on the top of Strawberry Hill, built about fifteen years ago. The top of the hill had been leveled off in order to form a foundation. * * * The settling of the foundation of fill under the vibration of the earthquake caused the structure to collapse. The slip (Pl. XXII, B) occurred principally on the north-east side, the movement being 4 or 5 feet. The principal crack in the base was about 11 inches wide, with a half-inch horizontal crack leading from it along the reinforcement. The floor is in good condition, except the pavement, which broke into blocks * * * .
229		●	A	1906	Gilbert, Humphrey, Sewell, and Soulé, 1907, p. 115.	Within the city proper the reservoir known as Lake Honda was damaged by the cracking of its concrete lining. It is reported that this cracking was due to the displacement of a retaining wall by a sliding bank set in motion by the earthquake.
		●	A	1906	Duryea and others, 1907, p. 249.	The slope, on the west side consisting of very sandy soil, was supported by a retaining wall which constituted the side of the reservoir basin. * * * The effect of the shock was to rupture this retaining wall, which failed by shearing near the bottom of the reservoir, although irregular cracks in one place extended to the top of the wall.
		●	A	1906	Schussler, 1906, p. 33.	Lake Honda Reservoir, * * * was injured by the earthquake cracking the heavy western wall, the shock coming from the west and shaking up a sandy mountain, about 100 feet high, causing the slope to slide down towards the wall.
230		▶	C	1906	Lawson and others, 1908, p. 231.	Ocean Avenue, between Ingleside and the sea, tho almost devoid of structures, shows by the unearthing, bending, and even breaking of drainage and water pipes, and by fissures in the road and asphalt paving, a change of intensity from Grade C to Grade B.
231		■	B	1906	Lawson and others, 1908, p. 231.	Near Lakeview, fairly well built frame buildings on dune sand of unknown thickness were caused to lurch and shift their positions.
232		■	B	1957	Bonilla, 1959, p. 34.	Landslides occurred at about a dozen different places along the shore of Lake Merced, and most, if not all, involved artificial fill. The width of the slides ranged from 75 to 300 feet and one series of slides extended along the lake shore for 800 feet. The slides produced scarps that were about 10 feet high. In many of the slides that affected the

TABLE 7.—*Specific descriptions of ground failures in San Francisco City and County—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						highway along the lake shore the pavement was rotated so that it dipped away from the scarp rather than toward the scarp as is normal in slump-type landslides. Very little debris from these slides was visible above the level of the lake a few hours after the earthquake. These two conditions support the interpretation that the sliding was in the nature of a flow and that the material spread out on the lake bottom. The material in the scarps was mostly uncompacted artificial fill made up of clean, loose, well-sorted sand which, because it was on the shore of the lake, must have been saturated. This sliding probably was of the type called sand-flow, which results from spontaneous liquefaction of sand.
233		✱	A	1957	Steinbrugge and others, 1959, p. 103.	At the Lake Merced Pump Station in San Francisco, a filled area settled 4 to 6 inches, severing a 12-inch pipe from the station.
234		●	A	1957	Bonilla, 1960, p. 6.	Table 1. Landslide number 11; slump in soil; 60 feet long and 150 feet wide.
235		●	A	1957	Bonilla, 1960, p. 6.	Table 1. Landslide number 10; slump in soil; 100 feet long and 100 feet wide. Also Landslide number 9; slump in soil; 60 feet long and 125 feet wide.
236	54	◀	A	1957	Bonilla, 1960, p. 6.	Table 1. Landslide number 8; slump in soil and sand flow; 100 feet long and 800 feet wide and consisted of several coalesced slides.
		◀	A	1957	Bonilla, 1960, p. 21, fig. 4.	Slide 8, shown on figure 4, probably started as a sand flow, but removal of support by the flow resulted in slump failure near the head of the landslide.
237		◀	A	1957	Bonilla, 1960, p. 6.	Table 1. Landslide number 7; sand flow and slump in soil; 80 feet long and 225 feet wide.
238		◀	B	1906	Lawson and others, 1908, p. 387.	A * * * sudden movement of the ground occurred on the west side of Merced Lake, whereby a large section of the slope sank toward and into the lake, and a portion of the bottom of the lake was lifted above the surface by the deformational rotation of the collapsed ground.
		◀	B	1906	Lawson and others, 1908, p. 251.	Just south of the bridge across Lake Merced, a sand-bar was forced up out of the lake, from water that was previously 6 or 8 feet deep. This bar is parallel to the west bank of the lake, and has a direction almost due north and south. This was probably caused by the same thing that wrecked the bridge; that is, the displacement and settling of the west bank of the lake at the time of the earthquake.
		●	A	1957	Bonilla, 1960, p. 6.	Table 1. Landslide number 4; slump in soil; 110 feet long and 200 feet wide.
239			A	1906	Lawson and others, 1908, p. 251.	<i>Lake Merced.</i> --About 6 miles north of Mussel Rock, where the Merced beds disappear under aeolian sands, the disturbance seems to have been quite violent. An old railroad trestle, that crosses the northern end of Lake Merced in the narrowest place, was badly wrecked. This

TABLE 7.—Specific descriptions of ground failures in San Francisco City and County—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
						bridge was broken in two places, and the intermediate piece was out of line with both ends. The direction of the offsets was very nearly due north and south. At one break the west piece was shoved 12 or 14 feet past the other section. The west end of the intermediate piece failed to join the section at the west bank by 6 or 7 feet. The west section that remained with the bank was from 4 to 5 feet lower vertically than the intermediate piece. The trestle was old, built of heavy timbers on a sharp curve, and not in use, which will in part account for its destruction. The swaying of this bridge destroyed a section of it 50 to 60 feet long. On the hillside where this trestle reaches the west bank of the lake, cracks parallel to the shore line suggest the cause of the destruction of the bridge. The displacements here are larger than any along the main fault line, and it is apparently entirely local, due to the slipping and settling of the west bank of the lake.
			A	1957	Bonilla, 1960, p. 6.	Table 1. Landslide number 3; slump in soil; 100 feet long and 100 feet wide.
240			A	1957	Bonilla, 1960, p. 6.	Table 1. Landslide number 2; debris slide; 100 feet long and 150 feet wide.
241			A	1957	Bonilla, 1960, p. 6.	Table 1. Landslide number 1; debris slide; 75 feet long and 80 feet wide.
242			A	1957	Bonilla, 1959, p. 34.	In addition to the failures along the roadway at the shore of Lake Merced, the failure of the artificial fill at the north end of the foot-bridge crossing the north arm of the lake also was probably caused by sudden liquefaction of sand. Some of the slides along Lake Merced were of the slump-earthflow type and displayed a backward rotation of the component blocks. These slides may have been caused by removal of support by sudden liquefaction of sand at the foot of the slope.
			A	1957	Bonilla, 1960, p. 6.	Table 1. Landslide number 5; sand flow; 70 feet long and 80 feet wide. Landslide number 6; slump in soil and earthflow; 125 feet long and 120 feet wide.
			A	1957	Bonilla, 1960, p. 21.	Slide 5 is an example of this type of landslide. It severed the artificial embankment north of the footbridge that crosses the north arm of Lake Merced, as shown on figure 3. The exact dimensions of the slide deposit could not be determined because it was under water but about 80 feet of the embankment was destroyed. The vegetation displaced by the slide is visible on air photos taken four months after the slide. Measurements made on the photos show that the vegetation on the sides of the embankment moved at least 70 feet both eastward and westward from the original shoreline of the embankment. The material visible in the north end of the embankment was artificial fill composed of clean sand, and as a large deposit of dune sand is found a short distance north of the site, it is probable that all of the embankment was clean well-sorted sand obtained from the dunes. The slope of the embankment above water was on the order of 20°, and under water was presumably less. The earthquake vibrations probably liquefied the saturated sand at the base of the embankment and the unsupported embankment collapsed and spread over the lake bottom.
243			B	1906	Lawson and others, 1908, p. 241.	On Ocean Avenue and X Street, near where the former outlet of Lake Merced flowed, fissures were developed in the street and in the sands on either side, and water was squeezed out so as partly to flood the roadway. Drain pipes were unearthed and bent or twisted.

TABLE 7.—*Specific descriptions of ground failures in San Francisco City and County—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
244			C	1852	Townley and Allen, 1939, p. 28.	1852 November 22. 11 p.m. VIII. Near San Francisco. Severe shock eight miles southeast (?) of San Francisco. Next morning a fissure half a mile wide and three hundred yards long was discovered, through which the waters of Lake Merced were flowing to the sea.
	C	1852	Coffman, 1973, p. 156.	1852. November 22 to 24. San Francisco Peninsula. This shock was severe 8 miles southwest of San Francisco. Apparently, considerable fissuring occurred from Lake Merced to the sea.
	C	1852	Holden, 1898, p. 39.	1852. November 22; 11 p. m.; VIII. Severe shock eight miles south- east of San Francisco. Next morning a fissure half a mile wide and three hundred yards long was discovered, through which the waters of Lake Merced were flowing to the sea.
	C	1852	Soulé, Gihon, and Nisbet, 1854, p. 408.	November 23d.--The waters of Lake La Mercede, in the vicinity of the city, and which cover several hundred acres, sank about thirty feet. Shortly before midnight of this day, a shock like that of an earth- quake was felt by parties residing near the place; and the following morning it was discovered that a great channel between the lake and the sea had been opened, through a broad and high sand bank, during the night, by which the waters had found a way and been discharged. * * * The most probable conjecture is, that the excessive rains of the season had simply forced open a passage through the broad and loose sand-bank from the lake to the ocean. Formerly the lake had no visible outlet whatever; and its waters had insensibly been kept about the same level * * *
245			A	1906	Schussler, 1906, p. 9.	* * * west and southwest from Lake Merced * * * the outlet, or ocean end, of our brick Lake Merced drainage tunnel was completely covered up and closed by a large slide.
246			A	1906	Lawson and others, 1908, p. 240.	Forty-eight Avenue, between K and N Streets, is a district underlain by deep sand where extensive grading operations were undoubtedly necessary to convert an area of sand-dunes into streets and building lots. Here small, substantial frame dwellings were shifted bodily from 1 to 2 feet out of position, and the streets were slightly dis- located.
247			A	1906	Lawson and others, 1908, p. 242.	* * * Forty-eight Avenue between K and L Streets, within a few hundred feet of the ocean * * * the sand in our basement raised from 1 foot to 18 inches. A wide and long 3-foot depression was raised level. Our lot, which was 120 feet deep, was shorted at least a foot, which was shown by the folding of the fence. Electric-light poles in the street in front of us, which were in the sand, were thrown down north, east, south, and west. There was a fissure for about a block, between Forty- seventh and Forty-eighth Avenues, about 3 feet wide and 6 or 8 inches deep, which was of course in the sand. There were also other blow- holes in the sand, which emitted water and sulfurous odors.
248			A	1906	<i>Seattle Post- Intelligencer</i> , 1906c.	There is one place within pistol shot of ruined San Francisco that the earthquake did not touch, that did not lose a chimney or feel a tremor--Alcatraz island. Despite the fact that the island is covered with brick buildings, brick forts, and brick chimneys, not a brick was loosened, not crack made, not a quiver felt.

TABLE 8.—Specific descriptions of ground failures in the north bay counties region

Location number is assigned to each reported ground-failure site. Corresponding numbers are found on plate 4. Figure number refers to figure in this report showing damage described under "Quotation" column. Failure type is indicated by the following symbols. Corresponding symbols are found on plate 4.

■ Hillside landslides including rotational slumps, block glides, debris avalanches, and rockfalls	⋮ River stretches with extensively fissured flood plains; pattern indicates stretches of river affected and not width of disturbed zone
● Streambank landslides including rotational slumps and soil falls	○ Sand boils
◁ Lateral spread	□ Absence of ground failure noted
✕ Ground settlement	⊠ Miscellaneous effects
▣ Ground cracks not clearly associated with landslides, lateral spreads, settlement or primary fault movements	←□→ Arrows showing extent of area affected. Symbol shows failure type

Accuracy with which failure sites can be located is given as follows: A, a site that can be accurately relocated; B, a site that can be relocated to within a few kilometers and probably could be located more accurately with further investigation; C, a site where the information is insufficient to allow precise location. Plate numbers in the "Reference" column refer to plates in the original source material.

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
249		●	C	1906	Jordan, 1907, p. 33.	At Sobrante, in Contra Costa County, east of San Francisco Bay there are large slumps or cracks in the earth.
250		✕	C	1906	<i>Salinas Daily Index</i> , 1906c.	The Santa Fe's Condition. * * * The railway bridges and railyards at Pinole sank two feet.
251		⊠	B	1906	Lawson and others, 1908, p. 212.	<i>Mare Island.</i> --The earthquake was much less severe than that of 1898, which wrecked many of the Government buildings in the navy-yard. None of the Government buildings was wrecked this time, nor was the damage at all serious except in the case of two or three new buildings recently erected on the "made" land near the water-front. Here the ground was thrown into violent undulations, and the buildings were so twisted that about \$2,000 worth of repairs had to be made. On this soft ground the brick walls were cracked * * * . In the case of the older buildings resting on hard ground, no cracks were formed, nor any injury reported.
		⊠	B	1898	Townley and Allen, 1939, p. 105.	1898 March 30. 11:43 p.m. VIII. Mare Island. San Pablo Bay. This earthquake wrought such damage at Mare Island Navy Yard that it may properly be known as the Mare Island earthquake. * * * Admiral H. W. Lyon, U.S.N., has furnished the following information: " * * * The violence of the shock was greater than any shock previously experienced on this island, as far as can be learned from the oldest inhabitants. "A detailed account of the damages done is set forth in a report to the commandant, dated April 5, 1898.
252		◁	B	1906	Lawson and others, 1908, p. 310.	The railroad track east of Martinez, near Bull's Head Oil Works, was thrown 3 inches out of alignment 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 about 0.5 mile west of Peyton Station. The distance between crests was about 10 to 15 feet; amplitude estimated at 3 inches. This embankment lies in flat marshy land. A small railroad bridge near Avon Station was thrown 4 inches toward the east abutment, but it had been repaired at the time of the visit.

TABLE 8.—Specific descriptions of ground failures in the north bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
253			C	1906	<i>San Francisco Chronicle</i> , 1906b.	<p>Stockton, April 30.--It was discovered to-day that in the vicinity of Woodbridge the Mokelumne River has fallen twelve feet, the bed of the river having dropped from the effects of the recent earthquake.</p> <p>The stream had been carrying a lot of water when it was noticed that the river was steadily falling, contrary to all precedent. The people could hardly believe their eyes. They watched the river recede for a day and made an investigation, with the result that the bed was found to be almost twelve feet lower than before.</p> <p>As the water way has been steadily filling up each year with silt from the upper portion of the river, farmers along that stream are highly pleased with the change, since it can carry far more water than heretofore, and not endanger their lands on either side of it.</p> <p>Another incident of the earthquake is the drying up of Tracy lake, in the northwestern part of San Joaquin county. Ever since the earthquake the water has been decreasing at a rapid rate, and at present it is almost on a level with the Mokelumne river.</p> <p>Whether or not there is a crack in its bed, or an underground passage connecting the lake with the river, is not known, but at the rate the lake has been falling it will soon be as low as the river. The benefit in both instances will be appreciated by farmers.</p>
	☒		C	1857	<i>Sacramento Age</i> , 1857.	<p>We have information of severe effects of the earthquake along the line of the lower Stockton Road. Below Benson's Ferry the waters of the Mokelumne river much swelled by recent rains, were thrown over the banks, leaving the bed of the stream almost bare. Houses were shaken violently, destroying articles of glassware and over turning furniture. Limbs were broken off from trees and the trees in some instances settled down two or three feet into the ground. The inhabitants of that section were terror stricken, whilst dumb brutes appeared to be paralyzed.</p>
254			C	1906	Duryea and others, 1907, p. 258.	At one point on the marsh between Benecia and Suisun, on the Southern Pacific, the settlement was 11 ft.; at another point, 5 ft. These were nearly vertical.
	✕		C	1906	Ransome, 1906, p. 294.	On the north shore of Suisun Bay part of the track of the Southern Pacific, laid on marsh, subsided several feet.
	✕		C	1906	Davison, 1906, p. 25416.	Three miles of railway have sunk out of sight between Suisan and Benecia * * * .
	✕		C	1906	<i>Engineering News</i> , 1906.	Farther east [of Oakland and Berkeley] the Southern Pacific Co. suffered much disturbance of its railway lines * * * . A section of track between Oakland and Sacramento sank several feet; a railway bridge over the San Joaquin settled some inches [see loc. 182].
	✕		C	1906	<i>The Evening Post</i> , 1906e.	Effect of Shock Between Susan [sic] City and Benecia. A telegram from Sacramento to the Western Union Telegraph Company's office in this city, reports that three miles of railroad sank out of sight as a result of the earthquake between Suisan [sic] City and Benecia, in Solano County, and all wires were taken with it. * * * reported sinking of a three-mile section of the railroad company's tracks between Suisun and Benecia, which are on the direct line between Sacramento and San Francisco. The road crosses some low land at the point where its tracks are reported sunk. The location of this sinking of the earth is about thirty miles from San Francisco.
	✕		C	1906	<i>The Evening Bee</i> , 1906a.	<p>Trains Brought Back. Trains which had been dispatched for San Francisco early this morning had to be brought back, and they were sent to the Bay City by the Lathrop route.</p> <p>It was at the spot where the track disappeared that the railroad company had so much trouble last Winter, when a loaded passenger train came near going out of sight. A great army of men was then set at work to fill up the sink. The task was a most difficult one,</p>

TABLE 8.—Specific descriptions of ground failures in the north bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						as enormous timbers which were thrown into the hole quickly sank from view, and the trainloads of earth dumped in disappeared like snow in a fierce sunshine. But the engineers finally mastered the situation, and after a week's time trains were sent over the route again. It is now feared that it will take several weeks' time to repair the present collapse, and in the meantime all trains will be sent by the Stocton [sic] route.
						EARTH CRACKED OPEN. There are great crevasses on each side of the track through the Suisun marshes and it is reported that a great ocean of water has flowed over the lowlands between Suisun and Benecia.
						ENGINE SINKS IN EARTH. A short distance below Suisun, a Southern Pacific switch engine sank into the ground for a distance of three feet, not far from where the track disappeared.
				C	1906 <i>Los Angeles Daily Times</i> , 1906c.	Sacramento, April 18.--A short time after the big shock came a message from Suisun, Solano county, saying that a long section of track had disappeared from view. It was learned later that, in one place between Sprig and Teal stations, in the Suisun marshes, for a distance of one mile and a half, the track had sunk down three to six feet, and at another point nearly one thousand feet of track went out. * * * The track sunk by the earthquake is near the place where a loaded passenger train came near going out of sight. * * * There are great crevices on each side of the track through the Suisun marshes, and it is reported that a great ocean of water has flowed over the lowlands between Suisun and Benecia.
						A short distance below Suisun, a Southern Pacific switch engine sank into the ground for a distance of three feet, not far from where the tracks disappeared.
				B	1906 <i>Public Ledger</i> , 1906.	Sacramento, April 18.--A short time after the shock of the earthquake a message came from Suisun, Solano County, saying that a long section of track had disappeared from view. One place between Sprig and Teal stations in the Suisun marshes for a distance of one mile and a half the track had sunk three to six feet, and at another point near 1000 feet of track went out.
				B	1906 <i>New York Tribune</i> , 1906.	Sacramento, Cal., April 18-- * * * It was learned that between Sprig and Teal stations for a distance of one mile and a half the track had sunk three to six feet. At another point nearly a thousand feet of track sank from sight.
				C	1906 <i>The Evening Bee</i> , 1906b.	The Southern Pacific Company repaired its tracks beyond Suisun yesterday afternoon and trains are now running direct to San Francisco. The local officials state that the rumor to the effect that the tracks had gone out of sight was not so, and it took but two or three carloads of dirt to level the tracks. This was done by 2:30 yesterday afternoon and last night trains were running through to Oakland on schedule time.
255				C	1892 Holden, 1898, p. 174 and 176.	1892. April 19; Vacaville. * * * The ground was fissured in many places.
256				C	1892 Holden, 1898, p. 187.	1892. April 20; Winters. At Winters there have been developed a number of fissures in the earth, water has been ejected, gas has escaped, and the bed of the creek has been filled up for a distance of over 70 yards. Many of the wells have been filled up by the collapse of the walls.
				C	1892 Holden, 1898, p. 178 and 179.	1892. April 19; Winters; 2h. 50m. a. m. On Putah Creek, half a mile west of Winters, a phenomenon was witnessed by a young man named Fred Willis, who was riding past at the time of the big shake. There seemed to be an explosion, and the water was thrown from the creek to a distance of 20 feet on either bank. Then followed a hissing sound as of gas escaping. At daylight several fissures

TABLE 8.—*Specific descriptions of ground failures in the north bay counties region—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		●				were found in the bed of the creek and in the roadway and fields adjoining. On each side of the creek where the explosion took place the banks caved in, the landslides being 75 feet in length and 12 feet deep.
		●	C	1892	Holden, 1898, p. 178.	1892. April 19; Winters; * * * near the town the bank of Putah Creek, ten feet wide, caved in, and along the bottom of the creek for a great distance rents were made by the shocks. West of here about three miles, an acre of ground slid into the creek.
		■	C	1892	Coffman, 1973, p. 160.	1892. April 19. * * * Fissures were found in the bed of Putah Creek, 1/2 mile west of Winters, and in the adjoining roadway and fields; banks of the creek were caved in.
		■	C	1892	Holden, 1898, p. 195 and 196.	1892. April 21; Winters. * * * The railroad track is all right, and telegraphic communication has been uninterrupted, but there are many nasty cracks and fissures in the roadways, and driving is dangerous.
		●	C	1892	Holden, 1898, p. 195 and 197.	1892. April 21; Winters. * * * The sand bars in Putah Creek near Winters opened and from the fissures the water spurted high up on the banks. In some places the creek became dry, in others it changed to a torrent. The banks caved in some places and almost dammed the stream.
257		■	C	1892	Holden, 1898, p. 178.	1892. April 19; * * * Up the Berryessa road the passage is blocked by immense boulders [sic], some weighing several tons, which were thrown down the hillsides into the road. It is near this point where the rents in the road were noticed.
258		⊠	C	1892	Holden, 1898, p. 195 and 197.	1892. April 21; * * * It was reported that several boiling springs had burst from the foothills on the north and west and were flowing steadily.
259		■	C	1892	Holden, 1898, p. 184.	1892. April 19; Esparto. * * * The earth opened in several places between here and Capay.
260		◀	A	1906	Duryea and others, 1907, p. 259.	The draw-bridge at Black Point, over Petaluma Creek, on the Sonoma Branch of the California Northwestern, was open at the time of the earthquake, and was thrown off its center 2 ft. to the east and 1 ft. to the north. This is a steel structure, 220 ft. long, on four iron caissons, filled with concrete, on pile foundations.
261		■	B	1906	Lawson and others, 1908, p. 192.	The buildings of the Dickson ranch, 2.5 miles south of Olema, are about 0.25 mile east of the fault-trace, standing on a hillside presumably on firm ground. They nearly all slid southwest--that is, downhill and toward the fault.
262		■	C	1906	Lawson and others, 1908, p. 75.	Bedrock cracks occurred at many points within the Rift, usually appearing as branches from the faults. They were seen also at a number of points west of the Rift, their distribution reaching to the ocean in the vicinity of Point Reyes, ten miles from the fault-trace. At the more remote points they were quite small, often barely discernible, and no system of arrangement was discovered. They are peculiarly prominent along the summit of the ridge constituting the southwestern rim of the main Bolinas-Tomales trough. This summit was visited on four lines of road [locs. 265, 275, 276] and at each locality conspicuous cracks were found. On the road from Inverness to Point Reyes Post Office [loc. 276], about a mile in a direct line

TABLE 8.—*Specific descriptions of ground failures in the north bay counties region—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						from Tomales Bay, a crack was traced for more than 800 feet. Its general trend is east and west, but its course is not straight and it has a branch diverging at 45°. Along this crack there is a horizontal throw of from 2 to 6 inches, the south side having moved westward with reference to the north side.
		■	C	1906	Lawson and others, 1908, p. 195.	In this region [Bear Valley] I saw only a few cracks other than road-cracks, and the road-cracks were unimportant.
263			B	1906	Lawson and others, 1908, p. 192.	Mr. Payne J. Shafter's place is near the village of Olema. The fault-trace is close to the house and other buildings. These stand on a bed of alluvium which is probably supported by bedrock at a short distance below the surface. In the barnyard men were milking, and were thrown violently to the ground, along with the cattle. The buildings were much damaged. During the earthquake a cow fell into the fault-crack and the earth closed in on her, so that only the tail remained visible. At the time of my visit the tail had disappeared, being eaten by dogs, but there was abundant testimony to substantiate the statement. As the fault-trace in that neighborhood showed no cracks large enough to receive a cow, it would appear that during the production of the fault there was a temporary parting of the walls. [Some have discredited this report. See Earthquake Engineering Research Institute Newsletter, v. 9, no. 1, p. 103.]
		⊗				
264			B	1906	Lawson and others, 1908, p. 193.	Olema.--The village of Olema is about 0.5 mile east of the fault-trace and at the edge of the Rift belt, the greater part being included within the Rift. The residence of Mr. Pease, standing on alluvium, was shifted south about 2 feet, falling from its supports. * * * A neighboring piece of alluvial land bordering Olema Creek sank about 2 feet.
		✱				
265		■	B	1906	Lawson and others, 1908, p. 75.	On Mount Whittenberg there are two bedrock cracks. One of these crosses the northeastern spur of the peak near its junction with the main crest. Its trend is approximately northwest and southeast and at one point it margins a fault-sag. As it assumes in one place the ridge phase of the fault-crop, I infer that it has horizontal displacement. On the opposite side of the main crest is a crack which was traced for about 1,000 feet. Its general course is northwest-southeast, but it is not straight and exhibits a vertical throw of 1 or 2 feet to the southwest. At one point it touches a fault-sag. Between these two long cracks a group of short cracks occurred, with similar trend, on a knob constituting a portion of the main divide. [These cracks may have been caused by secondary faulting.]
266	58	■	C	1906	Lawson and others, 1908, p. 74. plate 49B	They [cracks in alluvium] were seen from the train in the bottom-land of Papermill [Lagunitas] Creek within a mile of Point Reyes Station. They were also seen in the delta of Papermill Creek, in the bottom-land of Olema Creek near Olema, and in the delta of Pine Gulch Creek. They were seen in the bottom-lands and deltas of a number of small creeks entering Tomales Bay from the west between Inverness and the head of the bay. Other localities were tidal marshes at the head of Bolinas Lagoon (plate 49B), at the head of Tomales Bay, and in small estuaries near Inverness. They were seen in the marsh of Bear Valley Creek near where the stream joins Papermill Creek; and a road embankment crossing that marsh was elaborately cracked and faulted thru much of its extent.
			C	1906	Lawson and others, 1908, plate 50B.	[Picture caption] Faults in road embankment, southwest of Point Reyes Station. Fault-trace is beyond fence. Ground lurched toward marsh of Bear Valley Creek. G. K. G.
	59	◀				

TABLE 8.—*Specific descriptions of ground failures in the north bay counties region—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
				A	1906 Jordan, 1907, p. 19.	Paper Mill Creek [Lagunitas] runs past the same village [Point Reyes Station], * * *. The two banks of the stream were forced toward each other so that the length of the bridge was shortened by about six feet and the bridge was correspondingly humped at its north end, an arch about six feet high being forced up.
				B	1906 Duryea and others, 1907, p. 270, plate 54.	* * * a highway bridge across a creek tributary to Tomales Bay, near Point Reyes Station on the North Shore Railway, in Marin County, and within less than 2 miles of the fault line. * * * The bridge, originally, had eight panels, its total length being approximately 120 ft. It is located in a direction nearly north and south. The abutments are of piles and timber. The effect of the earthquake was to settle the north abutment some 2 or 3 ft., and move it southward so much that, in patching up the structure temporarily, the north end panel was not utilized as part of the span * * *.
				B	1906 Duryea and others, 1907, p. 258.	Portions of the trestle over Lagunitas Creek, about a mile from Point Reyes, were thrown entirely off the piles, the piles themselves being moved down stream.
				C	1906 Lawson and others, 1908, p. 196.	Beyond Garcia the creek has several reaches of alluvial bottom, and some of these were so badly shaken that the railway embankments and trestles had to be repaired. Railway traffic to Point Reyes [from Sausalito] was interrupted for about 10 days.
267				C	1906 Lawson and others, 1908, plate 50A.	[Picture caption] Road embankment broken by shaking of soft ground beneath. Southwest of Point Reyes Station and 10 rods from fault-trace. G. K. G.
60				B	1906 Lawson and others, 1908, p. 71.	The road running southwest from Point Reyes Station and crossing the valley at the head of Papermill Creek [Lagunitas] delta was offset 20 feet [by faulting]. * * * The embankment of the road rested on marshy ground so soft that a portion of the embankment sank into it, and material of this character was in other localities demonstrably shifted.
268				C	1906 Lawson and others, 1908, p. 196.	I drove a few miles north and east from the [Point Reyes] station, over a high terrace separating the upland from the bay at the east. * * * A few cracks were seen in the ground, but they were much smaller and less numerous than at a similar distance on the opposite side of the fault.
269				B	1906 Lawson and others, 1908, p. 197.	The "fills" across the arms of Tomales Bay generally sank from 2 to 8 feet. The 1,000-yard fill about 2 miles north of Point Reyes Station sank from 6 to 8 feet; as did the next fill, which is some 500 feet long. In one or two instances the pile-supported bridge in the middle of the fill remained at grade. * * * The bottom of the bay in these arms is usually sand.
				B	1906 Duryea and others, 1907, p. 258.	On the North Shore, about 2 miles north of Point Reyes, the road, originally, had been constructed with pile trestles across several arms of Tomales Bay; these trestles had been filled about 15 years ago, the road-bed being about 8 ft. above ordinary high tide. Two of these embankments, 2 200 ft. and 900 ft. long, respectively, sank until the water at high tide washed over the rails.
				C	1906 Weatherbe, 1906, p. 402.	Along the coast, the railway was greatly disturbed, invariably sinking in the low swampy land except where built on piling.
270				C	1906 Lawson and others, 1908, p. 78 and 79.	A large portion of the delta was thrown by the earthquake into gentle undulations, the difference in height between the swells and hollows being usually less than a foot. The chief evidence

TABLE 8.—*Specific descriptions of ground failures in the north bay counties region—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
	61 62				plate 54B, plate 55B, plate 56A.	<p>of this is found in the distribution of pools at low tide, and where vegetation is present the evidence from pools is supplemented by that from the condition of the plants. The undulations were not elongate and were not found to have a systematic relation to the fault.</p> <p>When the tidal mud was first seen after the earthquake, it was observed to be covered with ridges and troughs. (Plate 54B.) This corrugation was gradually smoothed out by the action of the waves (plates 55B and 56A), so that at the expiration of a year its expression was largely lost, tho a few of the larger ridges could still be traced, and much of the plain retained a pattern imprest on it by the ridging. It is probable that the entire tract of tidal mud was thus affected, altho the ridges were not seen on the area lying nearest to the east shore. That area did not come under observation until after the spring floods of 1907, and it was then overspread by a fresh deposit brought by Papermill Creek [Lagunitas Creek]. The ridges varied somewhat in height, the amplitude from crest to trough ranging from 1 to 3 feet and possibly more. Their general trend was parallel to the fault-trace, but there were notable exceptions, and over small tracts the direction was even at right angles to it. In some cases, where the minor ridges were parallel, there were larger ridges traversing them obliquely. Fig. 25 reproduces a sketch map of the locality showing the greatest complexity. [See fig. 25 at end of tables.] So far as the broad undulation of the tide lands were seen in conjunction with the ridging, the greater ridges were on the swells and not in the hollows.</p>
271	63A 63B	◀	A	1906	Lawson and others, 1908, p. 79 and 80, plate 55B, plate 57A, plate 57B, plate 58.	<p>[See text, "North bay counties region," paragraph 5, for additional discussion of failure mechanism and direction of movement.] There was also a horizontal shifting of mud over a considerable area. Residents familiar with depths of water in the vicinity of Inverness stated that the earthquake caused a decided shoaling along the coast, but that the relation of water levels to firm ground was unchanged. It was also stated that a channel which had existed parallel to the west shore of the bay, and to which piers had been run, was obliterated by the earthquake. The shoaling might have been caused either by an uplift of the bottom or by a shifting of the mud of which it is composed toward the shore. That the second of these explanations is correct seems to be shown by the following facts.</p> <p>At various places along the shore, from Inverness to a point 1.5 miles southward, the tidal mud seemed to be crowded against the firmer ground at the shore, being pushed up in a ridge, as shown in the accompanying photograph. (Plate 55B.) Two piers at Inverness, light wooden structures, resting on piles and extending out several hundred feet from the shore, were telescoped. (Figs. 26 and 27.) [See figs. 26 and 27 at end of tables.] In the case of Martinelli's pier the telescoping was shown by the inclination given to piles at the landward and bayward ends, from which it appears that the ground in which the piles were set was crowded together, so that the foundation of the pier was shortened, while the superstructure resisted shortening. The resistance was temporary only, for before the agitation ceased the pier was broken in two; and the inclination of the piles is supposed to have been given during the early stages of the tremor. Coincident with the movement of the ground toward the shore, there was a movement parallel to the shore which had the effect of offsetting the outer end of the pier about 25 feet toward the north-west. (Plate 57A.) The resultant of the two movements, or the actual direction of shifting of the mud, was westward, or a little to the north of west; and the maximum shifting in that direction was not less than 30 feet. Rather more than half the pier, the part nearer the shore, remained straight and suffered chiefly from the slanting of its supporting piles. This part stands on the submerged delta of a small creek, and its foundation appears not to have shifted. The outer part suffered most violence near the junction of the shifting mud with the firmer ground, being there so completely wrecked that its platform fell. The photograph and map represent it after repairs had been made.</p>

TABLE 8.—*Specific descriptions of ground failures in the north bay counties region—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						<p>In the case of Bailey's pier, which is beyond the delta, the most important telescoping, as shown by the slanting of piles (fig. 27), was close to the shore, and nearly the whole structure was transported by the shifting mud. It also sagged more than a foot just beyond the middle, and the attitudes of the associated piles suggest that the sag corresponds to a hollow made in the surface of the mud. The pier was so badly broken as to require extensive repairs, and in making these repairs Mr. Bailey used the old material for flooring, but found that he had enough lumber remaining for 12 feet of flooring, so that he inferred a shortening of 12 feet. The whole pier was shifted to the northwest, being given a curved form (plates 57B and 58), and the maximum amount of shifting in that direction was at least 25 feet, altho the circumstances did not admit of accurate measurement. Combining the movement toward the shore with the offset parallel to the shore, it is probable that the direction and the maximum amount of shifting were about the same as in the case of the Martinelli pier.</p> <p>It is a notable feature of this displacement that the disturbed material moved up the slope instead of down, so that the transfer was not only independent of gravity but opposed to it. The phenomenon, therefore, does not fall in the same category with landslides, and if properly interpreted it may throw light on the mechanics of the earthquake pulses.</p> <p>The area thru which the shifting of the mud took place is indeterminate. It affected a shoal parallel to the west shore of the bay and more than a mile long. At the piers the width of the affected region was at least 400 feet and may have been much more. The reported closing of the channel suggests 700 or 800 feet as a minimum estimate, but the outer margin of the affected area was probably beneath the water of the bay and outside the range of observation. The firmer part of the Papermill [Lagunitas] delta appeared not to be included in the movement. All of the area known to be affected lies southwest of the fault-trace, which in that neighborhood is about 2,000 feet from the shore.</p>
62 61			A	1906	Gilbert, Humphrey, Sewell, and Soule, 1908, p. 8 and 9, plate 7A, plate 8A.	<p>[By the same author as the above quotation.] * * * an extensive shifting of mud on the bottom of Tomales Bay. At the head of the bay and thence for a distance of several miles northwestward the soft mud was moved bodily westward. It not only descended from the northeast shore, so as to cause deeper water, but ascended toward the southwest shore, creating a broad shoal (Pl. VII). The horizontal change of position near the southwest shore was in places more than 25 feet, and the vertical change as much as 2 feet. As the ascending movement can not be ascribed to gravity, it must be referred to the earthquake, even though the way in which the earth waves produced the effect is not evident. The locality is adjacent to the fault trace, the position of which is along the bottom of the bay, east of the shoal.</p> <p>The illustrations may require a few words of explanation. The upper view of Pl. VII looks northward from the southwest shore of the bay. Tide being low, the newly formed shoal or mud bank is broadly exposed, but the receding tide has left a lane of water to mark the separation of the mud bank from the firmer ground that withstood the quaking. Immediately after the earthquake the mud was rigid, as in the tract shown in Pl. VII, A; but before the view of Pl. VII, A, was taken (April 28, 1906) the surface had been largely smoothed by the action of wind waves. A single ridge which escaped that action appears at the left in the upper view of Pl. VII and in the foreground of the lower view.</p>
			B	1906	Lawson and others, 1908, p. 194, plate 45B.	<p>Inverness is a village of summer residences on and near the southwest shore of Tomales Bay. The upland of the peninsula there closely approaches the bay. The village occupies two narrow valleys normal to the shore, and a mesa between them. Its site is within the Rift, and both valleys and mesa were traversed by many cracks, of which some had the character of branch faults. All the houses were of wood. About half of them were shifted on their foundations. To a certain</p>

TABLE 8.—Specific descriptions of ground failures in the north bay counties region—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
						extent the direction of shifting was determined by the slopes of the ground, the houses moving downhill; but where that factor did not control, the movement was toward the west or southwest. In one instance I noted a southwestward movement of several feet uphill.
272		■	B	1906	Lawson and others, 1908, plate 51B.	[Picture caption] Roadside crack a mile southeast of Inverness. G. K. G.
273		■	B	1906	Lawson and others, 1908, p. 195.	<i>Sunshine Ranch and Vicinity.</i> --I drove to the summit of the ridge southwest of the head of Tomales Bay, finding abundant and strong road-cracks all the way to the crest, which is about 1.5 miles from the fault-trace. There were also a number of landslides in this region, and a considerable number of trees were broken or uprooted.
274	64	■	C	1906	Lawson and others, 1908, p. 77.	On the west side of the main ridge west of the head of Tomales Bay there occurred two wet slides. In one case a hillside bog was loosened from the slope on which it rested and descended as a flow of mud to a canyon bottom 100 or 200 feet below. In the other case the earth beneath a wet meadow in a rather steep canyon flowed down the canyon for about 0.5 mile, overpowering trees on its way and leaving a deposit 15 or 20 feet deep in places. This was the largest individual slide observed. In all the cases mentioned the conditions were such that slides would have taken place at some time had the earthquake not occurred.
275		■	C	1906	Lawson and others, 1908, p. 75.	On the next road to the southward [from loc. 276] a group of cracks was seen at a point a mile from the shore of Tomales Bay. These cracks occur on a crest trending northwest and southeast, and their trend makes a small angle with that of the crest. The arrangement of the cracks suggests horizontal shear, but no definite observation was made on this point. They extend for several hundred feet at least, but were not traced out.
276		■ ■	C	1906	Lawson and others, 1908, p. 194.	<i>Inverness to Point Reyes Light-house.</i> --For the first 2 miles of travel, covering a right-line distance of about 1.5 miles, road-cracks were numerous and often large. There were also numerous small falls of earth from the road cliffs. Beyond that point there was a rapid falling off of such evidence, and tho road-cracks were frequently seen they were all small. [See loc. 262.] [Some of these cracks may have been caused by secondary faulting.]
		■	C	1906	Lawson and others, 1908, plate 51A.	[Picture caption] Roadside crack 2 miles west of fault, between Inverness and Point Reyes P. O. G. K. G.
	65	■	C	1906	Lawson and others, 1908, plate 53B.	[Picture caption] Landslide from road-cliff about two miles west of Inverness. Slide occurred at time of earthquake. G. K. G.
277		✱	B	1906	Lawson and others, 1908, p. 195.	At the U. S. Life Saving Station, on the coast 3 or 4 miles from the light-house * * * the filled ground about the house settled several inches.
278		✱	A	1906	Lawson and others, 1908, p. 197.	At Marshall's a hotel and a stable built on the west side of the track and on underpinning, resting in the tidal flat, went easily and gently into the bay. The occupants of the hotel did not realize that the hotel had fallen, but at first thought the water had risen. [Photographic evidence in the Branner Collection at Stanford suggests this may have been structural failure, that the building simply slid off its piles.]

TABLE 8.—*Specific descriptions of ground failures in the north bay counties region—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
279	✱ ☐		B	1906	Lawson and others, 1908, p. 197.	Just above Hamlet a trestle-work which had been filled in settled, leaving the trestle-work some 2 feet above. The bottom of the bay in these arms is usually sand. At Hamlet quite an extensive landslide has started in the hillside above the track. The railroad cut is in old rock, and the arch of the head of the slide is some 70 feet above the track. The country wagon road has been carried away by the slide for possibly 100 yards.
280		○	C	1906	Lawson and others, 1908, p. 65, plate 142B.	At the mouth of Tomales Bay there are two points projecting westward from the east shore, and both of these, according to the observations of Prof. R. S. Holway, are crossed by the fault-trace. * * * On each side of the crack [fault] are crater-like depressions, some of them being double or overlapping. Mr. Keegan, the owner of Dillon's Beach, reported that these craterlets were numerous and distinct. In some instances a great deal of sand and water had been ejected. Others are reported on the southwest side of the fault-trace, from which the belt containing them extends some 70 feet. The craterlets vary in size up to 6 feet in diameter and it is reported that on the day after the earthquake the water which stood in them could not be bottomed by a fishing pole.
281		○	B	1906	Lawson and others, 1908, p. 191, plate 142A.	[Near Salmon Creek] * * * a small mud-flat extends from the sea up to the road. Curious mounds of mud, shaped like truncated cones, were thrown up by the earthquake. Subsequent examination showed that the line of the earthquake fissure must have past near this spot.
282		◀	C	1906	Lawson and others, 1908, p. 199.	There are quite a number of cracks in the flat valley-bottom adjacent [to Valley Ford, Sonoma County]. A landslide of several hundred yards in length but of very slight movement is found on the side of the valley directly east of town. The slide has moved just enough to make a furrow-like ridge on the lower side and has developed cracks on the upper side. Other small slides occur in the vicinity.
283		◀	B	1906	Duryea and others, 1907, p. 258.	<i>Trestles.</i> --Trestles over marshes suffered more or less from the movement of the soft material into which the piles were driven. The most serious damage was at Fallons, on the North Shore, where a trestle, 600 ft. long and 70 ft. high, was thrown down. This trestle was constructed of framed bents on piles.
		◀	B	1906	Duryea and others, 1907, p. 214 and 215.	<i>Trestles.</i> --The damage to trestles was small, except on the North Shore Railroad, where a trestle of framed bents on piles, 600 ft. long and 70 ft. high, was thrown down, and portions of another trestle were thrown entirely off the piles, the piles themselves being moved down stream. These trestles were across soft ground, and near the fault-line.
284	■ ◀		B	1906	Lawson and others, 1908, p. 198, plate 129A.	<i>Tomales, Marin County.</i> * * * Cracks were reported in the street and near the depot. Just north of the depot there was an extensive landslide along the railroad, which threw one track over the other. (Plate 129A.)
	◀		B	1906	Weatherbe, 1906, p. 402.	At Tomales, about eight miles inland, the [railroad] line for over 1,000 ft. was carried down a gentle slope to the east for a distance of 50 ft. All these disturbances are exactly along the faulted line, now well defined, though the movement and action in each of the cases above noted has been entirely local and following the configuration of the ground. Little evidence, therefore, can be deduced pointing to a definite regional movement in any certain direction. Buildings on ground resting on long piles seem undisturbed and the worst effects are noted on or toward swampy ground.

TABLE 8.—*Specific descriptions of ground failures in the north bay counties region—Continued*

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
285		☑	B	1906	Lawson and others, 1908, p. 198, plate 129B.	At Freeman's, 3 miles northeast of Tomales, a large landslide was caused by the shock. (Plate 129B.)
286		☐	C	1906	Lawson and others, 1908, p. 199.	No cracks are reported in the low alluvial land around the lagoons nor in Chileno Valley.
287		⊗	B	1906	Lawson and others, 1908, p. 206.	At Jur's ranch, about 2.5 miles northwest [of Petaluma], 3 cracks with a very slight dropping of small blocks between them, are reported. A temporary flow of water was reported from a crack by the road.
288		▢	C	1906	Lawson and others, 1908, p. 206.	Small cracks were reported on the road about 4 miles [north] from Petaluma.
289		☐	C	1906	Lawson and others, 1908, p. 203.	A trip was made out on the Petaluma road to the Copeland district school, then to Cotate, to the Durham district school, and back to Santa Rosa. * * * I could hear of no cracks in the ground in the valley; and in only one place, about 2 miles from Santa Rosa, on the Petaluma road, could I hear of any increase or change in the flow of springs.
290		▢	B	1906	Lawson and others, 1908, p. 206.	Near Stony Point school-house, about 9 miles out [north from Petaluma], 19 cracks across the road were reported by the teacher.
291		☑	B	1906	Lawson and others, 1908, p. 206.	At Nason's ranch there is a landslide of the bank of the lagoon 100 yards or more in length. Four miles [south] from Sebastopol is another landslide at Davis' ranch, where a house was thrown from its underpinning.
292		▢	B	1906	Lawson and others, 1908, p. 206.	Cracks were reported at Hansen's and several places. There is a distinct increase in cracks and landslides in the approach to Sebastopol [from Petaluma].
293		◀	B	1906	Lawson and others, 1908, p. 205.	[G. K. Gilbert] On the Burbank farm a small landslide occurred, a layer of moist soil only a few feet in thickness moving down the slope, introducing bends in various lines of cultivated plants. I saw another feature of this sort on an adjacent farm, and was told of others which I did not visit.
			B	1906	Lawson and others, 1908, p. 204.	[David Starr Jordan] At Burbank's farm, 0.5 mile west of Sebastopol, I noted these things: In the lot adjoining, to the south, the soil being clayey, there is a large crack running northwest and southeast, or nearly so, and, according to Burbank, 0.25 mile long. It runs thru the fields and weeds, and was very distinct on August 6. The end of this crack comes up against the sandy hill occupied by Mr. Burbank's orchard. The crack does not show itself in the hill, but on the east side of the line of the crack the rows of trees and plants were shifted toward the south--or, if you prefer it, those on the west side toward the north--2 or 3 feet. A well of Mr. Burbank's, sunk in the sandy ground, is bodily shifted, without being injured, along with the rows of plants between which it is placed. No crack appears at the surface in Burbank's ground, but on the other side of the hills, to the north of it, I was told the crack reappears.

TABLE 8.—Specific descriptions of ground failures in the north bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
			B	1906	Jordan, 1907, p. 32 and 33.	There are distinct traces of great disturbance across Burbank's famous orchard at Sebastopol, but it is not clear that in any of these the underlying rock is really broken. Here on a slope lines of fruit trees were shifted, a well was moved bodily three or four feet, and a crack about one fourth mile long extended across a neighboring field, its direction parallel with that of the Tomales rift. Other similar cracks open at intervals on the road toward Point Delgada.
294	☑		C	1906	Lawson and others, 1908, p. 203.	Near the top of Taylor Hill, in a marshy place, there was a landslide, the earth having slid on a clayey bottom.
295	✕		B	1906	Lawson and others, 1908, p. 201.	The most marked physiographic effects in the vicinity of Santa Rosa were found near this [main Santa Rosa] cemetery. Just north of the cemetery hill is a swampy depression. Part of this settled 2 or 3 feet with the formation of a crack along the side, extending for some 200 feet. The cemetery is on a low hill which the sexton reports as being sand, gravel, and clay, but which shows a rocky outcrop, on the eastern side, near the base. A crack an inch or more wide was found on the northern end of the hill near the swamp mentioned above. This crack could not be followed for more than 100 feet, altho the sexton reports that at first it extended 2 or 3 times that distance. A small water-pipe on the southern part of the hill, running north and south, was pulled apart. A pipe on the northern part of the hill, running east and west, is reported by Mr. Weaver as pulled apart about 4 inches. On the southwest of the cemetery hill, Mr. John Livsey reports that several fine cracks formed across the road running north and south, and that the dust was blown away near the edges of the tracks.
	☐		C	1906	Jordan, 1907, p. 188.	San José's water works, like that of Santa Rosa, was not injured; its sewers also were left intact, showing that there was no unequal displacement of the ground.
	☐		B	1906	Lawson and others, 1908, p. 201.	A teamster working in the creek just south of the tannery [F and 2nd Sts.] says that he noticed cracks an inch wide and several rods long a few days after the shock. He "thinks the cracks were not there before."
	☐		B	1906	Moore, 1906, p. 527.	About 1 1/2 miles from the water tower in that city [Santa Rosa] there is a crack in the ground about 3 ft. wide at the top and about 20 ft. deep. A few hundred feet from the tower a man driving across the field in a buggy yesterday (April 28) struck an impassable morass, where before he had driven many times, and before discovering it had driven so far into it that the horse was with difficulty got out.
	✕		A	1969	Cloud and others, 1970, p. 54.	The earth-fill approaches to the Highway 12 bridge over Highway 101 subsided several inches in response to the shaking. The only other known bridge damage was repeated pounding at the construction joints in the sidewalks over the abutments of the Brookwood Avenue bridge at Matanzas Creek. No major landslides were triggered by the shock. A few minor rock falls were found along steep road cuts and several fissures were formed in a marshy area and on steep slopes. Some of these cracks may have been generated by landslide action (see article on Surface Breaks, page 60).
	☐		B	1969	Cloud and others, 1970, p. 60 and 61.	Adjacent to such principal drainage courses as the Santa Rosa and Matanzas Creeks, ground shaking and resultant cracking was particularly apparent. * * * On the crest of "moving mountain" north of the city along De Vera Way, a crack developed which passed through a house; the crack showed evidence of vertical movement. This crack appeared to be related to the landslide scarps immediately adjacent where several houses were destroyed a few years ago.

TABLE 8.—Specific descriptions of ground failures in the north bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						<p>A search for fresh ground ruptures along the Rodgers Creek fault was made but none were found. * * * A few boulders from steep road cuts in this area [of Crane Canyon Road] were dislodged but no sign of fresh landslides were detected other than a small slump beneath a part of the road bounded by a steep embankment.</p> <p>The most widespread cracking was found in the IOOF Cemetery on the north side of town. [See Lawson and others, 1908, p. 201 above, for 1906 comparison.] Here, along Poppy Drive, the asphalt paving was crossed by several dozen fresh cracks oriented both northwest across the road and also northeast, parallel to the road. The area lies in a low depression close to a swamp. The adjacent ground immediately to the north was also observed to be cracked, but the orientation of the cracks appeared to be random. The cracks in Poppy Drive, which opened from 1/16 to 1/4 inch, were pulled apart perpendicular to the crack faces. There was no apparent lateral motion component or vertical component, nor did the cracks form any en echelon or other regular pattern. The cracks appeared in a zone of filled ground adjacent to the swamp; thus they appeared to be the result of heavy shaking of marshy substrata. * * * The day following the October 1 quake, fresh irregular cracks 1/8 to 1/4 inch wide were noted in the hard-packed dry dirt roads in the central part of the Rural Cemetery; however, these were not oriented along any preferred trend. Streets in the immediate vicinity north and south of the cemetery area were carefully examined for cracks but no fresh cracks in the asphalt were found.</p>
296		✱	B	1906	Lawson and others, 1908, p. 201.	<p>The only other physiographic effects found were at the County Hospital, a little more than a mile north of the cemetery. Here low ground at the foot of a small hill sank for some 2 feet and springs were formed. These springs were reported as still running the last of July.</p>
		●	B	1906	Lawson and others, 1908, p. 203.	<p>In the vicinity of the Sonoma County Hospital, the soil is very like the Santa Rosa soil * * * at the hospital a marshy place along the creek slipt toward the creek and the flow of springs was greatly increased.</p>
297		■	C	1906	Lawson and others, 1908, p. 210.	<p>A few local slides on the south side of Mount St. Helena were confined to the alluvium.</p>
298		■	A	1906	Lawson and others, 1908, p. 184 and 185, plate 124A, plate 124B.	<p><i>Maacama Slide, 6 miles easterly from Healdsburg</i> (R. S. Holway).-- This slide is on the north side of a ridge that runs in an easterly direction and that is at this point from 225 to 300 feet above the bed of Maacama Creek, which runs along the foot of the north slope. Mr. Hugh Simpson, whose house is just beyond the foot of the slide, states that the entire slide took place at the instant of the earthquake. The slide is about 0.125 mile wide at the top and about 0.5 mile long. The rock is a very light, porous, volcanic tuff and seems to be free from water. A slicken-sided wall on the east shows a very smooth surface in spite of the soft rock. Striae near the top run N. 13° W. with a pitch of about 24°. The slide seems to have taken off some of the top of the ridge; that is, it started a few feet down the south slope of the ridge, cut its way thru a fir forest and dammed Maacama Creek with rocks and trees. Either two successive slides occurred or else the upper part of the moving mass was arrested part way down, for a bank with the vegetation of the top rests across the slide about one-third of the way down. (See plate 124A, B.)</p> <p>This slide was subsequently visited by Mr. G. K. Gilbert, who contributes the following supplementary note:</p> <p>At Maacama schoolhouse, I saw the large landslide described by Professor Holway. The rocks involved are in layers, with a dip of about 30° in the direction of the slide. It is therefore</p>

TABLE 8.—Specific descriptions of ground failures in the north bay counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						probable that the slide was partly determined by the dip, tho it seems to have been further determined by the erosion of the valley of Maacama Creek. * * * [Mr. Stimson] and others mentioned numerous cracks in the bottom lands a mile to the north, and especially in the bottom lands of the Russian River at its neighboring large bend.
	☑	A		1906	Lawson and others, 1908, p. 390.	Maacama slide, 6 miles east of Healdsburg. (Plate 124A, B.) The slide is about 0.125 mile wide at the top, and 0.5 mile long. The rock is a stratified volcanic tuff, and the slip was down the dip of the beds. The avalanche cut its way thru a fir forest and dammed Maacama Creek.
299	⋮	C		1906	Lawson and others, 1908, p. 184, plate 139A, plate 139B.	<i>Cracks in the Russian River Flood-plain</i> (R. S. Holway).--Cracks have been observed at intervals in the alluvial banks of the Russian River from near its mouth to Alexander Valley, 5 or 6 miles northeast of Healdsburg. These cracks are sometimes 100 yards in length and from a few inches to 2 feet in width. Sometimes near the bank there will be a deep fault 5 to 6 feet in width and 100 feet long, as shown in the photograph of the crack at Monte Rio. The direction of the cracks is usually parallel to the bank of the river or the bank of some small tributary. At Duncan Mills the cracks ran north and south above the bridge and nearly east and west just below the bend of the river. At Monte Rio they are east and west. In Alexander Valley they run north and south, while a mile or two below some are found nearly east and west running up a small tributary.
	☐	C		1906	Lawson and others, 1908, p. 183.	<i>Healdsburg, Sonoma County.</i> * * * Along the bottom-land of the Russian River, cracks from an inch to a foot in width opened at several places. * * *
	○					Fissures in the creek bed near the town [Healdsburg] are in evidence. Water was thrown out and continued to flow for several hours, at first with some considerable force; then it gradually diminished and finally disappeared.
	○	C		1906	Lawson and others, 1908, p. 184.	Along the creek and river bottoms the earth was fissured and water was forced up which, in some instances, flooded the orchards.
	◀	B		1906	Duryea and others, 1907, p. 259.	The bridges over the Russian River, at Healdsburg, and at Bohemia, on the California Northwestern, were both shifted slightly on the piers at one end.
	☐	B		1906	Lawson and others, 1908, p. 184.	Alexander Valley is part of the Russian River Valley lying east of Lytton Springs. The main bridge across the Russian River was wrecked, the trestle-work part going down. The bridge was old and was to have been rebuilt this year. At the east end of the bridge cracks cross the road, northwest to southeast, parallel to the river bank. These cracks appear at intervals northwesterly, at least as far as the ranch of Rev. E. B. Ware, about a mile up the river. The cracks vary from a few inches to over a foot in width, and are sometimes 200 to 300 feet long, roughly parallel to the river. Mr. Ware states that the shock threw the river water upon the sandbars to such an extent that he found fish there during the day. Other cracks are reported a mile or two northward. Subsidence frequently occurs where the cracks are near the bank.
	✱					
		C		1906	Lawson and others, 1908, p. 191.	<i>Duncan's Mills</i> (J. Parmeter).--On the Russian River, when fisherman tried to seine fish after the earthquake of April 18, their nets were torn to pieces by snags, etc., where there had formerly been no obstruction. Large trees that had been buried in the bed of the river were lifted up by the convulsion, while other trees vanished that had been in sight. Low places in the river bed were made high and <i>vice versa</i> .
	✱					The bottom of the river appears to have dropt 2 feet all along by Duncan's Mills for 2 miles; and at the mouth of the river, where there used to be water 12 or 14 feet deep, there is now only 2 feet, and a riffle till boats can hardly cross, for a length of almost a mile. For over a mile there is now a strong current, where there

TABLE 8.—Specific descriptions of ground failures in the north bay counties region—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
		<p>used to be quiet water with very little current. A man who was by the river, near Monte Rio, when the earthquake occurred, told the Farmers that he saw the muddy bottom of the river rise to the surface, and the water ran off over the banks. The bottom was the highest where the water had been 8 or 10 feet deep; then it settled back. A road and fence moved 10 feet. On the other side of Russian River from Duncan's Mills, 200 or 250 feet back from the stream, the earthquake made many holes thru which black sand and water blew up. Such blow-holes were made all along this river. Between the river and the ruined hotel at Duncan's is an irregular crack about 20 feet wide, 80 feet long, and 1.5 to 4 feet deep, with a blow-hole 4.5 feet wide and 2 feet deep where coarse river gravel came up. (R. S. Holway.)-- * * * [At Duncan's Mills] Along the river there was several cracks in the alluvium.</p>
300			C	1906	Lawson and others, 1908, p. 387.	<p>From Point Arena southward to Fort Ross, the cliffs are low, being for the most part not in excess of 100 feet. Earth-avalanches were nevertheless of common occurrence along this stretch of coast. South of Fort Ross to Bodega Head the cliffs are again, as far as the mouth of the Russian River, several hundred feet high and very steep. Here again earth-avalanches were extensive. The rocks along this entire stretch of coast from Cape Mendocino to Bodega Head are prevailingly sandstones and shales.</p>
301			C	1906	Lawson and others, 1908, p. 190 and 191.	<p>Several slides were seen about 3 miles south of the Fort [Fort Ross]. One of these was of great size, being between 300 and 400 feet in height. These are evidently old slides, and the amount of material brought down by the recent earthquake, though large, is insignificant compared with the size of the scar.</p>
302			A	1906	Lawson and others, 1908, p. 180 and 181, fig. 14.	<p><i>Gualala Valley.</i>--At Casey's ranch * * *. The ranch stands on the east edge of the ridge, west of the Gualala River, and the fault runs along the mountain side several hundred feet below it. The slope is a steep one, densely timbered except for its upper portion. Landslides were found over a large part of its surface, but only in a few isolated spots had they resulted in the complete removal of the original surface, and the forest growing thereon; so that a view from across the river revealed no appreciable changes in the landscape. The slopes east of the river were similarly affected and the fallen timber produced a tangle not unlike that of extensive windfalls. In at least two places the river was temporarily dammed up by slides from both slopes meeting in the stream bed, but none of these dams was of noteworthy size. [See fig. 14 at end of tables.]</p>
303			A	1906	Lawson and others, 1908, p. 180, plate 69D.	<p>East of Stewart's Point the bridge over the South Fork of the Gualala River (plate 69D) was damaged by the slumping of the river terrace on which its south end rests. It was subjected to a strong longitudinal, compressive stress, which resulted in a slight upward buckling of the bridge floor near the southern end, and marked bending and twisting of the tension rods in the 2 southernmost panels. The supports at the south end furthermore appear to have settled 13 inches, causing the floor and the last panel to assume a marked inclination. A hundred yards east of the wagon bridge is an older, dilapidated one, whose floor has been removed for some time. Its rickety aspect and crookedness render it an unsatisfactory object for study in this connection. There is, however, clear evidence of the slumping of the terrace at its south end, in a manner similar to that at the new bridge; yet the old bridge appears to have stood the compressive stress better than the new, and its south end has merely overridden [sic] the displaced masses of the terrace.</p> <p>On both sides of the sharp bend of the river east of the two bridges are extensive landslides, making a clean sweep down the mountain side. The slide on the north side completely blocked the wagon road and was being removed at the time of the visit (May 12). It is of such height and steepness as to menace the road at this point with renewed sliding in future, especially during wet weather.</p>

TABLE 8.—*Specific descriptions of ground failures in the north bay counties region—Continued*

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
		☑	A	1906	Lawson and others, 1908, p. 61, fig. 13.	[See fig. 13 at end of tables.]
304		☑	C	1906	Lawson and others, 1908, p. 180.	<i>Annapolis, Sonoma County</i> (G. W. Fiscus).--Buildings were destroyed and bridges wrecked in this neighborhood; landslides occurred and the waters of the Gualala River were thrown out 50 and 60 feet on a gravel bar. The river rose 12 or 14 inches in a few hours after the shock. * * * In several places along the line of the fault fissure, the earth has opened so as to allow gravel to fall into the cracks. In other cases water and sand were shot out of the openings, the sand remaining.
		○				
305		☒	B	1906	Lawson and others, 1908, p. 179, plate 68C.	<i>Gualala, Mendocino County</i> .--The wagon bridge over the Gualala River, south of the town, was seriously damaged. It consists of a trussed three-span structure 500 feet long, with a wooden approach of similar length built on trestles 20 feet high thru the swampy bottom-lands on the south side. This approach collapsed completely, the trestles being thrown flat and carrying with them the south end of the main span. The latter, however, did not leave its northern abutments and appears otherwise undamaged. It is considered safe to travel over, altho the bridge is now steeply inclined to the south. (See plate 68C.)
306		☑	C	1906	Lawson and others, 1908, p. 180.	A number of landslides blocked the wagon road and railroad track north of the river. A particularly extensive one occurred north of the junction of the branches of the Gualala, burying the tracks under many tons of rock and loose debris.
307	66	☑	B	1906	Lawson and others, 1908, p. 177.	Farther up, between the lumber camp and Hutton's ranch, extensive landslides occurred, chiefly on the east side, wiping out the wagon road which was graded along the mountain slopes. Immediately north of Hutton's ranch, a large landslide plowed into a grain field, producing a series of billowy wrinkles in the soft alluvial material. The outermost ridge has a steep front about 8 feet high and seems to have been thrust horizontally over the level surface of the field. The frontage of the slide is fully 400 feet.
308		☑	C	1906	Lawson and others, 1908, p. 177.	On the south side of Point Arena harbor, large masses of rock slid down to the beach. Small rock slides took place all along the coast in this neighborhood.
		○	C	1906	Lawson and others, 1908, p. 179.	[Point Arena] In many cases houses drifted away and left porches standing in their old location. On the creek-bottoms many small cracks or fissures appear, thru which fine slate-colored sand has been forced to the surface, forming cones.
309		☐	B	1906	Lawson and others, 1908, p. 188.	One mile south of Kelseyville and half a mile to the west, at the place of Mr. McLaughlin on the Lower Lake county road, a crack was found in the alluvium out of which gas escaped, burning upon ignition. About one mile north are gas wells in the same kind of rock, the gas being obtained by boring to a depth of 165 feet.
310		☐	B	1906	Lawson and others, 1908, p. 188.	About 3.75 miles south of Kelseyville on the road to Lower Lake, at the ranch of Mr. M. E. D. Bates, is a crack varying in width from 1 to 6 inches. It crosses the road about 200 feet below the house. At the right of the road going south it crosses the creek and can be seen no further. At the left of the road it passes up the hill

TABLE 8.—*Specific descriptions of ground failures in the north bay counties region—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						toward Uncle Sam Mountain [Mt. Konocti] for about a mile, but is not continuous. Near the road two small trees standing on the crack have been partly uprooted and a fence post has been thrown out entirely. The rock thru which the crack passes is alluvium and a loose, unconsolidated conglomerate. It apparently does not pass thru the hard Franciscan rocks. In places there are as many as 10 parallel cracks, separated by intervals of 5 to 10 feet, which could be traced for only short distances. On the right side of the road, about 100 feet south of the cracks, stands a schoolhouse. It has been slightly tilted to the south.
	☒ ④		C	1962	Coffman, 1973, p. 180 and 181.	1962. June 6. Near Lakeport. * * * About 2 miles west of Lakeport, Scott Creek rose 1 1/2 feet and flowed steadily for 11 days after being nearly dry before the shock. Several wells in Scott Valley rose 7 to 10 feet, and the water was milky white for 3 to 5 days. Four-inch-high undulating movement of fill soil was observed. About 10 miles southwest of Lakeport, a geyserlike spout of water in Clear Lake was reported by the press.
311	☐		C	1906	Lawson and others, 1908, p. 188.	On the side of Mount Konocti, several large loose boulders were caused to roll down, but no landslides nor cracks were observed.

TABLE 9.—*Specific descriptions of ground failures in the north coast counties region*

Location number is assigned to each reported ground-failure site. Corresponding numbers are found on plate 5. Figure number refers to figure in this report showing damage described under "Quotation" column. Failure type is indicated by the following symbols. Corresponding symbols are found on plate 5.

▣ Hillside landslides including rotational slumps, block glides, debris avalanches, and rockfalls	⋮ River stretches with extensively fissured flood plains; pattern indicates stretches of river affected and not width of disturbed zone
● Streambank landslides including rotational slumps and soil falls	○ Sand boils
◁ Lateral spread	□ Absence of ground failure noted
✕ Ground settlement	⊠ Miscellaneous effects
▢ Ground cracks not clearly associated with landslides, lateral spreads, settlement or primary fault movements	↔ Arrows showing extent of area affected. Symbol shows failure type

Accuracy with which failure sites can be located is given as follows: A, a site that can be accurately relocated; B, a site that can be relocated to within a few kilometers and probably could be located more accurately with further investigation; C, a site where the information is insufficient to allow precise location. Plate numbers in the "Reference" column refer to plates in the original source material.

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
312	↔		C	1906	Lawson and others, 1908, p. 175.	The road between Point Arena and Mendocino was cut off by numerous slides (report of tourist).
313	▣		B	1906	Lawson and others, 1908, p. 176.	<i>Bridgeport, Mendocino County.</i> --An extensive landslide came down into the cultivated fields on the flat, wave-cut terrace east of the road.
314	▢	▣	C	1906	Lawson and others, 1908, p. 175.	<i>Mendocino, Mendocino County.</i> -- * * * The day after the shock there were numerous cracks in the ground. * * * numerous slides on the cliffs took place, some very large.
		▣	C	1898	Coffman, 1973, p. 161.	<i>1898. April 14.</i> * * * Mountain roads east of Mendocino were rendered impassable by landslides and fallen trees.
315	▢		C	1906	Lawson and others, 1908, p. 187 and 188, plate 73B.	<i>Willeys, Mendocino County</i> * * * Small cracks across some of the streets were reported, but they are not now visible. * * * The valley is an old lake bed with ground water within 3 to 4 feet of the surface in April. (See plate 73B.)
316	▢		C	1906	Lawson and others, 1908, p. 174.	(W. T. Fitch.)--There were several small cracks across the roads a few miles south of Fort Bragg; and back in the hills there were more and larger ones.
	▢		C	1906	Lawson and others, 1908, p. 174.	There are a number of fissures in the mud flats in and near the Noyo River and Puddin Creek. The boys say there are cracks in the streams. There are cracks in the less solid rocks along the ocean shore line.
	◁		B	1906	Lawson and others, 1908, p. 174.	(Eri Higgins.)--My house faces west. The east part was moved 6 inches south, breaking water and sewer connections. The west end of the house did not move. Goods on shelves were thrown from the north side, but not from the south side. All brick buildings in town went down except two, and these were damaged.

TABLE 9.—Specific descriptions of ground failures in the north coast counties region—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
317			B	1906	Lawson and others, 1908, p. 172.	<i>Cleone, Mendocino County.</i> * * * All sway-braces on the wharf had to be replaced, and the railroad track was buckled in many places. The bridge across the lagoon sank 3 feet in some places, and was thrown out of line laterally, all the piling supporting the bridge being listed to the south.
318			B	1906	Lawson and others, 1908, p. 172.	<i>Inglebrook, Mendocino County</i> * * * On the banks of a small lake in the sandhills between the town and the ocean, some alders and willows fell owing to a slumping of the banks.
319			C	1906	Lawson and others, 1908, p. 174 and 175.	In the bed of the Ten-Mile River, 10 miles north of Fort Bragg, where level surfaces occurred before, there were noted after the earthquake funnel-shaped depressions resembling extinct volcanoes in miniature. These were only a few feet in diameter.
320			C	1906	Lawson and others, 1908, p. 172.	<i>Westport</i> * * * Large cracks were made in the ground, and after the heavy rains of this winter (March, 1907), large landslides occurred.
321			C	1906	Lawson and others, 1908, p. 172.	<i>Hardy</i> * * * The earth cracked, both upon the mountains and near the creek, where the earth was broken away from the banks.
322			C	1906	Lawson and others, 1908, p. 172.	<i>Monroe, Mendocino County</i> * * * Fissures opened in the mountain sides, and during the present winter (March, 1907) many large landslides have resulted from these openings. [Located 7 mi. northeast of Rockport according to Board of Geographic Names, Washington D.C.]
323			C	1906	Lawson and others, 1908, p. 170.	On the east bank of the main Eel River, to the east of Laytonville (A. S. Eakle), the ground was cracked for a distance of 300 yards, the trend of the crack following the course of the river. The crack was merely local in the alluvial bank of the stream, perhaps 100 yards from the water. A long bridge crossing the stream at this place showed no effects of the shock * * * .
324			B	1906	Lawson and others, 1908, p. 171 and 172.	Just north of W. Geforth's house is a crack 1,000 feet long, trending N. 55° E., and following roughly a low ridge running out from the main hills. It cuts almost at right angles to the main hills and is in soft material which has little slope. It could hardly be an ordinary slide. On the top of the ridge [Poonkinney ridge?], where the soft streak crosses the hills at an elevation of about 1,000 feet above the river, is a crack about 50 feet long just below a low sandstone knob, trending northwest partly across the draw at a considerable angle with the crest of the hills. It is irregular and shows no displacement of any kind. It could hardly be a slide. Still farther north, just beyond E. Gevire's house [not plotted on map] and about 5 miles from Robbins, is another crack trending northeast. It is probably a slide. Mr. Gevire stated that there were several slides in the hills on all sides of his house, but no other cracks were reported to the north. To the south the cracks extended to the river, but none were known south of the river. About a mile farther west, at Poon Kenney, several more short cracks were reported trending northerly but varying in direction, and not connecting along their trend, but I could not find any of these. About 6 miles north of the bridge on the Eel River, at a sheep camp called Hole-in-the-Ground [not plotted on the map], there are said to be a great many cracks running in various directions, but I did not visit them. On the whole, I believe that these cracks were all due to the earthquake, but that they are nothing more than surface cracks due to the jar. They occur only in the soft strips of weathered sandstone and where they seem to be related in trend they also seem to follow the strike of the rocks.

TABLE 9.—*Specific descriptions of ground failures in the north coast counties region—Continued*

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
325		C		1906	Lawson and others, 1908, p. 171.	One mile farther west toward the Eel River, a crack crossed the road toward the north. There is a strip of soft sandstones and shales thru here resembling that found at the Horse Ranch [loc. 330] and striking to the northwest. In this strip numerous cracks were found, often trending northwest but varying considerably. Four of these cracks were visible, but others could not be found as the rains had healed them. It was said that the downhill or southwest side was sometimes higher than the northeast side. Only one of these cracks could be ascribed to a slide. The other three might very well have been due to the shock.
326		C		1906	Lawson and others, 1908, p. 171.	Several cracks were reported crossing the road from Covelo to Laytonville near the top of the hill to the north of Middle Eel River. They are said to continue at irregular intervals for a mile or more to the north or slightly north of west. They generally trend north to northwest, but vary considerably.
327		C		1906	Lawson and others, 1908, p. 170.	There were a great many earth cracks formed in the Round Valley region. Some were examined, but many had been obscured by the winter rains, while others were not visited on account of the heavy rain which set in and made it impossible to cross the streams or get about in the hills.
328		C		1906	Lawson and others, 1908, p. 171.	No cracks were found between Dobbins and Covelo.
329		B		1906	Lawson and others, 1908, p. 171.	The extension [of loc. 330] should pass fairly close to the road from Covelo, but none of the ranchers along the road knew of any cracks in the hills until Dobbins' place was reached, 10 miles southwest, on section 14, township 23 N., range 13 W. Here a crack 600 feet long, trending N. 25° W., occurs on a bench 150 feet wide, made up of soft alluvium gravel, etc., bounded on the northeast by a steep hill of serpentine; in the southwest by a steep slope to the creek 200 feet below, and on the northwest and southeast by bedrock ridges. The crack occurs near the outer edge of the bench and the creek (southwest) side is a few inches higher than the hill side. It does not continue into the hard rocks at either end. Between the creek and the hill the ground is soft, miry, and full of springs, while at the edge of the hill irregular cracks are sometimes seen, showing that the muddy flat had likewise settled relative to the hill and indicating that the soft central area had settled relative to the hard, dry slope toward the creek and the bedrock of the hill. The crack runs under the cabin where there was the greatest movement, but tho the cabin is on four pegs, it was not disturbed.
330		A		1906	Lawson and others, 1908, p. 170 and 171.	About 20 miles north of Covelo, about section 2, township 24 N. range 14 W., on the Horse Ranch, and about 700 feet above the north fork of the Eel River, is a crack about 40 feet across and 600 feet long. At the southeast end a ridge of massive sandstone makes that part of the terrace somewhat wider. At either end are small gullies. At the back, to the northeast, a rather steep hill of sandstone rises abruptly from the terrace. Below, to the southwest, the terrace ends in a steep slope which shows evidence of repeated sliding and has several springs near its base. There are no trees on this slope, but the hill back of the terrace is covered with trees and there are some trees on the terrace, mostly on the hill side of the crack, altho several oaks 8 inches in diameter are on the side toward the river. The main crack is about 400 feet long. It is indistinct and disconnected at the northwest end, but gradually becomes more prominent till it reaches a point just beyond the center where the river, or southwest side, is 6 inches higher than the hillside, and there is an open gap of about 8 inches. It then begins to die out and upon reaching

TABLE 9.—Specific descriptions of ground failures in the north coast counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						the sandstone ridge turns about the edge of the ridge and continues about 100 feet more in the shape of irregular cracks along the ridge. * * * The hills for a considerable distance on all sides of this crack are covered with old slides.
331		☒	C	1906	California Department of Water Resources, 1971, p. 41.	An unpublished report in the files of the Northwestern Pacific Railroad refers to a large slide on the Eel River near Island Mountain which blocked its flow in April 1906. The slide was attributed to the San Francisco earthquake, but the exact date of the sliding in April is unknown. According to an article in a Eureka newspaper, the Humboldt Standard of April 26, 1906, the earthquake was distinctly felt in the Alderpoint-Fort Seward area and reportedly "stopped the water in the river". This may be in reference to a temporary blockage upstream, perhaps the slide at Island Mountain referred to in the railroad report.
332	←☒→		C	1906	Lawson and others, 1908, p. 387.	The most notable of the earth-avalanches occurred where the sea-cliffs are highest and steepest. This happens on the coast of Humboldt County, between Cape Mendocino and Point Delgada. Not only are the cliffs here particularly favorable for large earth-avalanches, but the coast here is close to the line of the fault which caused the earthquake, and so received an exceptionally severe shaking. For many miles of coast there was a general slipping of rock and earth into the sea, down very precipitous sea-cliffs ranging up to over 2,000 feet in height. Between Shelter Cove and Point Arena, the sea-cliffs are not so high nor so continuous, but there was nevertheless a very general, and locally large, shedding of material from their face; and the sea was muddy for many days after the earthquake in consequence of the defection of the debris upon the shore, within range of the attack of the waves.
333		☒	B	1906	Lawson and others, 1908, p. 58.	On the south side of the cove [Shelter Cove] there are three parallel deep gorges which extend a short distance into the hills; and their continuation over the hills is shown by slight depressions which appear to have been clefts which have become almost filled with the wash of the hills. Along all these lines of weakness fissures were opened and the ground subsided 2 to 3 feet. Cross fissures running from one depression to another are also present. The trend of the main fissures [fault?] followed the coast, which is northwest-southeast. On the high crests of the Cooskie and King Mountains, [see loc. 332] which border the coast north of the town, fissures and landslides were reported by ranchers looking for cattle, but this region was not visited. In the range south of the cove landslides were also reported and a photograph of a large one was taken.
		☑	A	1906	Lawson and others, 1908, p. 56, fig. 10.	[See fig. 10 at end of tables.]
		☑	B	1906	<i>Weekly Humboldt Times</i> , 1906a.	At Shelter Cove * * * the severe shock at 5 o'clock, with the help of the ocean waves, washed about twenty acres of land near the wharf into the sea, leaving a deep depression. The wharf road from the top of the bluff to the warehouse is completely destroyed by a huge slide, making it impossible to reach the wharf even on foot. * * * a chasm over a foot wide was made within a few feet of the hotel. The roads are blocked with fallen trees everywhere out this way.
334		☑	B	1961	Coffman, 1973, p. 180.	1961. April 5. Off coast of northern California. Felt principally in Humboldt County. At the Bear Harbor Ranch, about 10 miles south of Ettersburg, a 50-yard slide occurred. Magnitude 5.0.

TABLE 9.—Specific descriptions of ground failures in the north coast counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
335			C	1906	<i>Weekly Humboldt Times</i> , 1906a.	Briceland was more badly shaken up than this place [Garberville]. J. W. Bowden's store and Ben Harris' hotel were both moved from their foundations, and the store was badly twisted and shaken on one side. A fissure some inches wide runs the length of one of the streets.
336			C	1906	<i>Weekly Humboldt Times</i> , 1906a.	Miranda. The river became very muddy and the ground was cracked in places as much as two feet across and for several hundred yards in length.
337			B	1906	Lawson and others, 1908, p. 58.	South from Hadley's ranch at Big Flat, the precipitous mountain slopes have been destroyed by extensive and high landslides, the dislocated materials of which have frequently advanced out upon the beach in the form of glacier-like tongues. The waves at high tide have since nipt these protruding masses and truncated them at their ends. Many of the slides occurred apparently on the sites of older ones. Their continuity and extent made the discovery of the fault in this neighborhood impracticable. The prevalence of great slides along the coast, back inland, seems to suggest the possibility of the fault curving along the coast * * * .
338			B	1906	Lawson and others, 1908, p. 169.	<i>Petrolia, Humboldt County.</i> * * * Cracking of the land occurred along the edge of the river in close proximity to the hotel * * * A note from Mr. Blackburn regarding this same town says that the only place which is reported to have suffered relatively more than Ferndale is the little town of Petrolia, on the Mattole River; * * * the earth cracked very much and made wide fissures; many slides occurred and the shock was heavier.
			B	1906	<i>Weekly Humboldt Times</i> , 1906c.	Petrolia Badly Hit. The ground from the North Forks to the edge of town is furrowed, just as though it had been plowed. On the river bar near town the ground opened and water shot high in the air. One end of the approach to the North Fork bridge has settled one foot. The steel bridge across Cook's gulch [near Upper Mattole] settled at one end a foot and a half. Both bridges are passable.
			B	1906	<i>The Ferndale Enterprise</i> , 1956.	At Petrolia. * * * Cracks in the earth are noticeable in many places. * * * The bridge near Levant Cook's place sunk at one end about 18 or 20 inches. Across the river from Petrolia a huge slide occurred, the mountain side partly going into the water and throwing a dam half way across the stream.
			C	1923	Wood, Allen, and Heck, 1939, p. 19.	1923 January 22. IX. Upper Mattole and Petrolia, where most of the chimneys fell and there were many aftershocks. Bad slides on nearby roads.
			C	1906	<i>Weekly Humboldt Times</i> , 1906a.	Upper Mattole. * * * The waters of the Mattole river were splashed two or three rods each side of the natural channel along the valley. The roads are cracked and contain many piles of rubbish and gravel. Thousands of tons of dirt and rocks have slid over precipices.
			C	1968	Coffman, 1973, p. 184.	1968. June 25. Petrolia-Honeydew area. * * * At Petrolia, minor landslides were noted and the press reported large ground cracks along the Mattole River.
339	67A 67B		A	1906	Lawson and others, 1908, p. 390 and 391, plate 127A, plate 127B.	<i>Cape Fortunas</i> [False Cape] <i>earth-slump</i> (F. E. Matthes).--This landslide, immediately south of Cape Fortunas, is by far the most extensive one on the northern coast. (See plate 127A, B.) In May, 1906, it projected into the ocean for about 0.25 mile, like a hummocky headland of irregular outline; indeed, it formed a new cape on the coast-line, but will doubtless rapidly be cut back by

TABLE 9.—*Specific descriptions of ground failures in the north coast counties region—Continued*

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						<p>the action of the waves. Its length, in the direction of its movement toward the ocean, is estimated at little short of a mile; its width varies from 0.25 mile to 0.5 mile. Its total descent, from the summit of the higher scarps at its head to the level of the sea, is probably less than 500 feet. Its surface is exceedingly irregular, with many large humps and hollows. Over large areas the sod is more or less rhythmically broken by deep cracks extending at right angles to the direction of movement. These cracks are only a few feet apart, and the sod-blocks between them lie mostly in tilted attitudes, making the area exceedingly difficult to traverse. The general aspect is not unlike that of a much crevassed glacier. In some places, however, the mass seems to have been torn apart so completely that the sod is not merely broken but almost swallowed up or buried, the browns and yellows of the under soil being the prevailing tints. Around its head are a number of steep scarps, from 100 to 200 feet high. They are especially prominent on the north side, and again toward the southeast; but over considerable stretches between these two sets, the broken surface of the slide joins the unbroken hillsides to the east without significant offset. Owing to this, the slide is easily approached from the wagon road (from Centerville to Cape Town), which passes close by its head. The longitudinal profile of the landslide is one of gentle slopes for the most part; its declivity is not at all great, and in a few places even reversed slopes occur. Its noteworthy feature is not its vertical drop but its great forward movement. In a sense it has flowed like a partially plastic mass, expanding and advancing 0.25 mile beyond the coast-line, but descending only a few hundred feet.</p> <p>In its general aspect, as well as in the nature of its movement, the Cape Fortunas landslide is altogether different from those observed farther south, particularly along the mountainous coast both north and south of Point Delgada, which, in effect, did little else than revive a series of old landslide facets. This may not be apparent to an observer on the beach, but is quite striking when the coast is viewed in its entirety from a vessel off-shore. These facets existed before this earthquake, and had been recognized as such. They are conspicuously outlined against the dark timbered slopes behind them, rising from 1,000 to 2,000 feet above the shore, and affording an important series of landmarks for the mariner. In strong contrast with these bold mountain forms is the region in which the Cape Fortunas landslide took place. The land here can scarcely be called mountainous; and while it breaks off in cliffs at the coast and is traversed by many fairly deep draws, it is essentially a region of subdued relief. Great declivities are notably absent, except in the sea-cliffs, and even these are only a few hundred feet high. At the same time, evidences of former landslides may be seen on every hand. They are not extensive, as a rule, and are as likely to occur on gentle slopes as on steep ones. In a few cases only is a marked downslip noticeable, resulting in the uncovering of a steep scarp; in nearly every instance the dislocated mass appears not so much to have sheared off and dropt from its former position, as to have expanded or slumped, with an accompanying subsidence of its surface. The billowy and irregularly pitted appearance of these areas, together with the rank vegetation that covers them, afford the principal marks of identification. Both from their characteristic form, suggestive of plastic flow, and from their mode of occurrence, it seems reasonable to infer that ground-water plays an important rôle in their genesis. They are apparently masses which have changed their shape in obedience to a lessening of cohesion in their interior, through saturation with water. Whether the movement be initiated by an earth-tremor or not, it is in every case essentially an adjustment to a more stable position, rendered necessary by a change in the physical constitution of the mass.</p> <p>It is to this category of landslides that the one at Cape Fortunas belongs. While there are scarps in various places at its upper end, these are really insignificant features alongside of the extensive</p>

TABLE 9.—Specific descriptions of ground failures in the north coast counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
						tract of the slide itself. What downslopping occurred on these scarps was merely an incident in the entire movement. Both in the large ratio between its horizontal advance and its vertical drop, and in its general appearance, the Cape Fortunas landslide is closely analogous to the numerous lesser slides referred to; and there is good reason for the belief that, like them, it consisted essentially of an adjustment of equilibrium in a partially water-saturated mass. It probably had long been imminent before the earthquake started it.
	☑	A		1906	Lawson and others, 1908, p. 167.	Near the False Cape it threw the old hill, on which the Oil Creek coast road ran, out into the ocean for 0.5 mile. It is estimated that 200 acres were thrown into the ocean. Quite a number of cattle went with the hill. The slide is said to have obscured the view of Cape Mendocino light from Trinidad heads.
	☑	A		1906	Jordan, 1907, p. 296 and 299.	11. <i>Landslips, etc.</i> In the meiseoseismal area, there were a great many cases of mountain slides. The most remarkable among these was that which occurred near Cape Fortuna (False Cape), where an enormous quantity of debris was detached from a mountain side and was pushed into the ocean, creating a new promontory of about 3/4 mile length. [The name Cape Fortunas was officially changed to False Cape on Dec. 14, 1939, Board on Geographic Names, Washington D.C.]
	☑	A		1906	<i>The Ferndale Enterprise</i> , 1956.	At the Woodland Echo dairy ranch, just this side of Oil creek on the Centerville beach, a large mountain slid into the ocean and now extends into the water for a distance of probably a half mile, completely obstructing the view of the Cape Mendocino and Table Bluff lights, which before the upheaval were plainly visible to each station. On this mountain at the time of the quake were four or five head of cattle, and they are reported to have been wiped out of existence. The road leading from the Woodland Echo ranch to Ferndale has been completely obliterated near the slide.
340	☒ ○ ● ⋮	B		1906	<i>The Ferndale Enterprise</i> , 1956.	At the rear of A. Boyd's residence at Port Kenyon a large field bordering Salt river was spread open in many places, several acres of the land settling a couple of feet. From its appearance it would seem that water spurted in large quantities from the ground. On the north bank of Salt river at the lower bridge the land has slid in and cracked for a distance of several hundred feet and to a width of thirty or forty feet. The bridge itself does not seem to have been damaged any and is presumably in as good condition for travel as before the shock. All along Salt river, on either side, but more especially on the south side, fissures can be noticed, and in some instances of several feet in width, and we are told by those who have tried probing the gaps that they appear to be practically bottomless.
	☒	C		1906	<i>The Humboldt Times</i> , 1906.	At Fort Kenyon a vegetable garden turned into a lake, the water being a depth of about two feet.
	☒	B		1954	<i>The Humboldt Times</i> , 1954b.	[Ferndale] Structural damage was reported at Rings Pharmacy, where the building settled. * * * across the street a similar structural damage occurred to the Martin and Bettiga fountain.
341	☑	C		1906	<i>Weekly Humboldt Times</i> , 1906c.	On the Wildcat road, one and a half miles from Ferndale, the road was filled in by a big slide, but will be opened for travel today.
342	⋮ ☒	C		1906	Lawson and others, 1908, p. 167.	At Dungan's Ferry, on the north bank of the Eel River, the ground was full of fissures. Every bar on the river had been opened by fissures, and the gravel toppled over leaving big ditches, some 6 feet deep and over 500 feet long. Coming up on the mainland the road had dropt about 2 feet in one place and was full of small

TABLE 9.—Specific descriptions of ground failures in the north coast counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		<p>fissures. A 40-acre field was entirely ruined. It was heavily fissured, having dropt down in strips from 2 to 6 feet wide, from 4 to 6 feet deep, and from 5 to 500 feet long, the fissures pointing between south and southwest. All the fields were full of quicksand volcanoes, some 1 to 3 cubic yards in size. They were perfect miniature volcanoes, every one having a crater. It is said they extended 30 miles up the river.</p> <p>On the flood plain of the Eel River to the north of Ferndale, Professor Eakle reports that the ground was cracked for a distance of 0.25 mile on the west bank of the river. The cracks were in close vicinity to the river, and seemed to be on the line of an old channel. A series of parallel cracks, some having a vertical displacement of 2 feet, the surface being uplifted and deprest, followed the trend of the river and were evidently local in the soft alluvium. At the time of the earthquake water and sand spouted up in several places thru openings which were in some cases 4 inches wide. Mr. Blackburn reports that this water remained on the surface of the fields for some time after the earthquake. In this same connection, Mr. J. A. Shaw reports that "a field on a high bar near the Eel River was literally shaken to pieces, and water filled with quicksand was ejected several feet high. The rents run from north and south in a curve to east and west. Some parts are actually cut into squares. The jump vertically will reach 2.5 feet. There were no such large rents thru the valley generally, as the upper soil rests on a clay foundation which seemed to stand it all right."</p>
		C	1906	Lawson and others, 1908, p. 168, plate 138A, plate 138B.	
343			C	1906	<i>Weekly Humboldt Times</i> , 1906b.	The Scotia [railroad] line went out of commission by reason of a slide at the bluffs and the breaking of two of the heavy lateral rods on the Van Duzen Bridge.
344			C	1906	<i>The Ferndale Enterprise</i> , 1956.	Cock Robin Island came in for its share of the shake, chimneys being torn down and many holes and cracks in the ground made. The same destruction visited Cannibal Island, it being said that the land there that was quite high before the shake-up is now lowered from one to ten feet, while low places have been filled up. In many instances where the ground opened a kind of black sand or sediment oozed forth, showing that it must have been thrown from the very bowels of the earth. On the Hammer ranch on the Island, under lease to Rasmus Nielsen, we are told that this sand or sediment was very warm and that smoke arose from it for several hours after the convulsion.
		C	1906	<i>The Humboldt Times</i> , 1906.	On Cannibal island the earth trembled and cracked but the report that mud and water issued from the fissures and rose in the air 100 feet could not be verified.
345			C	1932	Coffman, 1973, p. 168.	1932. June 6. <i>Humboldt County</i> . * * * at Eureka Slough [loc. 349], a railroad drawbridge was put out of commission; at Loleta. small cracks appeared in the ground and a brick wall fell. Cracks 28 inches wide and several hundred feet long were observed on Cock Robin Island [loc. 344].
346			B	1906	Lawson and others, 1908, p. 166.	<i>South of Eureka</i> (H. H. Buhne).--A few days after the quake everything lookt all right along the road, excepting chimneys, until I reached Field's Landing, at South Bay. Here the shock opened a fissure over 100 feet long in the middle of the road, which 6 teams spent one day in filling. Pelican Island, as it is commonly called, opposite Field's Landing, dropt 3 feet at the point where the United States pile beacon stands. It left the beacon landing at an angle of 45° from the southwest.

TABLE 9.—Specific descriptions of ground failures in the north coast counties region—Continued

Loca- tion No.	Fig- ure No.	Fail- ure type	Accu- ra- cy	Year of earth- quake	Reference	Quotation
		○	B	1906	<i>The Humboldt Times</i> , 1906.	At Field's Landing around the home of John Johnson, small cracks in the earth became geysers throwing out warm water for several hours, the flow finally abating about noontime. In front of the hotel on the county road many cracks were in evidence but they finally closed up. A little beyond the Landing in the county road was a crack about 18 inches wide and twelve to fourteen feet long. A nine-foot stick failed to touch bottom and teams were busy all day to fill up the gulch.
347	☒		B	1906	<i>The Humboldt Times</i> , 1906.	Many are the reports of sinking in various sections but out the Elk river way it heaved up, breaking the water mains of the Eureka Water Company running through the Feckelstein place and the Russ claim.
348	□		C	1908	Coffman, 1973, p. 162 and 163.	1908. August 18. Eureka. * * * At Freshwater, a few miles north of Eureka, walls cracked, chimneys fell, and soft ground fissured.
	□		C	1908	Townley and Allen, 1939, p. 150.	1908 August 18. * * * VIII. Humboldt Bay. * * * Reports from the Seazy ranch, near Freshwater, six miles north of Eureka, state that the earthquake caused a big fissure in the earth for about one-half mile.
	□		C	1906	<i>Weekly Humboldt Times</i> , 1906.	Damage at Sweasey Ranch. * * * quite a good deal of water pipe across the slough had been broken, and in many places the road was cracked.
349	✕		B	1853	Holden, 1898, p. 41.	1853. October 23; VIII. Three heavy shocks at Humboldt Bay, Cal.--J. B. T. At Eureka * * * the wharf sank 4 feet.
	□		B	1865	Townley and Allen, 1939, p. 45 and 46.	1865. October 1. 7 a.m. IX. Eureka. Heavy Shock. * * * "Fort Humboldt, a few miles below Eureka on the Bay, was even more roughly handled; all fort buildings were injured and there was a fissure along the edge of the parade ground." [Also in Coffman, 1973, p. 157.]
	◊ □ ○ ✕		B	1906	<i>Weekly Humboldt Times</i> , 1906b.	GREAT GAPS IN THE EARTH. At the home of R. L. Haughey, the shingle manufacturer, was a scene of havoc after the earthquake had passed. A recent addition to the residence was torn loose and moved a foot to the southward, and at the same time sank about four inches. Another part of the dwelling also shrunk away from the main structure and took a little drop. Cracks were in evidence in the earth all around the property when the gentlemen got out of the house, and water was spouting up through them. The cracks were about ten inches wide, but during the day they closed up, and last evening were only about four inches across. AT THE EUREKA FOUNDRY. * * * the ground surrounding the plant was cracked by the tremor of yesterday morning. The ground sank materially also in places.
	☒		C	1906	<i>Weekly Humboldt Times</i> , 1906b.	The large water mains of the Eureka Water Company are badly twisted * * * .
	☒ ✕		C	1954	Coffman, 1973, p. 176.	1954. December 21 and 30. Eureka-Arcata areas. * * * In the poorly consolidated ground areas north and east of Eureka there were some pipeline failures, and Eureka's main water reservoir was cracked. A large section of the older, downtown filled area of Eureka settled from 2 to 6 inches.
	□		B	1954	<i>The Humboldt Times</i> , 1955.	[Picture caption] * * * the big shaker left this giant-sized fracture in the city's surface on Hawthorne street near Broadway. The crack's depth was unrecorded, but it measured up to 12 inches wide.

TABLE 9.—Specific descriptions of ground failures in the north coast counties region—Continued

Location No.	Figure No.	Failure type	Accuracy	Year of earthquake	Reference	Quotation
		■	B	1954	<i>San Francisco Chronicle</i> , 1954b.	[Picture caption] The Eureka quake opened a crack 5 feet deep in Hawthorne Street near Highway 101.
350		✕	B	1906	<i>The Humboldt Times</i> , 1906.	At Samoa. * * * where the Vance Company has its mill and warehouses. * * * one warehouse * * * The ground sunk beneath it several feet. The floor of the planing mill sank several inches on the east side and some are of the opinion that the factors settled also at one wall.
		■	B	1954	<i>The Humboldt Times</i> , 1954b.	Hammond Lumber Company brought its operations to a sudden halt when several breaks occurred in the underground main of the company's fire protection system. A. O. LeFors, spokesman for Hammond, stated that the mill will not operate in Samoa or at its Eureka plants until repairs have been made.
351		◀	C	1954	<i>Blue Lake Advocate</i> , 1954.	At about the same time Chief of Police Lance Peithman related that the waters of Davis Creek parted and a 12-year-old boy barely escaped being "swallowed up by the earth." James Linier, fishing in the creek, managed to run free of a "sudden crack" in the creek at about mid-stream which, traveling rapidly from the east bank, dug a trench about a foot wide and three feet deep. Linier and a companion, Larry DeVore, 13, also of Blue Lake, were almost struck by huge boulders crashing down from the hills. Peithman said the banks of the creek caved in at the time of the quake [sic]. [See also <i>The Humboldt Times</i> , 1954a.]
352		■	C	1954	<i>San Francisco Chronicle</i> , 1954a.	A crack opened across U. S. Highway 101, the Redwood Highway, between Eureka and Arcata, about ten miles north, and highway patrols reported several slides [loc. 354].
		■	C	1954	<i>San Francisco Examiner</i> , 1954a.	Some damage was reported on Highway 101 north and south of Eureka. Traffic was not impeded however.
		✕	C	1906	<i>Weekly Humboldt Times</i> , 1906b.	The San Francisco and Northwestern and California and Northern were inconvenienced to some extent by the shock. The marsh land between here and Arcata sank in places, causing the morning train to come late, while the drawbridge suffered the lifting of its counterweights. Out in the valley one of the cuts on the Loleta side of the tunnel caved in and the passengers had to be transferred to a train on this side of the slide.
353		✕	C	1954	Coffman, 1973, p. 176.	1954. December 21 and 30. Eureka-Arcata areas. * * * Some water main breaks were reported in Arcata * * * .
		■	C	1927	Coffman, 1973, p. 167.	1927. August 20. Humboldt Bay. At Eureka and Arcata * * * Cracks appeared in mud and gravel, and there were landslides of moderate extent.
354		■	C	1954	<i>San Francisco Examiner</i> , 1954a.	A large landslide was reported thirty miles north of Eureka, between Trinidad and Moonstone. The Beatrice Bridge, eight miles south of Eureka, had undetermined damage.
		■	C	1954	<i>Blue Lake Advocate</i> , 1954.	The highway patrol reported "a few" minor slides south of Trinidad and south of Big Lagoon bridge.
		✕	C	1954	<i>San Francisco Examiner</i> , 1954a.	ROAD BUCKLES. There was a small slide between Trinidad and Moonstone Beach. Between Eureka and Arcata [loc. 352], the roadbed buckled as much as three-quarters of an inch, but did not crack; at Beatrice, repair crews were working on a bridge over the railroad where the footings had settled.

The following figures are those
referred to in the preceding tables:

Table 6, location 118

FIGURE 7.—Dam at Crystal Springs Lake showing cracks formed by the displacement (Taber, 1906, p. 310).

Table 6, location 179

FIGURE 68.—Map of landslide caused by the earthquake east of San Pablo (Lawson and others, 1908, p. 392).

Table 6, location 179

FIGURE 69.—Section of landslide shown in fig. 68, along the line A-A' (Lawson and others, 1908, p. 392).

Table 8, location 270

FIGURE 25.—Arrangement of ridges on tidal flat near Inverness. Map. (Lawson and others, 1908, p. 79).

Table 8, location 271

FIGURE 26.—Sketch of Inverness piers. Full lines show positions of piers after earthquake; broken lines show positions before earthquake. Dotted line shows shoreward limit of the shifting of bottom (Lawson and others, 1908, p. 79).

Table 8, location 271

FIGURE 27.—Diagrams with exaggeration of vertical scale, to illustrate deformation of Inverness piers by shifting of mud toward the shore. Bailey's pier above; Martinelli's below (Lawson and others, 1908, p. 79).

Table 8, location 302

FIGURE 14.—Profile of southwest side of South Fork of Gualala River, showing relation of fault to geomorphic features (Lawson and others, 1908, p. 62).

Table 8, location 303

FIGURE 13.—Map of valley of South Fork of Gualala River, showing relation of fault-trace to geomorphic features (Lawson and others, 1908, p. 61).

Table 9, location 333

FIGURE 10.—Map of country traversed by fault to north of Shelter Cove, Humboldt County (Lawson and others, 1908, p. 56).