UNITED STATES
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

FORESHOCKS AND AFTERSHOCKS OF THE GREAT 1857 CALIFORNIA EARTHQUAKE

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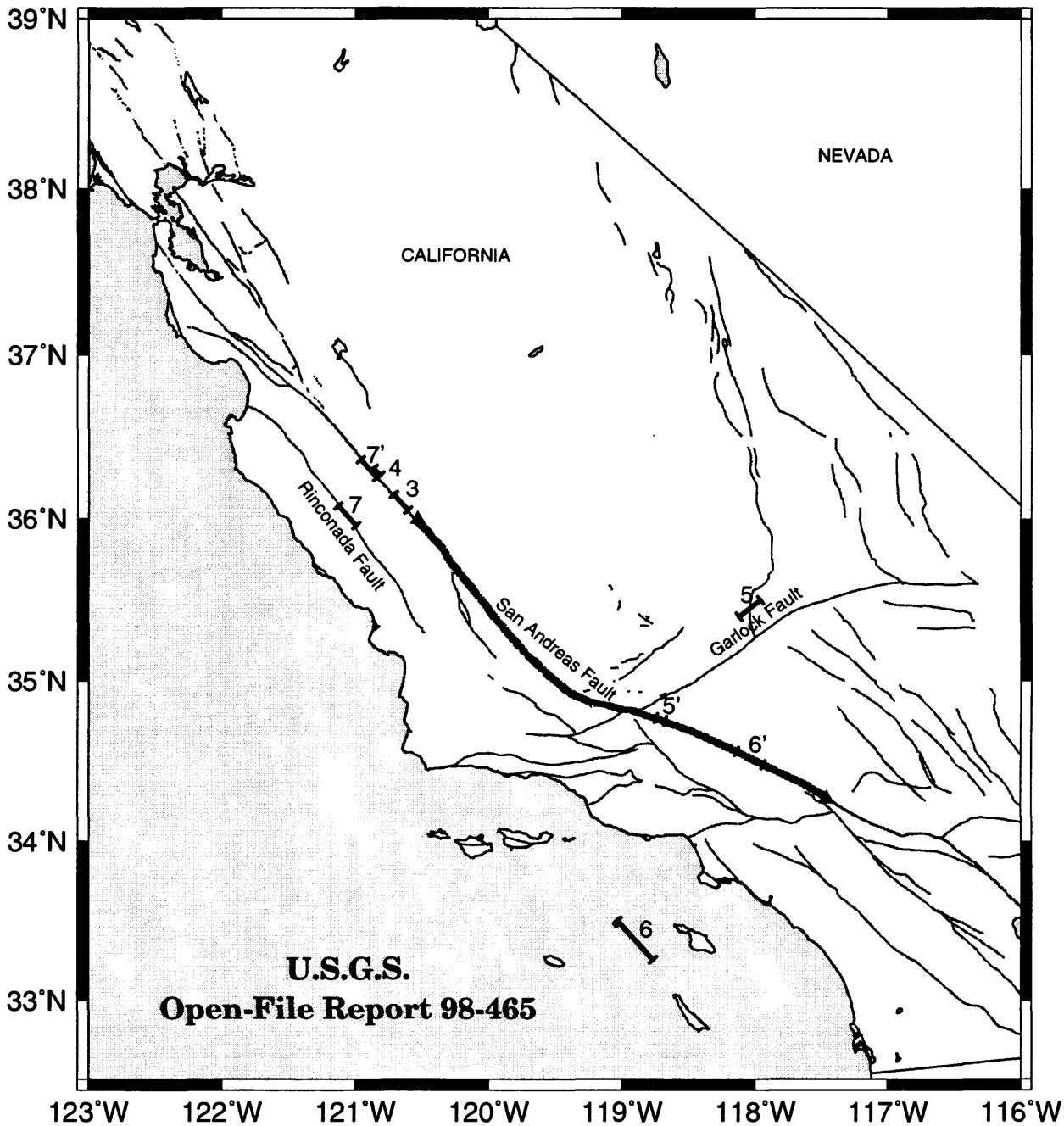

Pasadena, California
1998

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U.S.G.S. Open-File Report 98-465

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Abstract.

As part of a larger effort to understand more about the behavior of the San Andreas Fault through analysis of aftershocks to major San Andreas earthquakes, we have attempted to "map out" the largest foreshocks and aftershocks of the 1857 "Fort Tejon" earthquake on the central and southern segments of the fault. We searched carefully and systematically through archived first-hand accounts from 1857 through 1862, associated felt reports temporally, and assigned Modified Mercalli Intensities to each site. We then used the grid-search algorithm of Bakun and Wentworth (1997), derived from empirical analysis of modern earthquakes, to find the location and magnitude most consistent with these estimated intensities. Our analysis confirms the conclusions of Sieh (1978b) that at least two foreshocks ("dawn" and "sunrise") on or near the Parkfield segment shortly preceded the mainshock, and we estimate their magnitudes to be $M \approx 6.1$ and $M \approx 5.6$, respectively. The aftershock sequence was energetically low to average, compared with the number of aftershocks expected based on statistics of modern southern California mainshock-aftershock sequences. The most significant aftershocks included two events within just over a week of the mainshock, $M \approx 6.25$ and $M \approx 6.7$, near the southern half of the rupture, as well as a $M \approx 6$ event near San Bernardino nearly two years later, and a $M \approx 6.25$ event near the Parkfield segment in 1860.

INTRODUCTION

The San Andreas Fault (SAF) is the longest fault in California and one of the longest strike-slip faults anywhere in the world, yet we know little about many aspects of its behavior before, during, and after large earthquakes, because the two great historic earthquakes (1857 and 1906) occurred before the advent of many of the modern seismological tools we take for granted today. This is particularly true of the 1857 "Fort Tejon" (FT) earthquake, for which no seismometric recordings were made. (In contrast, the 1906 "San Francisco" (SF) earthquake was recorded at over one hundred seismic stations worldwide.) In this paper, we attempt to "map out" the foreshocks and aftershocks to the last major event on the central and southern segments, the FT earthquake of January 9, 1857; in a separate study we will do a similar analysis for the SF quake of April 18, 1906, the last significant event on the northern segment. The spatial and temporal distribution of aftershocks for both earthquakes will then be compared, and analyzed in the context of modern seismological insights into stress loading and redistribution as well as fault property heterogeneity.

Although a handful of aftershocks of the great 1857 quake are mentioned in various catalogs and articles (Townley and Allen, 1939, which was drawn largely from Holden, 1898; Agnew and Sieh, 1978; Sieh, 1978b; Agnew *et al.*, 1979; and Toppozada, 1981), no systematic search for aftershocks has heretofore been carried out, and none of the existing catalogs are complete, or as complete as they can be. The data for our study has been extracted mostly from preserved newspapers, diaries, and meteorological reports, with occasional supplements from the catalogs above. A number of the documents we used were taken from the appendix to Agnew and Sieh (1978), which contains, in addition to first-hand accounts describing the mainshock, references to foreshocks and to aftershocks in the first few weeks following the mainshock. A series of foreshocks were identified and discussed by Sieh (1978b), as were two large aftershocks within the first week; we started with a list of these events and expanded upon it.

DATA SOURCES AND COMPLETENESS OF DATA

Rupture during the great FT earthquake has been documented to extend from near Parkfield to near San Bernardino by Sieh (1978a). In looking for aftershocks, we searched any documents we could find in and around that geographical region. (Agnew, 1991, discusses newspapers in California in the latter half of the nineteenth century, and the Library of Congress, 1984, provides a useful index to any newspapers available in microform today.) The most valuable sources of information for our study came from Fort Tejon, located north of Los Angeles and 5-6 km from the SAF (in 1857, this was the closest population center to the fault rupture itself) -- these included a daily log of weather phenomena and disturbances (which included earthquakes), and the monthly reports to the superintendent, which often included a list of felt earthquakes. These lists continue until the abandonment of the Fort in June of 1861, and do not resume again until August of 1863.

Los Angeles also provided a regular source in the Los Angeles *Star*, which was published on a weekly basis uninterruptedly from 1851 through 1864, and other newspapers and diaries were checked on occasion. The letters to the U.S. Coast Survey superintendent from the Survey stations at Sycamore Valley and San Fernando, dated January and February, 1857, respectively (which were included in the appendix to Agnew and Sieh, 1978), do not appear to have been repeated, as no further earthquake reports appear in letters held in the Records of the Superintendent. Although San Bernardino had a newspaper beginning in 1860, no known copies of that newspaper still exist; nevertheless, there was a regular correspondent from San Bernardino to the Los Angeles *Star* who often reported on felt earthquakes in the area, and two diaries, both covering the year 1857, were checked. For San Diego, we used the list of earthquakes catalogued by Agnew *et al.* (1979), which is believed to be as complete as can be for the period.

Santa Barbara had a regular newspaper in the Santa Barbara *Gazette*, although no preserved copies appear to exist for dates after May 14, 1857,[1] and no other regular source exists for the Santa Barbara area. Information from the California Newspaper Project at U.C. Riverside (written communication, 1997) indicates that a paper under the title San Luis Obispo *Gazette* was published in San Luis Obispo from 1858 to 1860, although no preserved copies are known to exist for that paper either. Visalia had a regular paper beginning in June, 1859 (which underwent a series of name changes), but had no regular source before that. Mission records were also checked, but as a result of secularization in the 1830s, few records were kept, and none of what was kept was helpful in our search.

As for northern California, newspapers were checked from Santa Cruz, San Jose, San Francisco, and Stockton, although in these cases they were only checked on dates which corresponded to earthquakes in southern or central California, and for the weeks which followed. (It was assumed that an earthquake felt in northern California, but not anywhere in southern or central California, was not an aftershock of the 1857 FT mainshock.) Records for Fort Miller (near Fresno) were also checked, although nothing was reported besides the January 9th mainshock and a foreshock.

We chose May 1862 as a cutoff for the end of our search for aftershocks; this date (May 27) corresponds to a large earthquake which occurred in San Diego, and which was followed by many widely-felt and widely-reported aftershocks. In looking over the existing catalogs for the time, it was observed that no earthquakes were listed for the remainder of 1862 for southern California that were *not* felt in San Diego (with the exception of one *undated* event in Santa Barbara and Goleta). With Fort Tejon having been abandoned in June of 1861, it is believed that if there were any aftershocks to the FT quake this late in the sequence, they would have been buried in the San Diego sequence, and if that were the case, we would be unable to properly identify them.

A location map, showing the extent of mainshock rupture and all locations used as data points, is given as Figure 1. All primary documents relevant to our study are reprinted as Appendix 2B to

[1] Only one additional isolated issue, for February 11, 1858, has been located and microfilmed.

this article. A list of these sources appears as Appendix 2A. A table cataloging all reports of earthquakes in southern and central California (with some reports added for northern California) for January 8, 1857 through May 26, 1862 is given as Appendices 1A ("foreshocks") and 1B ("aftershocks"). It should be emphasized, however, that whereas the catalog for southern and central California is as complete as may ever be possible, it is *not* complete for northern California or elsewhere; specifically, a number of small, local earthquakes which were reported in various locations of northern California, but which did not coincide temporally with any reports from southern or central California, were *excluded* from our catalog. Hence we attempted to catalogue only immediate aftershocks, not triggered (or unrelated) distant events.

Contemporary reasoning estimates that shaking of intensity V (felt by all) would almost certainly be reported in a daily paper, and very likely in many weeklies, and intensity VI would almost certainly show up in both types; as for meteorological journals, intensity V would almost certainly have been reported, and lower intensities could have been as well, depending on the alertness of the observer (Agnew, 1991). Based on the *regular* sources that comprise our database, these estimates indicate that for Fort Tejon, shaking of intensity V or greater has, for the most part, been recorded for February 1, 1857, through June 30, 1861. For Los Angeles, most events of intensity V and greater should be recorded (and incidents of intensity VI and greater should *all* be recorded) for the extent of the aftershock period. For San Bernardino, our own judgment is that shaking of intensity VI and greater would have been reported entirely, especially for the year 1857, although one or two incidents may have slipped by. Agnew *et al.* (1979) used several sources in their compilation of the catalog for San Diego, one of which was the weekly San Diego *Herald*; intensity V and greater should typically be recorded (and incidents of intensity VI and greater should *all* be recorded) for the extent of the aftershock period; the same holds for Santa Barbara up until May 13, 1857, and for Visalia from June 18, 1859 onward.

Specifically, we feel that we have been able to identify (on our list of "noteworthy aftershocks," Table 8B), at the least, all of the following aftershocks:

- all aftershocks SE of the Carrizo Plain, Jan. 1857 to June 1861, M6.0 or greater
- all aftershocks SE of Fort Tejon, Jan. 1857 to May 1862, M6.0 or greater
- all aftershocks, on or near any portion of the mainshock rupture, M6.5 or greater

The list in Tables 8A and 8B, and likewise the catalog given in Appendices 1A and 1B, should *not* be considered complete below these magnitudes, although a number of smaller earthquakes are included in each. Additionally, it is uncertain whether or not we would be able to distinguish a distant moderate-sized event, such as a $M \approx 6$ near the Carrizo Plain (were one to occur), from smaller local earthquakes felt in southern California population centers, and it is unknown whether such an event would have been reported in Visalia or elsewhere.

TIME-KEEPING IN CALIFORNIA IN 1857

Imprecision in time-keeping. Looking through the various accounts of felt earthquakes (listed in Table 2B), it is clear that in some cases the witness or reporter was not concerned with precise reporting of the time the event was experienced. If the time was stated as "about 8 o'clock" this is clearly not precise, but even if the time is stated as "at 8 o'clock," we cannot necessarily assume that the word "about" is not implied. (On the other hand, "twenty seven minutes past 8 o'clock" or "8 o'clock sharp" are more precise times.) In other cases, wording may be even less precise ("in the morning," "at night," etc.). Some of the more vague cases occur in the Fort Tejon Meteorological Records (see Appendix 2B), where an event is listed as occurring on a particular date "during the night"; this probably means that it occurred in the early morning hours (midnight to dawn) of that particular day, although one cannot rule out the possibility of it meaning late at night (say bedtime to midnight) of that date, or even in the early

morning hours (midnight to dawn) of the following day. "At night," on the other hand, would probably mean any time from dusk to bedtime, although it may also have covered anything as late as midnight, or it could even have been used interchangeably with "during the night." Another point of confusion is the time "midnight," which is referred to three times in the Meteorological Records. In one case (March 27/28, 1858), the time (night of the 27th / morning of the 28th) is clearly stated, although in the two other cases, it is ambiguous as to whether "midnight" meant the very late night or the very early morning of the date in question.

Local time. A factor that must be considered in comparing reported times between separate localities is that all observers were using "local" time in 1857, as "standard" time was not adopted until the 1880s. Between San Francisco (at 122.43° W) and San Diego (at 117.10° W), for example, the difference in local time at any one instant is about 22 minutes (4 minutes per degree of longitude). Appendices 1A and 1B include a column which lists the reported times corrected to Pacific Standard Time (PST), which is actually local time along the 120th meridian.

Inaccuracy in time-keeping. We must also realize that, even when times are given precisely, they may not necessarily be accurate. Even with corrections for local time, reported times of the mainshock were as much as one hour early or two hours late of the "true" time, as reported by chronometer in San Francisco (Sieh, 1978b). And even within the city of Los Angeles itself, reported times varied by up to 30 minutes. As we cannot expect any more accuracy in reporting the times of the aftershocks than we can in reporting those of the mainshock, we should allow for such discrepancies when we attempt to associate felt reports temporally.

METHODOLOGY

Traditionally, historic earthquake magnitudes are constrained by estimating the area (square km) of a particular Modified Mercalli intensity value, for instance the area enclosing Intensity VI or greater, and relating this area to magnitude through empirical relationships derived from modern events (e.g., Toppozada, 1975). The epicenter is normally assumed to be near the center of the vaguely concentric isoseismal intensity pattern. It is impossible, however, to estimate the area of a particular intensity for 1857, because the population was sparse and the shaken regions often extended into the Pacific Ocean. But recent work by Bakun and Wentworth (1997) has extended the utility of past intensity observations by making use of them even in cases where few observations exist and where the felt area (or area of a particular intensity) is difficult to ascertain. By using twenty-two California "training" events, they developed a strategy for constraining both epicenter and magnitude for early California earthquakes, as well as for providing uncertainty estimates for these parameters, from sparse intensity observations alone. The procedure,[2] which we followed, is briefly summarized as follows.

First, we estimate the Modified Mercalli intensity from preserved reports of felt shaking and/or damage for each site. Next, we compute the best magnitude, M_I, and the total rms error between observed and estimated intensities, rms[M_I], for that magnitude for a grid of potential epicenters in the felt region. Here, M_I is the mean of M_i, and

$$M_i = [(MMI_i + 3.29 + 0.0206 * \Delta_i) / 1.68],$$

where Δ_i is the distance of observation MMI_i from the assumed grid point. The epicenter is bounded by the contours of

$$rms[M_I] = [rms(M_I - M_i) - rms_0(M_I - M_i)],$$

where $rms_0(M_I - M_i)$ is the minimum rms over the grid of assumed epicenters. For more details of the methodology and its derivation see Bakun and Wentworth (1997).

The potential epicenter is hence bounded by the rms[M_I] contours (for example, Figure 3, dotted black lines), and the level of confidence can be assigned to each contour based on the number of intensity observations. The rms contours corresponding to the 95%, 90%, 80%, 67%, and 50%

[2] The procedure given here is slightly modified from that discussed by Bakun and Wentworth (1997) -- namely, it is lacking distance and site corrections introduced by Bakun and Wentworth. See Appendix 4 for a discussion of modifications we made for our analysis.

confidence levels, for various quantities of MMI observations (based on the specific results of Bakun and Wentworth), are given in Table 1A. A further discussion on the values in the table is presented in Appendix 4. The "best" epicenter is assigned based on *both* the lowest rms error contours and tectonic considerations; that is, we look for tectonically-attractive locations in light of the rms contours.

The magnitude associated with a particular (potential) epicenter can be read from the magnitude contours (for example, Figure 3, white lines) for the grid. M_I at tectonically-attractive potential epicenters within the appropriate confidence-level contours are the best estimates of magnitude for those epicenters. However, for the earthquakes we are dealing with, there are two separate sources of uncertainty in magnitude, which we will here distinguish, and which we must assess separately in this paper. The first potential for error arises from uncertainties in the earthquake's location (which are inherent in Bakun and Wentworth's algorithm) and from the possibility of a report coming from within a geographic pocket of anomalously high or low intensity; this first potential for error is accounted for and statistically assessed by Bakun and Wentworth, with uncertainty in M_I appropriate for the different confidence levels and quantities of MMI observations listed in Table 1B.

The second potential source of error is more unique to our situation. Because many of the first-hand reports we are dealing with are vague (and in some cases have only a one-word description such as "severe" or "slight"), we have many cases where we are not completely certain of intensity for a particular location. In their algorithm, Bakun and Wentworth assumed intensity for each location was known unambiguously (even if it may have been anomalous geographically) and did not consider uncertainties in intensities. We must therefore address the question: *if our assignment of intensity was skewed from the "true value" -- either by a bad report or by our misinterpretation of a (vague) report -- then to what extent would our results be thrown off?*

The best way to deal with this issue is to be conservative, and to account for all possibilities. Whenever an intensity value is in question, we assign a *range* of values so that all possibilities are included. We then plot different versions of each map (not all are included in this paper) so that we have one version for each of the possible combinations of potential intensities, and we analyze the effect of varying the intensity values within our degree of uncertainty.

(For all but the 16 January aftershock, the maps presented in this paper are the "average" maps, generated using the average of possible intensity values for each location. Any variations from the given map resulting from uncertainties in intensity values are discussed in the paper. For the 16 January aftershock, however, we instead present the extremes, maps generated using the minimum, then the maximum possible intensities at the two sites where intensities are uncertain; compare Tables 6A and 6B.)

The end result is a series of maps showing a range of possibilities for both location and magnitude. We still pick the most tectonically-attractive epicenter as before, although for magnitude, we must subjectively determine (albeit by a straightforward process of looking at the magnitude for a particular location on each version of the map) the range of magnitudes possible for a given assumed epicenter, allowing for any and all uncertainty present in the intensity data.

Finally, we must combine the two sources of error and determine the overall uncertainty. We begin with the best magnitude and uncertainty as determined from the range of possible magnitudes considering *uncertainties in intensities*. We then "add on" an additional uncertainty (to allow for the uncertainty in epicenter and the possibility of geographically anomalous intensities) as determined in Table 1B for 5 intensity data points (or for 3, in the case of the "sunrise" foreshock). For this paper we are interested in the standard error associated with the 50% confidence interval (because the locations themselves are typically at no better than 50% confidence), and we can approximate the *total* uncertainty by adding an additional magnitude error of ± 0.2 (± 0.3 for the "sunrise" foreshock) to the error associated with the uncertainty in intensities. Although this is not a completely rigorous statistical approach, it gives us reasonable numbers as to the overall error at 50% confidence.

CALIBRATION

Although the method described above had been calibrated by Bakun and Wentworth using earthquakes with known locations and magnitudes, their data sets were typically much larger than those of the foreshocks and aftershocks of the FT earthquake, which consist of seven or fewer data points. We therefore conducted a series of tests in an effort to gain an understanding of the capabilities of the algorithm in cases when fewer intensity values were available. We created seven data sets each consisting of five intensity observations from the January 17, 1994, Northridge, CA, earthquake (taken from Dewey *et al.*, 1995; see Tables 2A, 2B, 2C, 2D, 2E, 2F, and 2G), which we mapped according to the methods of Bakun and Wentworth (see corresponding Figures 2A, 2B, 2C, 2D, 2E, 2F, and 2G). In all cases we were careful to choose data sets such that the geographical distribution of each set resembled that of the sparse population of mid-19th century California. Thus, we chose a "spread out" set such as one covering Santa Barbara, Avalon, San Diego, San Bernardino, and Visalia, as opposed to a more "localized" set such as Fillmore, Lebec, Palmdale, Granada Hills, and Los Angeles. A composite list and the associated map are also given for the 25 distinct intensity observations used in Tables 2A-2G (see Table 2H and Figure 2H).

To a limited extent, moving between the various sets of five values caused the point of least rms (the "intensity center") to wander and caused slight variations in the magnitude at both the intensity center and the known epicenter (in this case, knowing the epicenter can be analogous to our assumption that the foreshocks and aftershocks of 1857 occurred on the SAF, as discussed later in this paper). However, *in five of seven cases*, the true (known) epicenter falls *well* within the 50% confidence interval calculated by Bakun and Wentworth for five data points, and in the other two cases, it falls within or at the boundary of the 67% confidence interval. As for magnitude, *in all cases*, the magnitude at the known epicenter was either within or at the boundary of the 50% confidence interval. By these analyses and by previous work by Bakun and Wentworth, we determined that this method is useful for such sparse data sets, provided that we understand and remember that our results will be somewhat imprecise.

FORESHOCKS

The foreshock sequence for 1857 has already been analyzed extensively in a study by Sieh (1978b). In that study, Sieh identified a swarm of small foreshocks scattered across much of northern and central California in the early morning hours prior to the 8:24 am mainshock, as well as more widely-felt "pre-dawn," "dawn," and "sunrise" foreshocks in the region northwest of Parkfield, CA. He compared the geographical distributions of intensities from the two largest foreshocks ("dawn" and "sunrise") to those of more modern earthquakes, and then used intuition to locate the epicenters and assign approximate magnitudes. Although no new "original" data has been uncovered subsequently which relates to any of the foreshocks, we took another look at the "dawn" and "sunrise" foreshocks, and applied to them the methods of Bakun and Wentworth. For the late-night (January 8th) and very-early morning foreshocks, however, it remains unclear as to where each of them were felt, due to imprecision in timing in the reports, and we did not attempt to map the location or magnitude, or in any other way improve on the work of Sieh (1978b), for those early foreshocks. As best as Sieh could conclude, a large number of smaller foreshocks were felt over a scattered area of northern California during the night and early morning hours preceding the mainshock.

"Dawn" foreshock. The list of intensities is given in Table 3, and the associated map appears as Figure 3. The location of the intensity center implies an epicenter near that of the 1952 *M*6.0 Bryson earthquake on either the Rinconada or Nacimiento faults along coastal central California (see Figure 1 for location, or see Sieh, 1978b, and references therein, for further discussion), with a magnitude slightly larger ($M \approx 6.2$), although we see that the rms contours are elongated in a direction roughly

perpendicular to the SAF and to the coastline. This elongation occurs naturally as a result of the population distribution: there are intensity readings for locations within 80 km of both the coast and the fault which bound the rms contours from the northwest and the southeast, but there are no data points to bound the rms values from the northeast or southwest; the effect is elongation in the latter directions. In addition to the Bryson location, the 50% confidence interval (rms value 0.152) on the map in Figure 3 also includes the northwestern extent of the 1857 mainshock rupture and 40-45 km of the SAF to the northwest (and hence the locations of the Parkfield earthquakes of 1901, 1922, 1934, and 1966), as well as the epicenter of the 1983 *M*6.7 Coalinga earthquake.

Varying the intensity values as noted in Table 3 has very little impact on the results: the contour shapes remain elongated, the point of least rms *on the SAF* ranges from latitude 36.1° N to 36.2° N. In Figure 3, $M \approx 6.1$ along this stretch of fault, but alternative MMI selections allow the magnitude to wander between 6.0 and 6.3. We must remember, however, that this event was *not* reported as felt by Dr. Canfield 15-20 miles northwest of San Benito, which leads us to believe that a magnitude of 6.3 is too high (Sieh, 1978b). (A lack of a felt report, or a "not felt" report, is *not* accounted for mathematically by the method of Bakun and Wentworth.) If we assume the "dawn" foreshock occurred on the SAF, its most likely location, based on rms contours, is within the stretch of fault lying roughly 10 km to 30 km northwest of Parkfield. In this case we assign a magnitude of $M = 6.1 \pm 0.1$, with the "error" a consequence of uncertainty in intensities, although we must also allow for uncertainty in magnitude, as determined in Table 1B and as discussed earlier in this paper. Adding an additional error of ±0.2 for uncertainty in magnitude to the error determined for uncertainty in intensities, we get a magnitude of $M = 6.1 \pm 0.3$ (50% confidence) for the "dawn" foreshock. The location for this earthquake is consistent with Sieh (1978b), and this magnitude is at the upper end of the possible range he determined.

"Sunrise" foreshock. The analysis of the "sunrise" foreshock is a little more difficult, as many of the primary reports upon which we would need to rely for data for this foreshock are ambiguous and unreliable, and based on our analysis, it was considerably smaller than the "dawn" foreshock. Review of these documents (see Appendices 1A and 2B) reveals that all accounts at Fort Tejon (Documents 12c, 19, 38a, and 39b) report *one* foreshock at 6:00 or 6:30 a.m., or that the shocks *started* at 6:00 a.m., but no account at Fort Tejon specifically mentions an earthquake at sunrise or just after 7 a.m. The one report from Monterey (Document 32a) mentions only *one* earthquake at about 7 a.m. and describes long-period motion (which would contradict the description given by Dr. Canfield, 15-20 miles northwest of San Benito, of the "sunrise" foreshock), but says nothing of any later earthquakes -- it is more likely that the Monterey report was actually that of the mainshock, with the reported time in error by over an hour. All the reports from Santa Cruz should be regarded carefully, as the *Sentinel* appears in general to be ambivalent about the earthquake times it reports. Their initial report (Document 28a, 10 January) appears to be the most accurate; however, the *Sentinel* appears to have been convinced (possibly by the Monterey report, 32a) that its own observations of an 8 o'clock mainshock were in error, as in future articles (Documents 28b, d, and e), the editors kept modifying the reported times of the mainshock and foreshocks. They eventually reported (28e) the mainshock at 7:00 a.m., with a lighter shock later at 8 a.m., which contradicts both Dr. Canfield to the south and the San Francisco *Daily Sun* (the most reliable of all the sources) to the north. Curiously, the editors themselves indicated in an article on 31 January (28e) that they were not completely confident in their reported earthquake times. (For further discussion, see Note 2 in Appendix 2B under Source #28, or see Sieh, 1978b, pp. 1745-1748.) In San Jose there is a report of a foreshock (Document 29a) at about 6 a.m., and only by assuming an error of an hour or more could this be a felt report of the "sunrise" foreshock. Thus we have only three locations with concrete reports of an earthquake felt around sunrise: three reports from San Francisco, one by Dr. Canfield, and one from Visalia. It is not even

clear that this was one moderately-sized event as opposed to two or three local events. Nevertheless, we assume it is a single earthquake, and we attempt to estimate its magnitude and location, but we emphasize that there is no concrete evidence that *requires* a single event.

In an effort to consider all possibilities, we present *two* maps for this foreshock: the first uses the data *only* from those locations for which we have reliable felt reports, and the second incorporates *all seven* data points used by Sieh (1978b). Intensities are given in Tables 4A and 4B, and the maps appear as Figures 4A and 4B, respectively. The two maps are very similar; on both maps, the intensity center is in the Sierra Nevada mountains, between latitudes 37.5° N and 38.0° N. Yet this is unlikely, as the earthquake was *not* reported in the Meteorological Records at nearby Fort Miller. We see again that the rms contours are elongated (as in the "dawn" foreshock), although they are more poorly constrained north-to-south; if we assume the event was on the SAF, it would probably have been located between 10 and 100 km northwest of Parkfield, between latitudes 36.0° N and 36.6° N. The magnitude with error based solely on uncertainties in intensities is $M = 5.6 \pm 0.1$, although factoring in uncertainty in magnitude according to Table 1B gives us $M = 5.6 \pm 0.4$ (50% confidence, for 3 MMI values). This region of the SAF is characterized historically by creep, although recent work by Toppozada and Borchardt (1998) indicates the occurrence of a $M \approx 5.25$ along this portion of the SAF in 1855 (see Figure 1). Alternatively, Bryson and Coalinga locations fall *outside* the 50% confidence intervals of both maps, in Figures 4A and 4B. Our results are consistent with those of Sieh, although this may be a consequence of making many of the same assumptions that he did.

AFTERSHOCKS

9 January 1857 (night) aftershock; Scenario 1. The first significant aftershock occurred on the night of January 9th. On the first day and night following the mainshock, many aftershocks were reported across the state, but on that night many localities reported *one* aftershock that was particularly strong, between 10:26 p.m. and 10:53 p.m., PST. If we were to assume it was a single shock, it would appear to have been felt throughout southern and central California, as well as in Sacramento. Intensities are given in Table 5A, and the corresponding map appears as Figure 5A ("Scenario 1"). The map generated from this data tends to indicate a $M \approx 6.8$ earthquake on the SAF southeast of Parkfield or at the northern end of the Carrizo Plain, or a *stronger* event along the central California coast or offshore. Both of these scenarios are unlikely, however, since (1) such an earthquake would almost certainly have been felt and recorded by Dr. Canfield at his home northwest of San Benito, and it probably would have also been felt in the cities of Santa Cruz, San Jose, San Francisco, and Stockton; and (2) the effects of such an earthquake as far away as San Buenaventura (Ventura), Sycamore Valley (Sycamore Canyon, just west of Malibu), or Los Angeles would be those of long-period motion, in contrast to the actual reports of "momentary," "short," and "4 seconds" of shaking.

9 January 1857 (night) aftershock; Scenario 2. It seems more likely that the report in Sacramento was that of a smaller separate earthquake that occurred at approximately the same time as the one further south. We therefore discarded the data for Sacramento and re-plotted the map as "Scenario 2." Intensities for "Scenario 2" are given in Table 5B, and the corresponding map appears as Figure 5B; a number of other possibilities were also examined (not shown), as there were uncertainties in intensities at three of the five localities. (None of these latter plots included data for Sacramento.) In *all* of these cases, the intensity center occurs in the mountains northwest of the Garlock Fault, in a region bounded roughly by CA State Highways 14, 58, and 178. The 50% confidence intervals (0.152 rms contours) from each map together cover a slightly broader area, which includes much of the Garlock Fault west of longitude 117° W and the mountains to the northwest of that segment of the fault; the map in Figure 5B is typical. The magnitude estimate based on the magnitude at the intensity center on each map is $M = 6.25 \pm 0.3$, although incorporating the

algorithm's uncertainty in magnitude increases the error to $M = 6.25 \pm 0.5$ (50% confidence). In *none* of the cases, however, is any portion of the SAF included in the 50% confidence interval. Thus, if we assume that the felt reports from San Buenaventura, Sycamore Valley, Los Angeles, the Cajon Pass, and Visalia describe the same event, the most likely scenario is that of an earthquake on or near the Garlock Fault, probably triggered by the FT mainshock. Nevertheless, given the uncertainties in the intensity estimates, we should not rule out the SAF (with $M = 5.6 \pm 0.4$, 50% confidence, incorporating uncertainties both in intensities and in magnitude) or other potential sources in the region.

9 January 1857 (night) aftershock; Scenario 3. (No map plotted.) There remains at least one significant inconsistency with "Scenario 2": observations from the Tejon Indian Reservation are inconsistent with an earthquake of such magnitude on or near the Garlock Fault. Indeed, the Tejon Indian Reservation, 20 km northeast to east-northeast of Fort Tejon, at the mouth of Tejon Canyon in the Tehachapi Mountains, would have been the closest observation point to any location in the region of intensity centers determined in "Scenario 2." In "Scenario 2," for which we assumed a single earthquake was felt with intensity IV or V in Visalia, Sycamore Valley, and Los Angeles, and with intensity III to IV in San Buenaventura, one would expect the intensity at the Tejon Indian Reservation to be V or greater; yet in the daily journal of the Tejon Indian Reservation, only "ten slight shocks during the day" following the mainshock are noted for January 9th, suggesting that nothing was felt with intensity greater than III or IV. (Fort Tejon records are inconclusive on this matter.) Additionally, based on large uncertainties in the reported times, and the fact that numerous aftershocks were felt over much of California in the hours following the mainshock, it is not certain that the observations used in "Scenario 2" all described the same event; we must realize that temporally-coincidental locally-strong shocks on the night of January 9th are *not* unlikely. (Contrarily, we cannot assume every shock at Tejon Reservation was recorded. It is possible that the reporter at Tejon Reservation downplayed the intensity of the aftershocks, and that by "slight" he only meant that the aftershocks were less intense than the mainshock, or that the reporter filed his report before 10 or 11 p.m. and never made mention of the 11 p.m. aftershock; in other words, we should not discard "Scenario 2" solely based on the inconsistency of the report from Tejon Indian Reservation.) We therefore propose a $M = 6.25 \pm 0.5$ event on or northwest of the Garlock Fault, although we cannot be certain the event was quite that large or quite in that location. Alternatively, we propose a $M = 5.6 \pm 0.4$ SAF event, and still other scenarios are possible.

16 January 1857 (afternoon) aftershock. On the afternoon of January 16th, another significant aftershock occurred, which was felt in much of southern California. Although the reported times are spread out over nearly an hour (3:59 p.m. to 4:58 p.m., PST), all reporting localities indicate only one earthquake that afternoon. That only one moderately large earthquake is responsible for the reports is also suggested by the high intensities at widely separated localities. In particular, it was described in *both* Los Angeles and San Bernardino as the strongest earthquake since the mainshock, and besides the January 9th mainshock, it was the *only* reported earthquake for the month of January in San Diego.

The list of intensities is given in Tables 6A and 6B, and the corresponding maps appear as Figures 6A and 6B; once again, the rms contours point to a source off the SAF, although this time it is offshore. The intensity center ranges in the plots from 40 to 80 km southwest of the Palos Verdes Peninsula, and the 50% confidence intervals (0.152 rms contours) form broad ellipses, elongated in a southwesterly direction, as a consequence of being unbounded offshore. The SAF lies *outside* the 50% confidence interval on each of the maps, although the coastal areas of the Los Angeles Basin lie *within* the 50% confidence interval in Figure 6B. In the region of the intensity center on each map, the magnitude is within $M = 6.7 \pm 0.3$, and accounting for magnitude uncertainty yields $M = 6.7 \pm 0.5$ (50% confidence); however, if the earthquake occurred on the SAF, the magnitude would be $M = 6.3 \pm 0.3$ (50% confidence, accounting for uncertainties both in intensities and in magnitude).

16 April 1860 (evening) aftershock. Although this aftershock came late in the sequence, it was the *only* aftershock strong enough to stand out among our records for central California and the northern extent of the rupture. In general, it appears to have been a repetition of the "Parkfield" foreshocks (that is, the foreshocks on or near the SAF northwest of Parkfield), having been felt from Fort Tejon to Visalia to San Francisco. Intensities are given in Table 7, and a map appears as Figure 7. The intensity center is offshore, roughly 170 km WSW of San Luis Obispo, but again the rms contours are highly elongated perpendicular to the SAF, and the offshore location of the intensity center may result more from a lack of offshore data points than from any other factor. A Bryson location on the Rinconada (or Nacimiento) fault (again, see Figure 1 for location, or see Sieh, 1978b, and references therein, for further discussion) is possible, as the location would fall on or near the boundary of the 50% confidence interval, but a Coalinga location and locations on the SAF *fail* to fall within that interval. Nevertheless, a comparison of intensities in this earthquake with those in the "dawn" and "sunrise" foreshocks and in other, more modern Parkfield events leaves open the possibility of an event on the SAF. The main difference in the area of felt shaking in the 1860 aftershock is the lack of reporting sources from Santa Barbara, the Carrizo Plain, and northwest of San Benito. The Rinconada Fault location would correspond to $M = 6.25 \pm 0.3$ (50% confidence, accounting for uncertainties both in intensities and in magnitude); similarly, if we assume the earthquake occurred on the SAF, the associated magnitude would be $M = 6.2 \pm 0.3$ (50% confidence, again accounting for uncertainties both in intensities and in magnitude). Both the Rinconada fault and the SAF locations are shown on Figure 7.

Other aftershocks. There were nine aftershocks in addition to the three we mapped that were noteworthy for one reason or another. All twelve of these aftershocks are listed and discussed in Table 8B. (A list of the largest foreshocks is given in Table 8A.) All cases in which an earthquake was reported at about the same time in separate localities are included in the list. Sometimes they were clearly significant events, but other times it may simply have been a case of two small, local earthquakes occurring nearly coincidentally. In each case, the likelihood of it being a single event, as opposed to two or more "local" events, is discussed under the corresponding date on the list.

Two significant events on this list occurred near San Bernardino on the night of December 15, 1858, and the early morning of December 16. They were felt most strongly at San Bernardino (Modified Mercalli intensities V-VI and VII, for the December 15th and 16th events, respectively), although they were also felt rather sharply at Los Angeles (intensities IV and IV-V). Ellsworth (1990) estimates *M*6 for the December 16 event. Unfortunately, we are unable to plot a map for this event, as we need a minimum of three intensity data points (at three separate localities) for the map to be useful, but we can reasonably conclude that it was the strongest earthquake *in the San Bernardino area* in the years following the January 1857 mainshock.

We should re-emphasize that, although the "list of noteworthy aftershocks" in Table 8B is probably complete for aftershocks of *M*6 and over for the area southeast of Fort Tejon, and although it undoubtedly lists some aftershocks of lower magnitudes, this list should not be considered complete (for the entire extent of the 1857 rupture) below *M*6.5. In addition, it is possible that some of the "noteworthy" aftershocks on the list are $M \geq 6.5$ events but have not been identified as such.

FORT TEJON SEISMICITY

Because of the relative completeness of the seismic record at Fort Tejon for January 1857 through May 1861, it is worthwhile to discuss this record. If we assume that the background rate of seismicity at Fort Tejon for pre-1857 was the same as it is during a typical period of seismic activity in the region today, we can determine a lower bound for the duration of the FT aftershock sequence. Looking over the list of earthquakes, it is apparent that the rate at which earthquakes were felt at Fort Tejon was significantly higher, through September 1860, than

the rate today. One can argue as a consequence that the aftershock sequence continued through at least September 1860, although the significance of the absence of reported earthquakes after that date at Fort Tejon remains unclear. Meteorological Records from Fort Tejon (see Appendix 2B, Source #21) were filed consecutively for eight more months, although the lack of mention of earthquakes may be the result of either a lack of earthquakes or simply a lack of reporting. In addition, we cannot tell how much longer small ($M < 3$) earthquakes continued at elevated rates, as these would probably not have been felt or recorded anyway. Nevertheless, based on records from Fort Tejon, the aftershock sequence of the 1857 earthquake continued for at least 3.75 years.

CONCLUSIONS AND IMPLICATIONS

We have performed a careful, systematic search of primary documents from 1857 to 1862, relating to reports of foreshocks and aftershocks of the 1857 FT earthquake. We have found no evidence of aftershocks stronger than those of 9 and 16 January 1857 and 16 April 1860 (9 Jan.: $M = 6.25 \pm 0.5$; 16 Jan.: $M = 6.7 \pm 0.5$; 16 Apr. 1860: $M = 6.25 \pm 0.3$). Indeed, it appears that only the January 16th event exceeded *M*6.5.

Regarding the foreshocks, Sieh's (1978b) original analysis, based on a comparison of the foreshocks to more recent earthquakes, held up to the more objective methods of Bakun and Wentworth, although here we were able to estimate the magnitude more precisely for each of the two larger foreshocks and estimate the uncertainty of the locations. The largest foreshock (at "dawn") was $M = 6.1 \pm 0.3$.

The two largest foreshocks and three largest aftershocks are plotted together on a summary map, Figure 8. For the foreshocks, we assumed locations on the SAF, but the intensity centers for all three *aftershocks* were off the SAF; for the aftershocks, we plotted the preferred off-fault locations, but we also plotted "San Andreas scenarios" -- that is, the best on-fault location, based upon rms contours, were we to require the aftershock to have occurred on the SAF. For all the larger foreshocks and aftershocks, we determined empirical strike-slip rupture lengths appropriate for each magnitude, based on the moment magnitude - rupture length regression of Wells and Coppersmith (1994), and we represent these rupture lengths on Figure 8, centered at our preferred location. The preferred (and alternative SAF) latitude-longitude coordinates for all five events are given in Table 9.

It is interesting to see how well the aftershock sequence of the FT earthquake fits a typical aftershock sequence. The magnitudes of aftershocks generally follow a Gutenberg-Richter relation, with each unit decrease in mainshock magnitude leading to a 10-fold decrease in the total number of aftershocks (Reasenberg and Jones, 1989). Using the statistics of Reasenberg and Jones, we calculate that in a 5-year period following a *M*7.9 mainshock, we would typically expect one aftershock of $M \geq 6.9$, roughly 4 events of $M \geq 6.4$, and roughly 13 events of $M \geq 5.9$ within the aftershock zone. Yet based on our data, we can conclude that *no* aftershocks equaled or exceeded *M*6.9 and only one aftershock exceeded *M*6.4. (If the January 16th event occurred on the SAF, none exceeded *M*6.4.) We have identified four aftershocks that exceeded *M*5.9, and one could reasonably argue that we could not have *missed* more than a handful of events of *M* 5.9-6.4, if we missed any at all -- either way, the total number of aftershocks of $M \geq 5.9$ would be below the expected amount. The observed aftershock sequence for the FT earthquake appears to be marginally lower than, although not inconsistent with, what would be expected based on statistics of smaller events.

Yet, regardless of whether future SAF aftershock sequences are similarly low or are higher, they should not be dismissed as "only" aftershocks. Hough and Jones (1997) proposed a future SAF aftershock scenario involving a $M \geq 6$ aftershock on or near the Sierra Madre Fault in the San Gabriel Valley; although "only" an aftershock, it could be equally if not more devastating than the *M*5.9 Whittier Narrows earthquake of October 1, 1987, which damaged 10,000 buildings (Jones and Nicolaides, 1990). Our findings indicate that the largest aftershocks from 1857 occurred off the SAF, with magnitudes as high as *M*6.7. The Hough and

Jones scenario is therefore entirely consistent with observed aftershocks from 1857, as well as with aftershocks from more recent events -- including the 1992 *M*7.3 Landers earthquake (the *M*6.5 Big Bear aftershock was located roughly 36 km from the mainshock epicenter; Jones and Hough, 1995). While there is no reason to believe that a large aftershock to a San Andreas event will necessarily occur near the population centers of the greater Los Angeles region, there is also no reason to rule it out (Hough and Jones, 1997). Off-fault aftershocks to a SAF earthquake are likely, and they should be included in planning scenarios for Los Angeles and other southern California population centers.

As a final point, one should note that the FT earthquake aftershock sequence was characterized by a slower-than-average decay, with several large events late in the sequence, and only one large aftershock within the first twenty-four hour period. Poor reporting does *not* appear to be a factor in this apparent lack of other sizable aftershocks early on, as the resolution of earthquake reporting in the hours and days following the mainshock was higher than at any time later in the aftershock sequence. Unless an aftershock occurred before shaking from the mainshock had ended (as in the 1994 Northridge earthquake; Hough and Jones, 1997), such that the mainshock and aftershock would not be distinguishable to observers, it is extremely unlikely that any large aftershocks ($M \geq 5.9$) occurred on January 9th which were overlooked.

Beyond what we have just stated, we cannot draw any more general conclusions, for we are lacking data for significant reaches of the fault. We were unable to locate any copies of the Santa Barbara *Gazette* dating from after May of 1857, although it is known to have remained in existence until at least 1860; nor were we able to track down any newspaper from San Luis Obispo, although one is believed to have existed from 1858 to 1860 (also called the *Gazette*). If copies of either paper are ever found, it may be worthwhile to examine them, as information gained from either of those sources (be it in the form of earthquake reports or a lack thereof) may allow us to more directly select among our possible scenarios.

We are now conducting a similar analysis of the aftershocks of the 1906 SF earthquake, searching for felt reports, assigning intensity values, and using the grid-search algorithm of Bakun and Wentworth (1997) to estimate magnitudes and locations. Due to the rapid increase in the population in California in the latter half of the 19th century, the availability of local newspaper accounts of aftershocks is greatly improved with respect to the situation in the 1850s. Hence, we hope to have more conclusive constraints on the aftershocks of the 1906 earthquake. Taken together, we hope to provide the basis for understanding the behavior of the SAF before, during, and after major earthquakes. The sizes, and temporal and spatial pattern of foreshocks and aftershocks for such large SAF earthquakes should allow further analyses of stress loading and redistribution as well as more general fault properties. In particular, it will be interesting to see if the SAF, with such a large total offset, behaves differently than smaller, less well-developed faults.

RESOURCES CONSULTED

The Huntington Library, Art Collections, & Botanical Gardens -- Rare Books Collection (San Marino, CA)

California State Library, California History Room (Sacramento, CA)

U.C. Berkeley -- Bancroft and Doe Libraries (Berkeley, CA)

Cal Poly San Luis Obispo -- Robert E. Kennedy Library (San Luis Obispo, CA)

San Luis Obispo County Historical Society and Museum (San Luis Obispo, CA)

Santa Barbara Public Library (Santa Barbara, CA)

San Bernardino Public Library, California Room (San Bernardino, CA)

San Diego Central Library (San Diego, CA)

San Diego Historical Society & Research Archives (San Diego, CA)

The California Newspaper Project, U.C. Riverside (Riverside, CA)

The National Archives (College Park, MD, and Laguna Niguel, CA)

Utah State Historical Society (Salt Lake City, UT)

Church of Jesus Christ of Latter-Day Saints -- Historical Department (Salt Lake City, UT)

ACKNOWLEDGMENTS

We benefited greatly from discussion or help from William Deverell, Jim O'Donnell, and Kerry Sieh at Caltech; William Bakun and James Dewey of the U.S. Geological Survey; Tousson Toppozada of the California Division of Mines and Geology; and Duncan Agnew at U.C. San Diego. We also thank William Bakun and Lucile Jones of the U.S.G.S. for their helpful suggestions during the review process, and Lisa Wald of the U.S.G.S. for editorial assistance.

Many historians and librarians have helped us in our search for information. We gratefully acknowledge the help of California State Park Historian George Stammerjohan, Cathy Correia at the California State Library, Dan Krieger at Cal Poly San Luis Obispo, Lynne Landwehr at the San Luis Obispo County Historical Society, Hynda Rudd and Jay Jones at the Los Angeles City Archives, Chris Shovey at the San Bernardino Public Library, Jean Griffing of the California Newspaper Project at U.C. Riverside, and Rick Crawford at the San Diego Historical Society.

Maps in this report have been created using GMT (Wessel and Smith, 1991).

This work has been supported with funds provided by the Summer Undergraduate Research Fellowship program at the California Institute of Technology, and by the U.S. Geological Survey.

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Table 1: Confidence Parameters

TABLE 1A: Location of Epicentral Region

# of MMI	rms [M_I] contour				
Confidence Parameter:	95%	90%	80%	67%	50%
5	0.507	0.417	0.313	0.227	0.152
10	0.311	0.245	0.175	0.122	0.076
15	0.232	0.182	0.128	0.086	0.054
20	0.187	0.145	0.102	0.068	0.042

TABLE 1B: Magnitude

# of MMI	limits				
C.P.:	95%	90%	80%	67%	50%
3*	-0.90, 0.63	-0.71, 0.56	-0.51, 0.47	-0.35, 0.38	-0.21, 0.29
5	-0.72, 0.53	-0.56, 0.46	-0.42, 0.38	-0.29, 0.31	-0.18, 0.24
10	-0.54, 0.42	-0.44, 0.37	-0.33, 0.31	-0.24, 0.25	-0.15, 0.19
15	-0.48, 0.37	-0.39, 0.33	-0.30, 0.28	-0.22, 0.23	-0.14, 0.18
20	-0.45, 0.35	-0.36, 0.31	-0.28, 0.26	-0.21, 0.22	-0.14, 0.17

See Appendix 4 for a discussion of these parameters.

All values in Tables 1A and 1B are taken from Bakun and Wentworth (1997), except:
** The values for 3 MMI in Table 1B are taken from Bakun (in press).*

Tables 2 A-H: Intensities for Northridge Test Plots

Table 2A -- Map 1

Location	Intensity
Avalon	V
San Bernardino	V
Santa Barbara	V
San Diego	IV
Visalia	IV

Table 2B -- Map 2

Location	Intensity
Granada Hills (Kaiser Permanente)	IX
Baker	V
Escondido	V
Lebec	IV
San Luis Obispo	III

Table 2C -- Map 3

Location	Intensity
Los Angeles (I-10/Fairfax)	IX
Avalon	V
San Bernardino	V
Bakersfield	IV
Lompoc	IV

Table 2D -- Map 4

Location	Intensity
Santa Monica (St. John's Hospital)	IX
Los Angeles (Hancock Park)	VI
San Bernardino	V
San Diego	IV
Visalia	IV

Table 2E -- Map 5

Location	Intensity
Fillmore	VIII
Seal Beach	VI
Baker	V
Kernville	IV
Nipomo	IV

Table 2F -- Map 6

Location	Intensity
Santa Monica (Ocean Park)	VIII
Palmdale	VI
Santa Barbara	V
Palm Springs	IV
Fresno	III

Table 2G -- Map 7

Location	Intensity
Moorpark	VII
Los Angeles (Hancock Park)	VI
Escondido	V
Nipomo	IV
Thermal	III

Table 2H -- Map 8

Location	Intensity
Granada Hills (Kaiser Permanente)	IX
Los Angeles (I-10/Fairfax)	IX
Santa Monica (St. John's Hospital)	IX
Fillmore	VIII
Santa Monica (Ocean Park)	VIII
Moorpark	VII
Los Angeles (Hancock Park)	VI
Palmdale	VI
Seal Beach	VI
Avalon	V
Baker	V
Escondido	V
San Bernardino	V
Santa Barbara	V
Bakersfield	IV
Kernville	IV
Lebec	IV
Lompoc	IV
Nipomo	IV
Palm Springs	IV
San Diego	IV
Visalia	IV
Fresno	III
San Luis Obispo	III
Thermal	III

Table 3: Intensities for the Dawn Foreshock

Location	Reported Time(s)	Corrected Time (to PST)	Range of Possible MMI Values	Intensity (MMI), as mapped
Carrizo Plain	early morn. hours, before daybreak		V +	5
Santa Cruz	betwn. 05:00 and 06:00		IV ±	4
San Jose	~ 06:00	06:08	III-IV	3.5
Santa Barbara	06:00	05:59	III	3
San Francisco	06:08	06:18	II-III	2.5
Fort Tejon	06:00, 06:30	05:55, 06:25	II	2

Table 4A: Intensities for the Sunrise Foreshock
(using data from the 3 "known" locations)

Location	Reported Time(s)	Corrected Time (to PST)	Range of Possible MMI Values	Intensity (MMI), as mapped
15-20 miles NW of San Benito	about sunrise		IV ±	4
San Francisco	07:00, 07:15	07:10, 07:25	III	3
Visalia	about sunrise		III	3

Table 4B: Intensities for the Sunrise Foreshock
(using data from all 7 locations)

Location	Reported Time(s)	Corrected Time (to PST)	Range of Possible MMI Values	Intensity (MMI), as mapped
15-20 miles NW of San Benito	about sunrise		IV ±	4
San Jose (??)	~ 06:00	06:08	III-IV	3.5
Monterey (??)	~ 07:00	07:08	III-IV	3.5
Santa Cruz (??)	~ 06:55, 07:00	07:03, 07:08	III-IV	3.5
San Francisco	07:00, 07:15	07:10, 07:25	III	3
Visalia	about sunrise		III	3
Fort Tejon (??)	06:30	06:25	II	2

Table 5A: Intensities for the 9 January 1857, Night Aftershock
Scenario 1

Location	Reported Time(s)	Corrected Time (to PST)	Range of Possible MMI Values	Intensity (MMI), as mapped
Sycamore Valley	22:40	22:36	IV-V	4.5
Visalia	~ 22:30	22:27	IV-V	4.5
Los Angeles	~ 23:00, 23:00	22:53	IV	4
Cajon Pass	~ 23:00	22:50	IV	4
San Buenaventura	22:36	22:33	III-IV	3.5
Sacramento (??)	22:20	22:26	II-III	2.5

Table 5B: Intensities for the 9 January 1857, Night Aftershock
Scenario 2

Location	Reported Time(s)	Corrected Time (to PST)	Range of Possible MMI Values	Intensity (MMI), as mapped
Sycamore Valley	22:40	22:36	IV-V	4.5
Visalia	~ 22:30	22:27	IV-V	4.5
Los Angeles	~ 23:00, 23:00	22:53	IV	4
Cajon Pass	~ 23:00	22:50	IV	4
San Buenaventura	22:36	22:33	III-IV	3.5

Table 6A: Intensities for the 16 January 1857 Aftershock (Version 1)

Location	Reported Time(s)	Corrected Time (to PST)	Range of Possible MMI Values	Intensity (MMI), as mapped
Castaic Junction	afternoon		V-VI	5
Los Angeles	17:00	16:53	V-VI	5
Santa Barbara	~ 16:00	15:59	V	5
San Bernardino	16:45, ~ 17:00	16:34, 16:49	V	5
San Diego	17:10	16:58	IV	4

Table 6B: Intensities for the 16 January 1857 Aftershock (Version 2)

Location	Reported Time(s)	Corrected Time (to PST)	Range of Possible MMI Values	Intensity (MMI), as mapped
Castaic Junction	afternoon		V-VI	6
Los Angeles	17:00	16:53	V-VI	6
Santa Barbara	~ 16:00	15:59	V	5
San Bernardino	16:45, ~ 17:00	16:34, 16:49	V	5
San Diego	17:10	16:58	IV	4

Table 7: Intensities for the 16 April 1860 Aftershock

Location	Reported Time(s)	Corrected Time (to PST)	Range of Possible MMI Values	Intensity (MMI), as mapped
Monterey			V	5
Santa Cruz			III-V	4
San Francisco	19:16	19:26	III	3
Visalia	~ 19:30	19:27	III	3
Fort Tejon	19:00	18:55	III	3

Table 8A: Noteworthy Foreshocks*

** for a discussion of all other 1857 foreshocks, please see Sieh (1978b)*

Dawn Foreshock

$M = 6.1 \pm 0.3$, probably a "Parkfield" event (e.g., an event on or near the SAF northwest of Parkfield); See Figure 3 Map

Sunrise Foreshock

approximate magnitude $M = 5.6 \pm 0.4$, possibly a "Parkfield" event; See Figures 4A and 4B Maps

Table 8B: Noteworthy Aftershocks

January 9, 1857, 11 pm

$M = 6.25 \pm 0.5$, on or near the Garlock Fault, although we should not rule out the San Andreas Fault; See Figure 5B Map

January 11, 1857, night

an earthquake was felt in Los Angeles and Sycamore Valley at about the same time, but it might have been two separate local events

January 16, 1857, 5 pm

$M = 6.7 \pm 0.5$, probably offshore Los Angeles, although we should not rule out the San Andreas Fault; See Figures 6A and 6B Maps

January 20, 1857

an earthquake was felt at night in Santa Barbara, and an earthquake was also felt at Fort Tejon, but no time was given; it could be the same event, or it could be two separate events; MMI-III at Santa Barbara, MMI-V(?) at Fort Tejon; another quake felt that morning in Santa Cruz and San Francisco

January 28, 1857, 2 am

an earthquake was felt in Sycamore Valley and Santa Barbara at about the same time but it might have been two separate local events

March 14, 1857, 3 am

an earthquake was reported felt in Santa Barbara and possibly at Fort Tejon; but it may have been two separate local events; MMI-IV at Santa Barbara

May 23, 1857

an earthquake was felt in both Los Angeles and Fort Tejon, but it might have been two separate local events; MMI-III at Los Angeles, MMI-V at Fort Tejon

July 9, 1857, 2 am

a strong earthquake was felt in both Los Angeles and Fort Tejon at about the same time; at Tejon, it was described as very long; MMI-IV at Los Angeles and MMI IV-V at Fort Tejon

December 15, 1858, 7 pm

a strong earthquake was felt in both Los Angeles and San Bernardino at about the same time; MMI-IV at Los Angeles, MMI V-VI at San Bernardino

December 16, 1858, 3 am

a very strong earthquake was felt in both Los Angeles and San Bernardino at about the same time; MMI IV-V at Los Angeles, MMI-VII at San Bernardino; $M \approx 6$

May 4, 1859, 11:30 pm

this earthquake was reported felt ONLY at Fort Tejon, but it was described as very long -- there are a number of possible causes of such an earthquake; MMI-V(?) at Fort Tejon

April 16, 1860, 7 pm

$M = 6.2 \pm 0.3$ near the Parkfield segment of the SAF, or a $M = 6.25 \pm 0.3$ on the Rinconada or Nacimiento fault; See Figure 7 Map

Table 9: Latitude-Longitude Coordinates for Mapped Events

Event	Preferred Version			SAF Version		
	Lon (°W)	Lat (°N)	Magn	Lon (°W)	Lat (°N)	Magn
Dawn FS *	120.65	36.10	$M = 6.1 \pm 0.3$	*see preferred version*		
Sunrise FS *	120.85	36.29	$M = 5.6 \pm 0.4$	*see preferred version*		
Jan 9 1857 AS	118.00	35.44	$M = 6.25 \pm 0.5$	118.71	34.76	$M = 5.6 \pm 0.4$
Jan 16 1857 AS	118.90	33.38	$M = 6.7 \pm 0.5$	118.04	34.52	$M = 6.3 \pm 0.3$
Apr 16 1860 AS	121.06	36.02	$M = 6.25 \pm 0.3$	120.88	36.31	$M = 6.2 \pm 0.3$

* Preferred version is on SAF.

FIGURE CAPTIONS

Figure 1. Location Map, showing 1857 mainshock fault rupture and locations for intensity data points used in this paper (locations for San Benito and Sycamore Valley are from Agnew and Sieh, 1978). The approximate locations for three earthquakes (Feb 1853, Sept 1853, Jan 1855) mentioned in Toppozada and Borchardt (1998) are denoted by dashed ellipses; the approximate location for the 1952 Bryson earthquake, as discussed by Sieh (1978b), is denoted by the ~1cm-diameter circle. See text for details.

Figures 2A - 2G. Calibration tests for 5 MMI values, using intensity data from the 17 January 1994 Northridge earthquake, from Dewey et al (1995). Thin lines are faults; white triangles are stations with intensity data (some are located off the map); dotted lines are rms contours; the clear star is the location of the least rms value (the "intensity center"); white lines are magnitude contours; and the filled star is the true (known) epicenter. See text for details.

Figure 2H. Calibration test for 25 MMI values, using intensity data from the 17 January 1994 Northridge earthquake, from Dewey et al (1995). Thin lines are faults; white triangles are stations with intensity data (some are located off the map); dotted lines are rms contours; the clear star is the location of the least rms value (the "intensity center"); white lines are magnitude contours; and the filled star is the true (known) epicenter. See text for details.

Figure 3. Map of rms contours and magnitude contours for the "dawn" foreshock. Thin lines are faults; the *thick* line is the extent of the 1857 rupture, and the black triangles mark the ends of the rupture; white triangles are stations with intensity data (two are located off the map); dotted lines are rms contours; the clear star is the location of the least rms value (the "intensity center"); the filled star is the location of the least rms value *among points on the SAF*; and the white lines are magnitude contours. See text for details.

Figure 4A. Map of rms contours and magnitude contours for the "sunrise" foreshock, *using only the data from the 3 locations for which we have reliable felt reports.* Thin lines are faults; the *thick* line is the extent of the 1857 rupture, and the black triangles mark the ends of the rupture; white triangles are stations with intensity data (one is located off the map); dotted lines are rms contours; the clear star is the location of the least rms value (the "intensity center"); the filled star is the location of the least rms value *among points on the SAF*; and the white lines are magnitude contours. See text for details.

Figure 4B. Map of rms contours and magnitude contours for the "sunrise" foreshock, *using all 7 data values.* Thin lines are faults; the *thick* line is the extent of the 1857 rupture, and the black triangles mark the ends of the rupture; white triangles are stations with intensity data (two are located off the map); dotted lines are rms contours; the clear star is the location of the least rms value (the "intensity center"); the filled star is the location of the least rms value *among points on the SAF*; and the white lines are magnitude contours. See text for details.

Figure 5A. Map of rms contours and magnitude contours for the January 9th night aftershock, *including* the data value from Sacramento *(Scenario 1).* Thin lines are faults; the *thick* line is the extent of the 1857 rupture, and the black triangles mark the ends of the rupture; white triangles are stations with intensity data (one is located off the map); dotted lines are rms contours; the location of the least rms value (the "intensity center") is off the map; the filled star is the location of the least rms value *among points on the SAF*; and the white lines are magnitude contours. See text for details.

Figure 5B. Map of rms contours and magnitude contours for the January 9th night aftershock, *excluding* the data value from Sacramento *(Scenario 2)*. Thin lines are faults; the *thick* line is the extent of the 1857 rupture, and the black triangles mark the ends of the rupture; white triangles are stations with intensity data (all are located *on* the map); dotted lines are rms contours; the clear star is the location of the least rms value (the "intensity center"); and the white lines are magnitude contours. See text for details.

Figures 6 A-B. Two maps of rms contours and magnitude contours for the January 16th aftershock, showing slight variation as a result of uncertainties in two of the intensity values. Thin lines are faults; the *thick* line is the extent of the 1857 rupture, and the black triangles mark the ends of the rupture; white triangles are stations with intensity data (all are located *on* the map); dotted lines are rms contours; the clear star is the location of the least rms value (the "intensity center"); and the white lines are magnitude contours. See text for details.

Figure 7. Map of rms contours and magnitude contours for the April 16th, 1860 aftershock. Thin lines are faults; the *thick* line is the extent of the 1857 rupture, and the black triangles mark the ends of the rupture; white triangles are stations with intensity data (two are located off the map); dotted lines are rms contours; the location of the least rms value (the "intensity center") is off the map to the west; the shaded (filled) star is the location of the least rms value *among points on the SAF*; the black (solidly filled) star is the location of the least rms value *among points on the Rinconada Fault*; and the white lines are magnitude contours. See text for details.

Figure 8. Summary Map, showing the best locations for the foreshocks and aftershocks plotted in Figures 3-7. The bars represent empirical strike-slip rupture lengths appropriate for the event's magnitude, based on Wells and Coppersmith (1994), and are oriented according to the dominant local fault trend. The numbers correspond as follows:

3 best location for the dawn foreshock, which is assumed to be on the SAF
4 best location for the sunrise foreshock, which is assumed to be on the SAF
5 best location for the Jan. 9th aftershock
5' best location for the Jan. 9th aftershock, *if constrained to the SAF*
6 best location for the Jan. 16th aftershock
6' best location for the Jan. 16th aftershock, *if constrained to the SAF*
7 best location for the Apr. 1860 aftershock
7' best location for the Apr. 1860 aftershock, *if constrained to the SAF*

Note that the latitude-longitude coordinates for all of these points are given in Table 9. See text for details.

Location Map

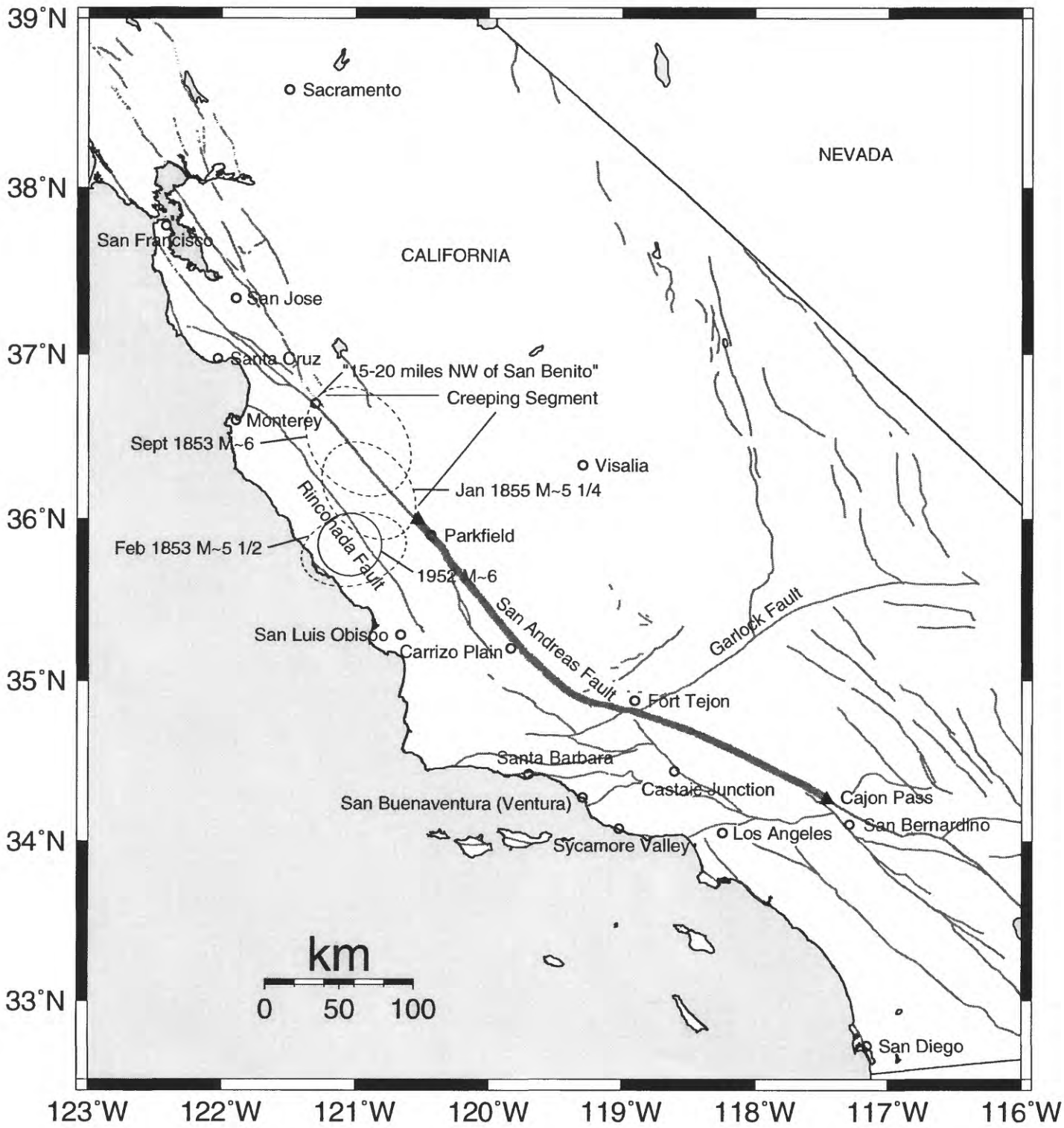

Figure 1

Map 1, using 5 MMI Observations

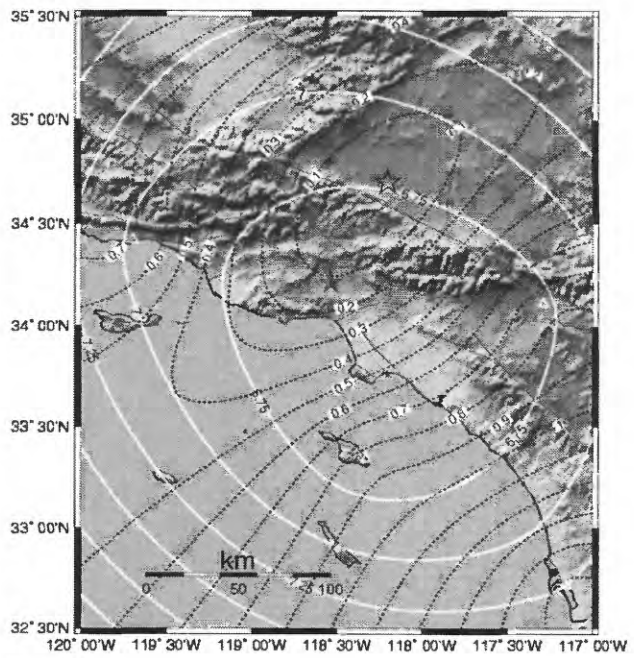

Figure 2 A

Map 2, using 5 MMI Observations

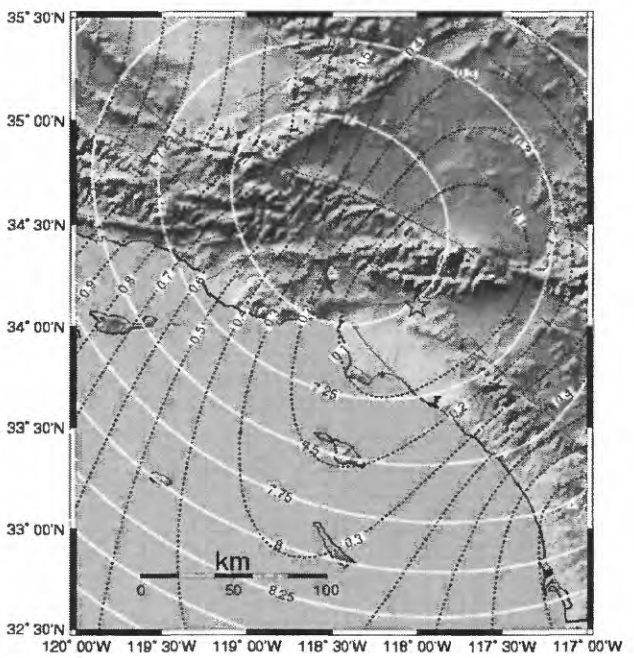

Figure 2 B

Map 3, using 5 MMI Observations

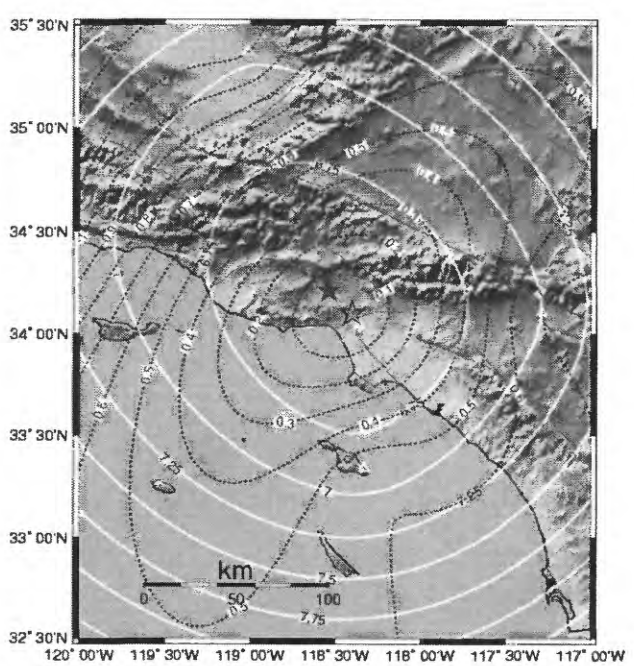

Figure 2 C

Map 4, using 5 MMI Observations

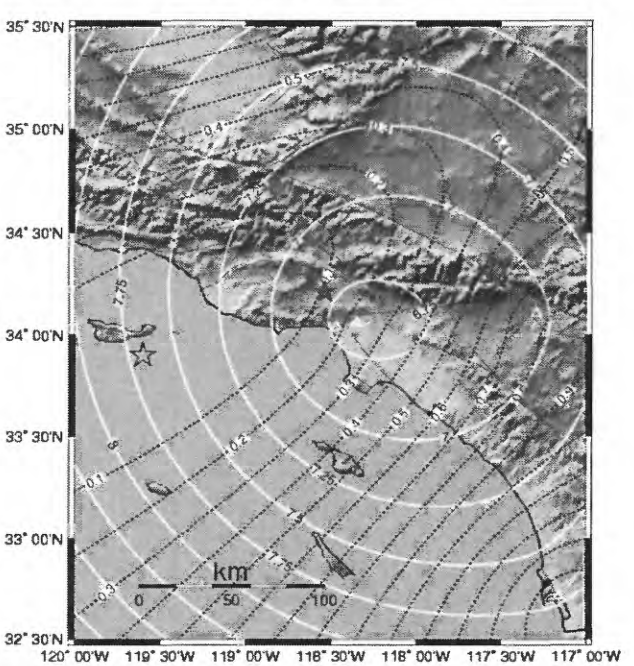

Figure 2 D

Map 5, using 5 MMI Observations

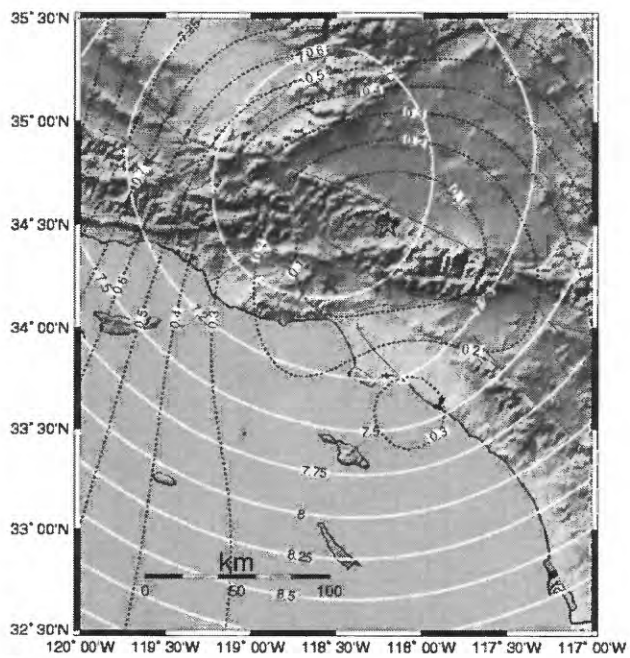

Figure 2 E

Map 6, using 5 MMI Observations

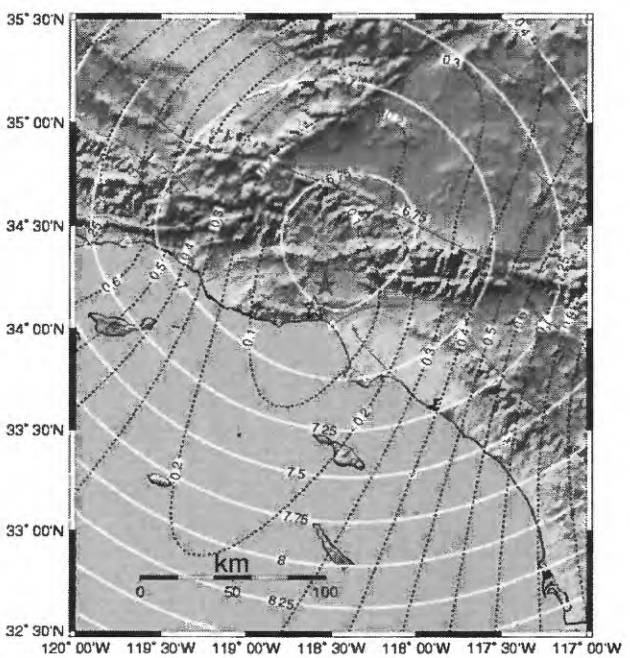

Figure 2 F

Map 7, using 5 MMI Observations

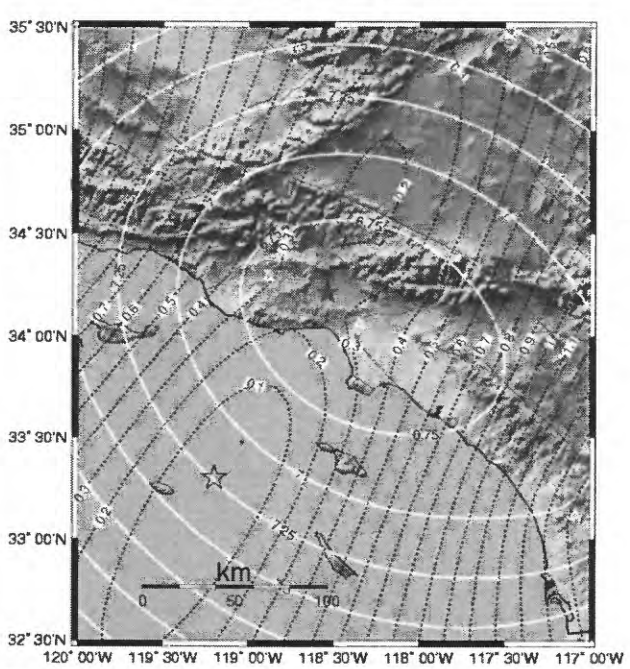

Figure 2 G

Map 8, using 25 MMI Observations

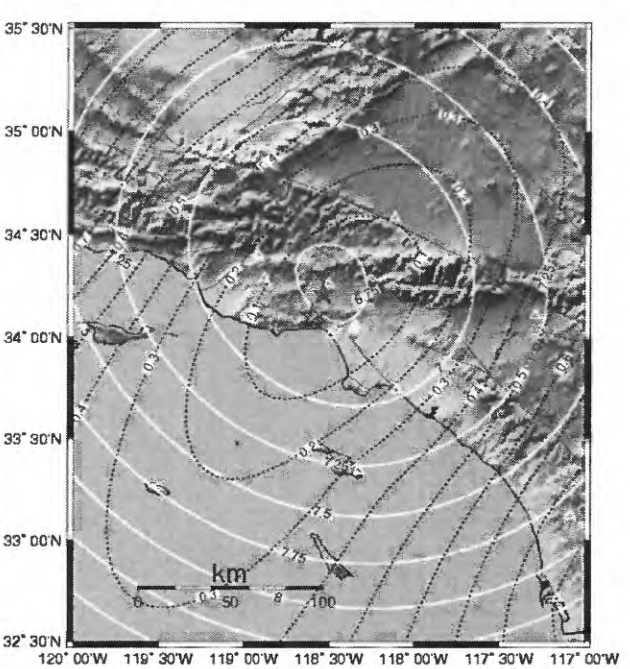

Figure 2 H

Figures 2E-H

1857 January 9, DAWN FORESHOCK

Using 6 MMI Observations
Selected Epicenter: 120.65 W, 36.10 N

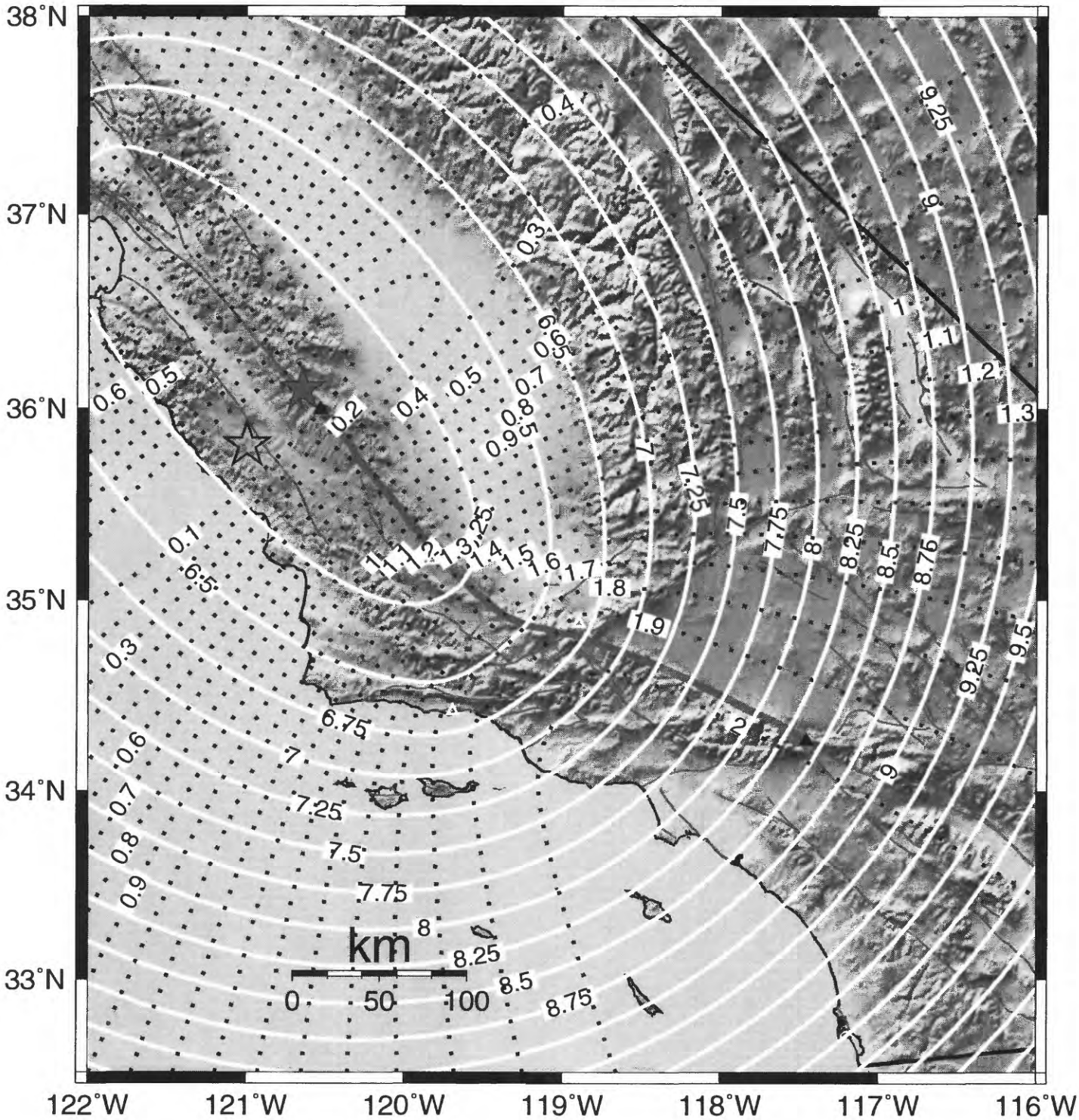

Figure 3

1857 January 9, SUNRISE FORESHOCK

Using 3 MMI Observations
Selected Epicenter: 120.96 W, 36.38 N

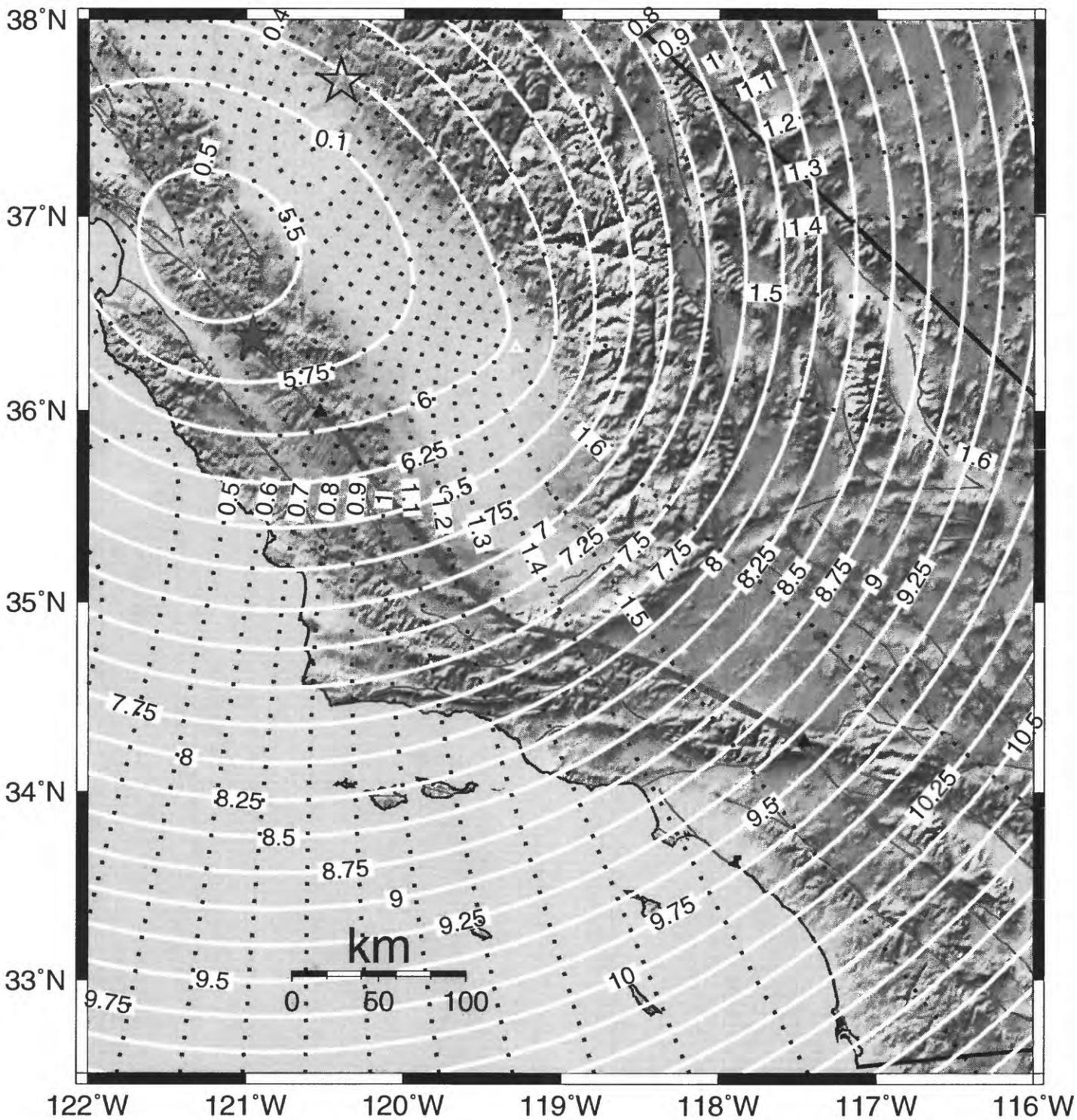

Figure 4A

1857 January 9, SUNRISE FORESHOCK

Using 7 MMI Observations
Selected Epicenter: 120.75 W, 36.20 N

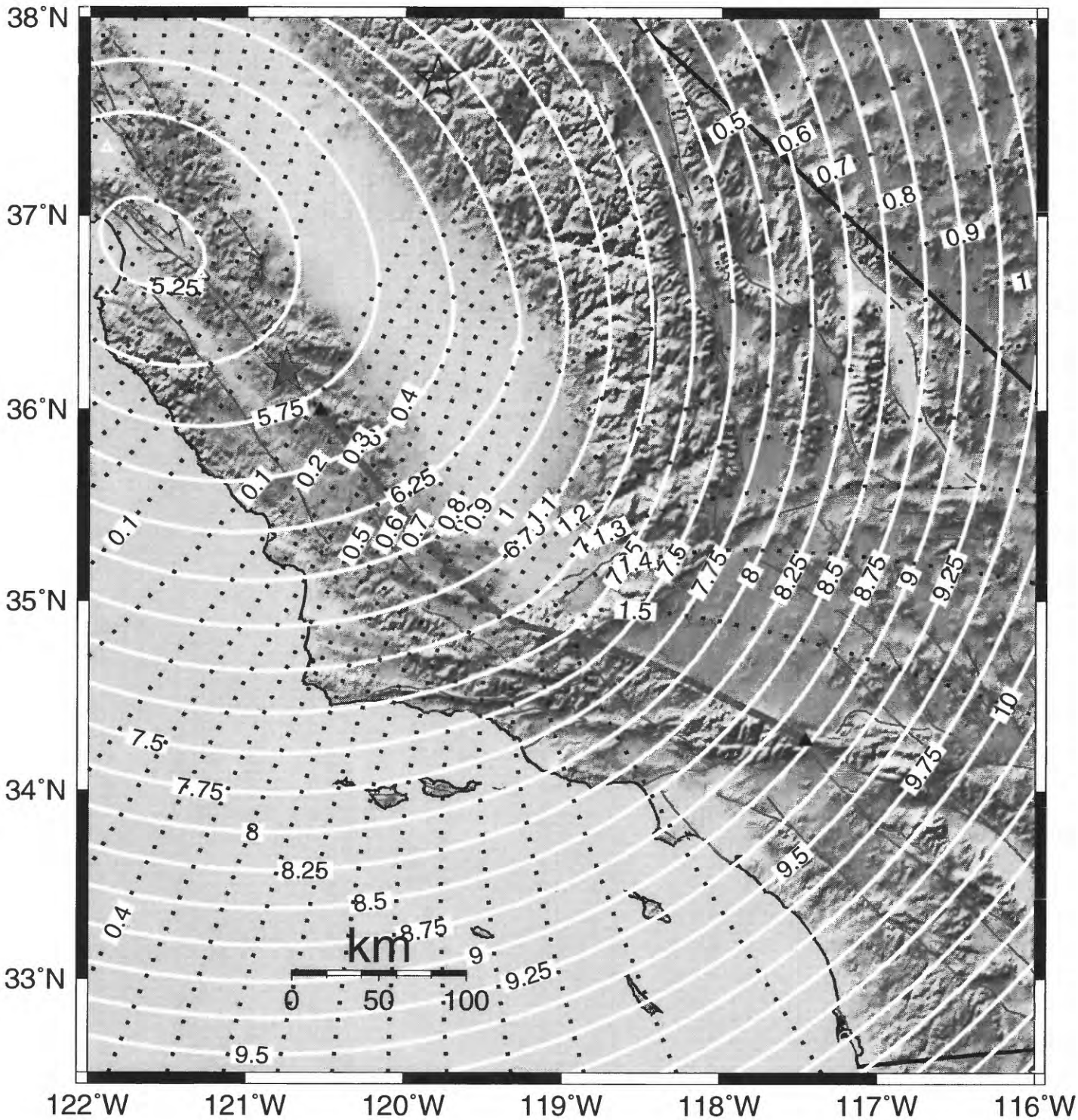

Figure 4B

1857 January 09, 11pm

SCENARIO 1, Using 6 MMI Observations
Selected Epicenter: 120.16 W, 35.62 N

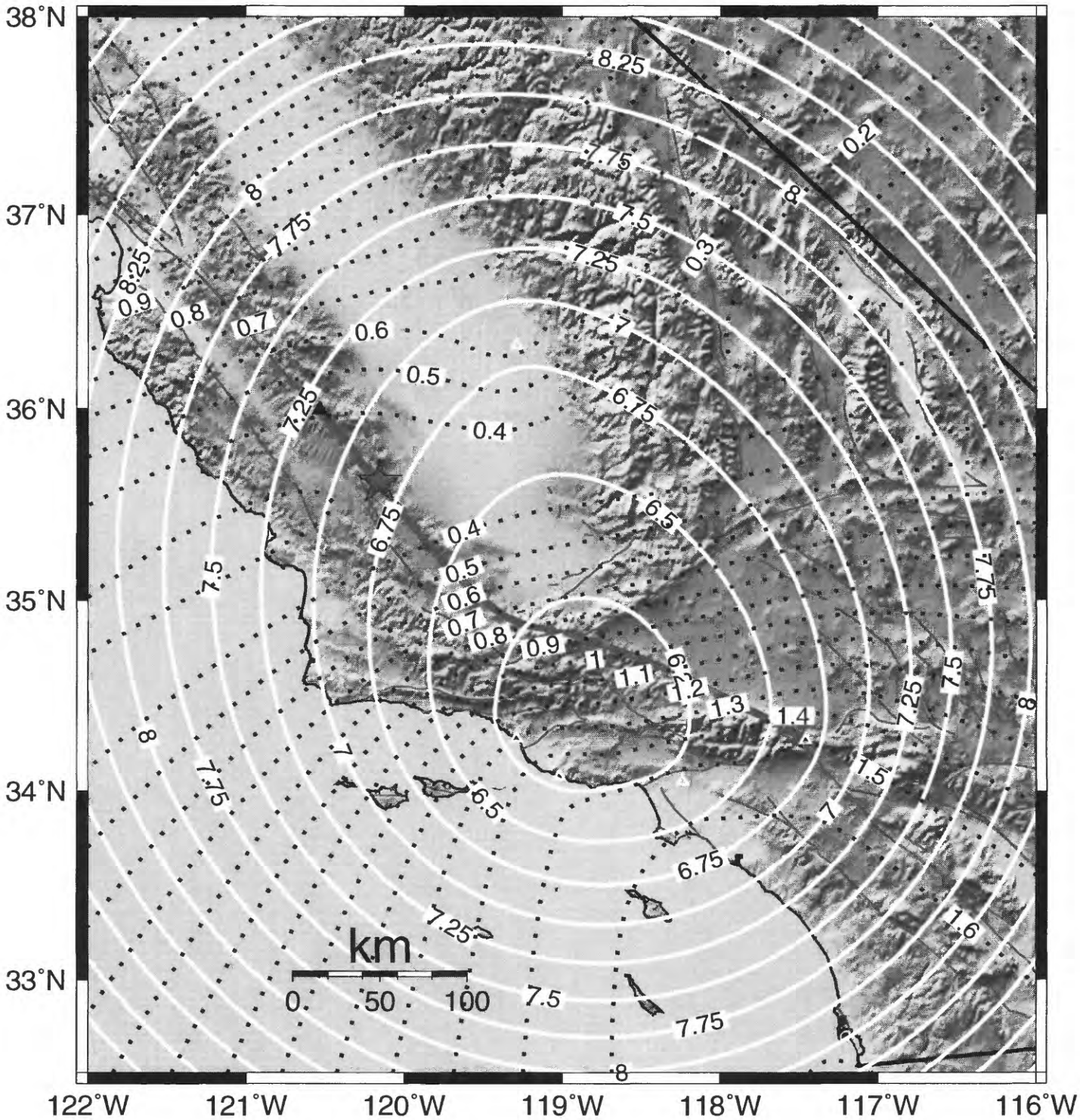

Figure 5A

1857 January 09, 11pm

SCENARIO 2, Using 5 MMI Observations
Least RMS (Most Likely Epicenter): 118.00 W, 35.44 N

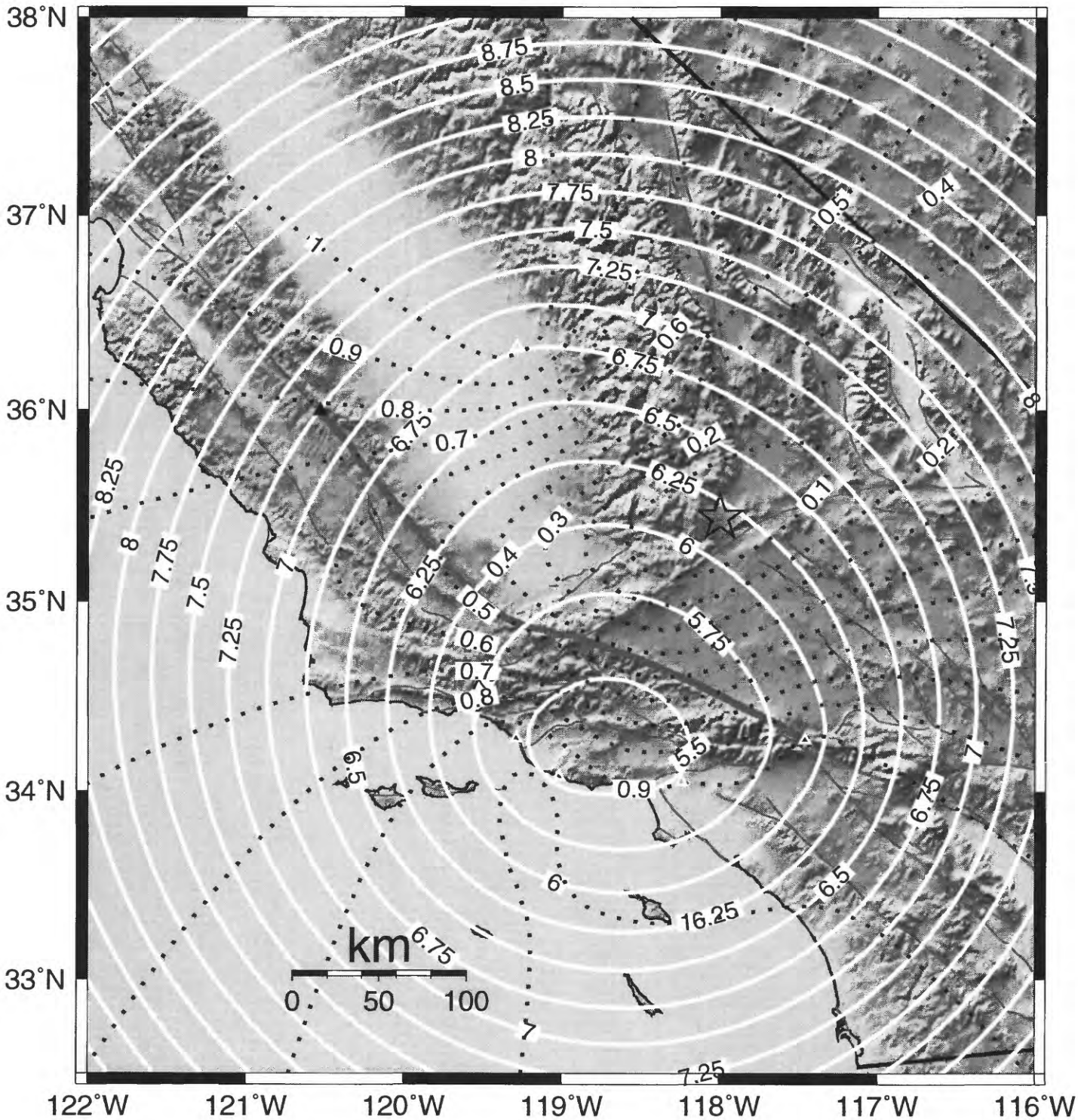

Figure 5B

1857 January 16, Afternoon

Using 5 MMI Observations
Least RMS (Most Likely Epicenter): 119.00 W, 33.19 N

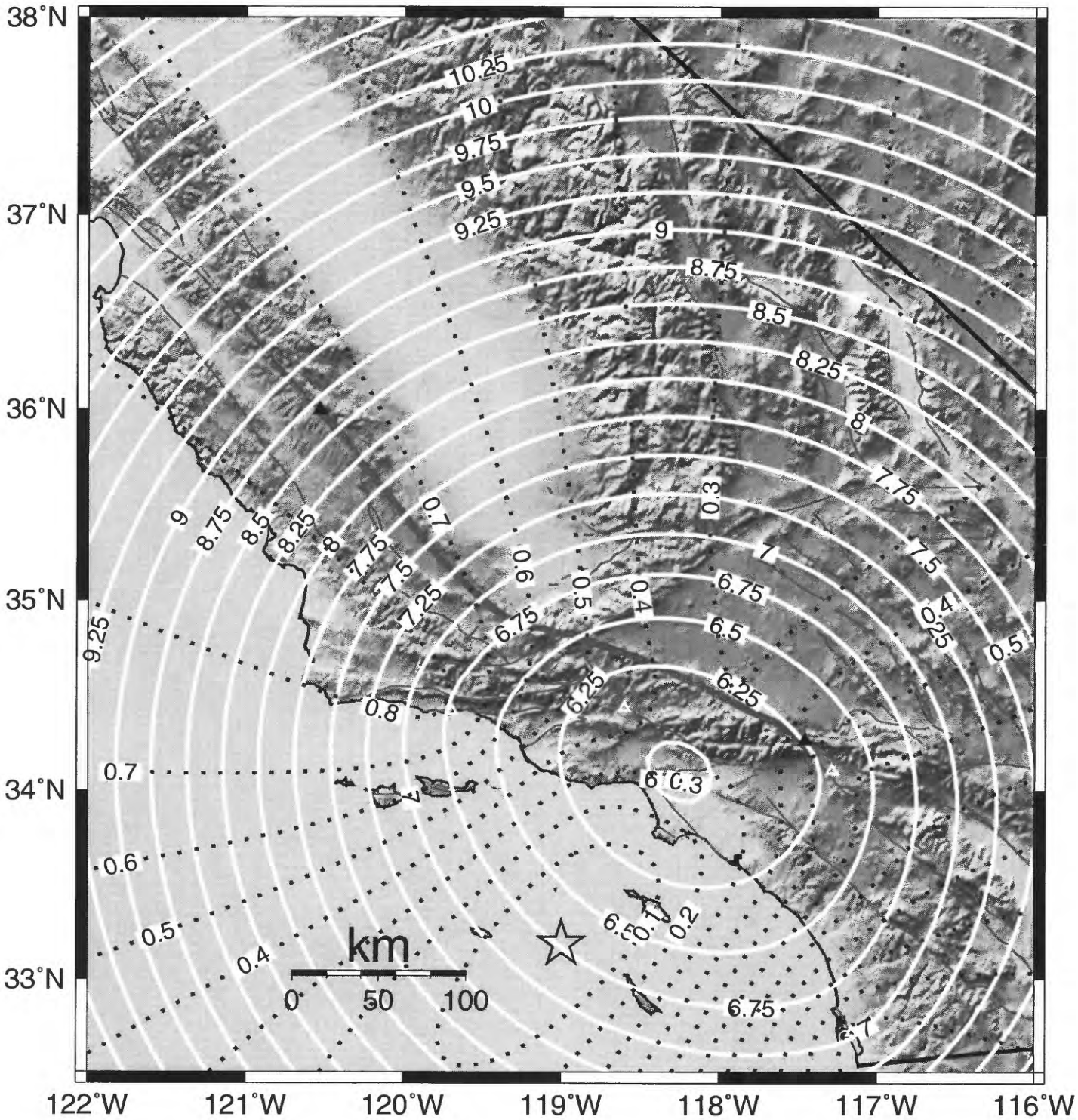

Figure 6A

1857 January 16, Afternoon

Using 5 MMI Observations
Least RMS (Most Likely Epicenter): 118.80 W, 33.56 N

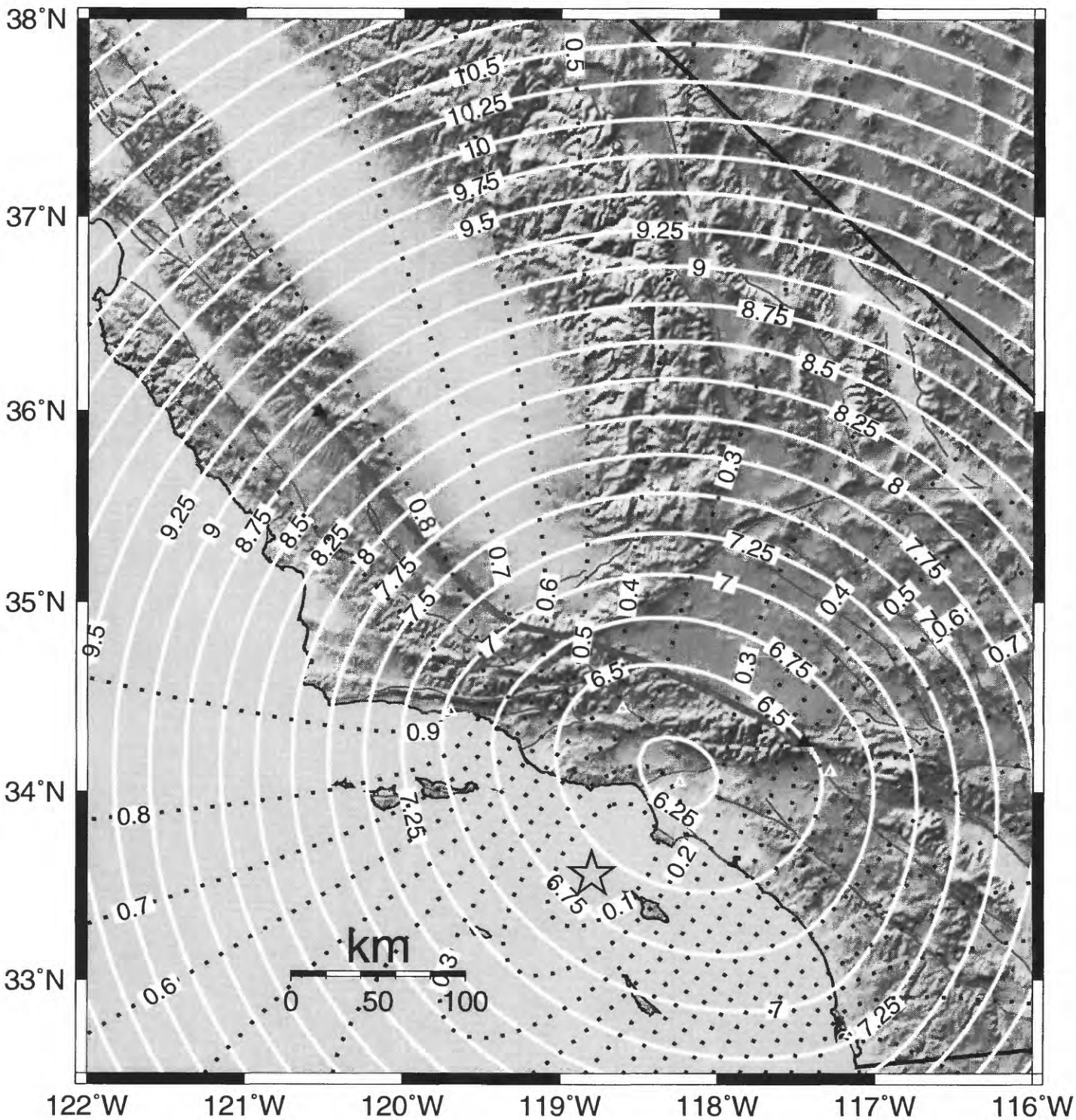

Figure 6B

1860 April 16, Evening

Using 5 MMI Observations

Selected Epicenters:

120.88 W, 36.31 N (SAF) OR 121.06 W, 36.02 N (Rinconada Fault)

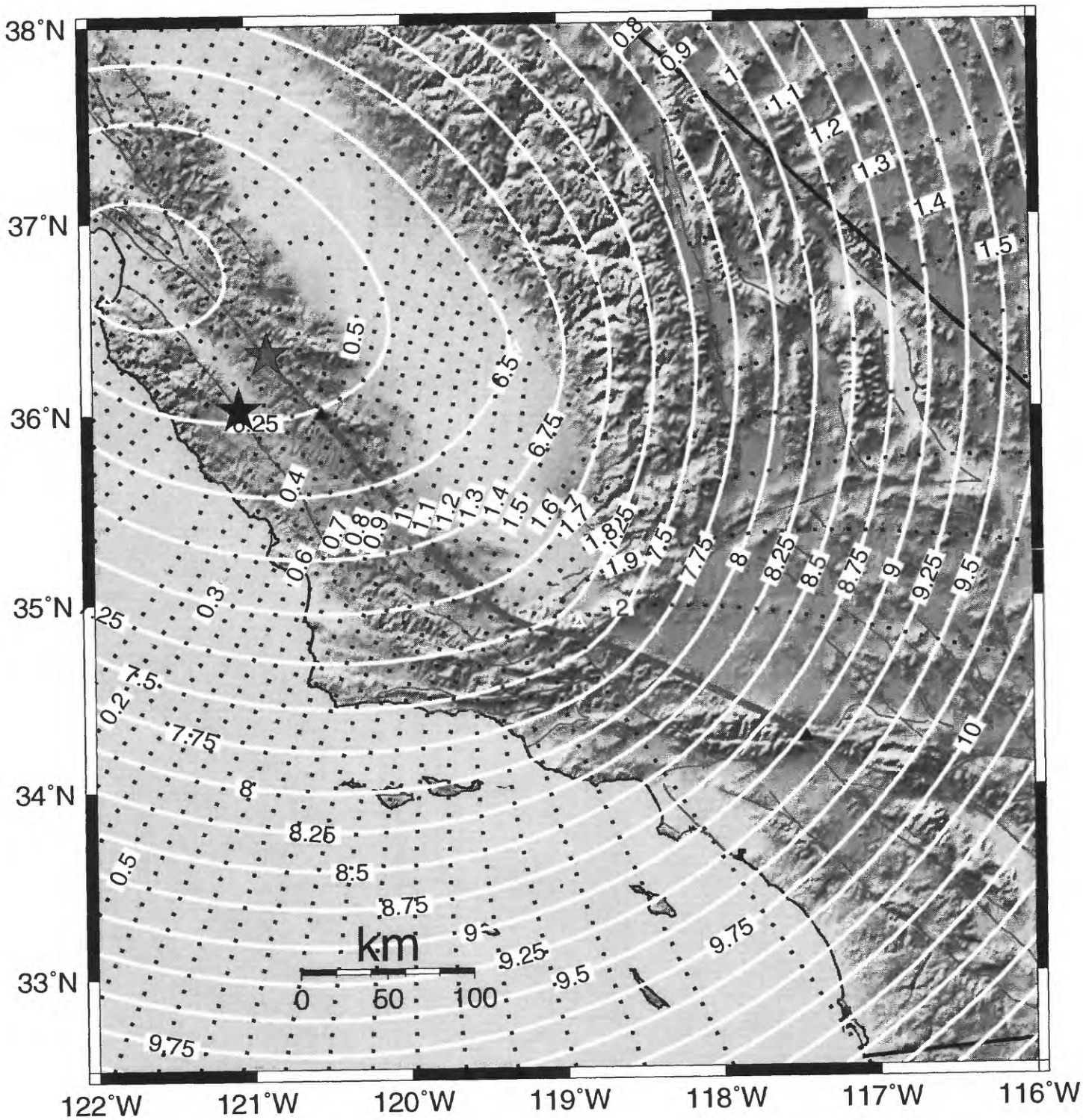

Figure 7

Summary Map

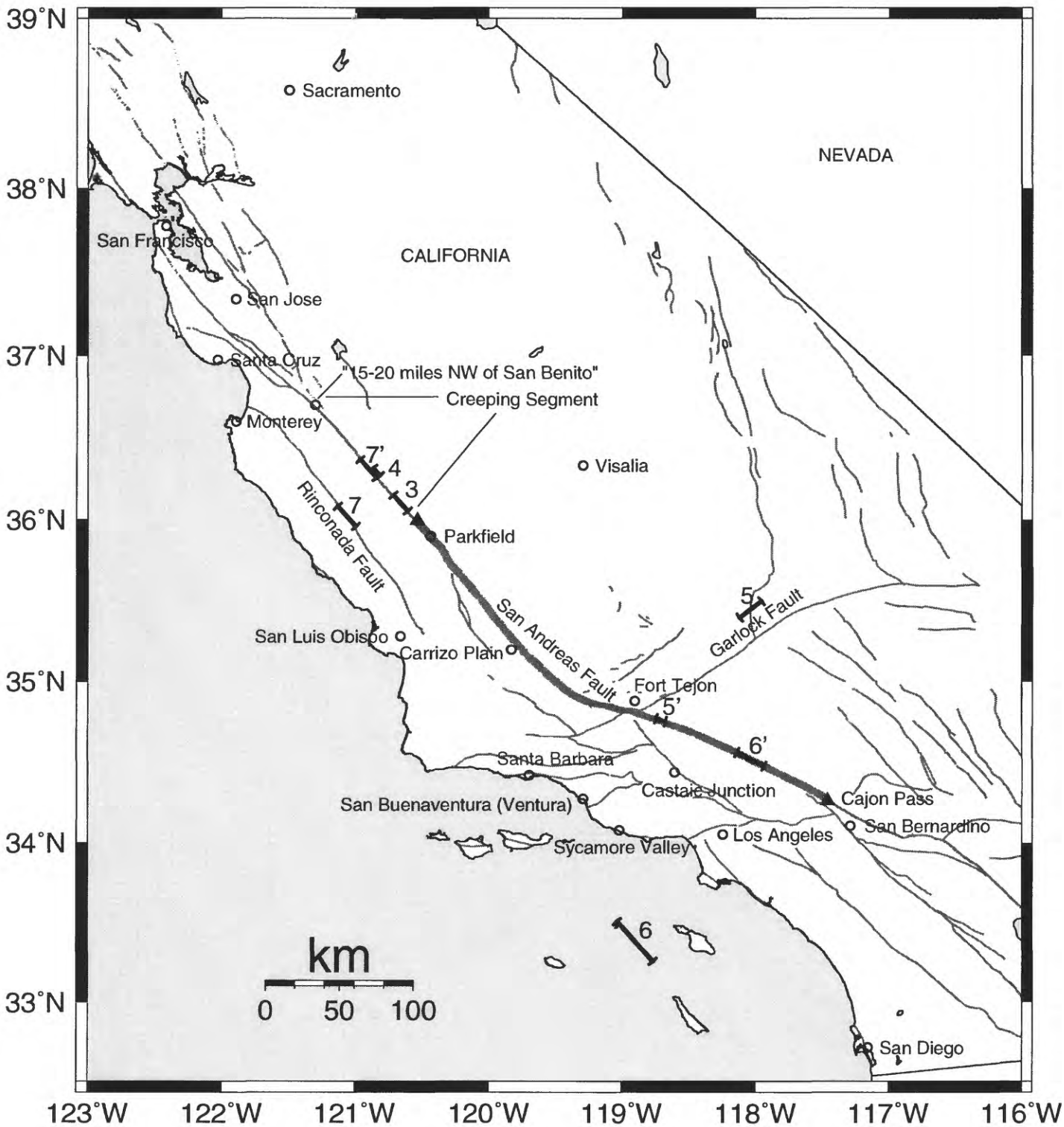

Figure 8

Appendix 1A: Felt Foreshocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes
FORESHOCKS (JAN. 8-9, 1857)								***by geographic location***
January 09	06:00	05:59	Santa Barbara	Letter dated S. Barbara, 9 Jan. 1857, appearing in the San Francisco *Daily Alta California*, 13 January 1857	38	31a	III	
January 09	08:10	08:09	Santa Barbara	Santa Barbara *Gazette*, 15 January 1857 San Francisco *Daily Alta California*, 28 January 1858	20, 39	17a, 31b		"of brief continuance, unnoticed by many people"; about 12 minutes before mainshock
January 09	06:00	05:55	Fort Tejon	Letter of Lt. Col. B.L. Beall, dated 9-10 January 1857	23	19	II	"shocks ... commenced"
January 09	06:00 or 06:30		Fort Tejon	Stockton *Daily Argus*, 16 January 1857 Stockton *Daily San Joaquin Republican*, 16 January 1857	57, 61	38a, 39b	II	"light ... scarcely perceptible"; "slight, and barely perceptible" each source reported only *one* foreshock felt; see Documents 38a and 39b
January 09	~ 06:30	06:25	Fort Tejon	Letter dated Fort Tejon, 11 Jan. 1857, appearing in the Los Angeles *Star*, 17 January 1857, under the heading "FROM FORT TEJON"	14	12c	II	reported only *one* foreshock felt
January 09	early morning hours, before daybreak		Carrizo Plain	Reminiscence of Mr. Bell, ca. 1905	73	24	V +	caused cattle to stampede; however, in this reminiscence, Mr. Bell appears to be confused as to the timing, sequence, and details of events on the morning of the earthquake; see Note 2, in Appendix 2B, under Source #24
January 09	about sunrise		Visalia	Letter dated Visalia, 9 Jan. 1857, appearing in the Stockton *Daily Argus*, 19 January 1857	58	38b	III	"slight"
January 09	02:30	02:29	Fort Miller (Lake Millerton, near Fresno)	Meteorological Report for Fort Miller, CA, January 1857	29	26		"slight"

Appendix 1A: Felt Foreshocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes [‡]
January 09	about sunrise		15-20 miles NW of San Benito	Diary of Dr. C.A. Canfield	30	27a	IV ±	"lasting not over 5 seconds, accompanied by noise"
January 09	~ 07:00	07:08	Monterey	San Francisco *Daily Evening Bulletin*, 12 January 1857	41	32a	III-IV	If the earthquake described in this article is indeed that of a foreshock, then the mainshock is not mentioned. This article mentions nothing about any other shocks. From the description, it is probably describing the mainshock; thus it appears we have NO report from Monterey of a foreshock.
January 09	01:00	01:08	Santa Cruz	Santa Cruz *Pacific Sentinel*, 31 January 1857	32, 33	28d, 28e		See Note 2, in Appendix 2B, under Source #28.
January 09	~ 04:00	04:08	Santa Cruz	Santa Cruz *Pacific Sentinel*, 17 January 1857	75	28b		"quite severe, causing buildings to tremble considerably and accompanied with a noise resembling a heavy wind" See Note 2, in Appendix 2B, under Source #28.
January 09	between 05:00 and 06:00		Santa Cruz	Santa Cruz *Pacific Sentinel*, 10 January 1857	31	28a	IV ±	"severe" See Note 2, in Appendix 2B, under Source #28.
January 09	~ 06:55	07:03	Santa Cruz	Santa Cruz *Pacific Sentinel*, 17 January 1857	75	28b	III-IV	("a few minutes before 07:00") "Not as severe as" other quakes at 4 am and 7:30 am. This article describes the mainshock (the strongest shock) as occurring at around 7:30am, which contradicts information given in their article on January 10. See Note 2, in Appendix 2B, under Source #28.
January 09	07:00	07:08	Santa Cruz	Santa Cruz *Pacific Sentinel*, 31 January 1857	33	28e		This article describes the 7 am quake as the strongest, which is probably erroneous. See Note 2, in Appendix 2B, under Source #28.
January 09	~ 04:00	04:08	San Jose	San Jose *Tribune*, 14 January 1857	36	30a		"pretty severe"
January 09	05:00	05:08	San Jose	San Jose *Telegraph*, 13 January 1857	35	29a		"very distinct"
January 09	~ 06:00	06:08	San Jose	San Jose *Telegraph*, 13 January 1857	35	29a	III-IV	"very distinct"
January 08	23:00	23:10	San Francisco	San Francisco *Daily Town Talk*, 10 January 1857	52	36a		"At eleven o'clock on Thursday night the first shock occurred, and a moderate one ensued...." Unclear if this describes one or two events.

Appendix 1A: Felt Foreshocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes [‡]
January 08	23:20	23:30	San Francisco	San Francisco *Daily Sun*, 10 January 1857	49	35a		
January 09	01:33	01:43	San Francisco	San Francisco *Daily Sun*, 10 January 1857	49	35a		
January 09	04:15	04:25	San Francisco	San Francisco *Daily Sun*, 10 January 1857	49	35a		
January 09	05:00	05:10	San Francisco	San Francisco *Daily Herald*, 10 January 1857	47	33a		
January 09	~ 05:30	05:40	San Francisco	San Francisco *Daily Morning Call*, 10 January 1857	45	34a		"slight"
January 09	06:08	06:18	San Francisco	San Francisco *Daily Sun*, 10 January 1857	49	35a	II-III	
January 09	07:00	07:10	San Francisco	San Francisco *Daily Sun*, 10 January 1857	49	35a	III	
January 09	07:00	07:10	San Francisco	San Francisco *Daily Town Talk*, 10 January 1857	52	36a	III	
January 09	~ 07:15	07:25	San Francisco	Letter of G. Davidson, dated 19 January 1857	53	37	III	
January 09	~ 06:00	06:05	Stockton	Stockton *Daily San Joaquin Republican*, 10 January 1857	59	39a		?? A man believed he felt a shock at 6am, but not the mainshock -- it is possible that he felt the mainshock, but was just off on his timing.
January 08	(late?) night		Mokelumne Hill	San Francisco *Daily Sun*, 20 January 1857	50	35b		It is difficult to tell if in fact any shocks were felt at all.
January 09	02:15 ??	02:21	Sacramento	Sacramento *Daily Union*, 10 January 1857	65	40a		"slight" Note that the article says the mainshock was at 10:15 am, almost two hours off.
January 08-09	Thurs night and Fri morn		Marysville	Marysville *Herald*, 13 January 1857	69	41a		"several slight shocks"

For a more complete discussion of the foreshocks see Sieh (1978b), especially the timetable (p. 1736) and the appendix (pp. 1745-1748). Note that no reports of the mainshock are included in this table. For a list of reported mainshock times, please see Sieh (1978b); for a transcript of the related articles, please see the appendix to Agnew and Sieh (1978).

[‡] See p. A-29.

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
1857								
January 09	~ 08:05	07:58	Los Angeles	*El Clamor Público*, 17 January 1857	9	9b		"a few minutes after [the mainshock] was another earthquake which lasted for a short time"
January 09	~ 08:00	08:08	Santa Cruz	S. Cruz *Pacific Sentinel*, 31 January 1857	33	28e		This article describes the mainshock as occurring at around 7am, which contradicts information given in their article on 10 Jan. See Note 2, in Appendix 2B, under Source #28.
January 09	~ 08:35	08:24	San Bernardino	R.R. Hopkins, Journal of San Bernardino Mission, entry dated Friday 9	6	5a		about ten minutes after the mainshock; "a second shock not so violent [as the mainshock] which lasted about one minute" (mainshock stated to last "two minutes")
January 09	08:31	08:25	Oat Mountain, near San Fernando	Letter of W.E. Greenwell, dated 24 February 1857	18	15		six minutes after the mainshock; "another slight shock" *
January 09	08:34	08:30	Sycamore Vly.	Letter of W.M. Johnson, dated 19 January 1857	19	16		ten minutes after the mainshock; "lasted but a few seconds and not so violent as the first" **
January 09	08:36	08:32	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"a third shock quite violent lasted about 10 seconds" **
January 09	08:38	08:34	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"a fourth shock accompanied by a loud rumbling noise like distant thunder" **
January 09	08:48	08:44	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"a fifth shock slight and momentary" **
January 09	~ 08:55	08:48	Los Angeles	Los Angeles *Star*, 17 January 1857	14	12c		**two events:** "in half an hour after [the mainshock], another shock occurred, much less violent; another within an hour from that"
January 09	09:00	08:54	Oat Mtn., near San Fernando	Letter of Greenwell, dated 24 February 1857	18	15		"a very slight shock" *
January 09	09:02	08:58	Sycamore Vly.	Santa Barbara *Gazette*, 15 January 1857	20	17a		?? "slight" The *Gazette* says it got its information from W.M. Johnson, but Johnson's letter contains no mention of this aftershock -- the original manuscript was checked. This may be a bogus report, but it is also possible that Johnson told the *Gazette* about this aftershock, then left it out of his own letter. **

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	## Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes #
January 09 1857	09:31	09:25	Oat Mtn., near San Fernando	Letter of Greenwell, dated 24 February 1857	18	15		another slight shock *
January 09	~ 10:00	09:59	Santa Barbara	Letter dated S. Barbara, 9 Jan. 1857, appearing in the San Francisco *Daily Alta California*, 13 January 1857	38	31a		"slight"
January 09	~ 10:00	10:05	15-20 miles NW of San Benito	Diary of Dr. C.A. Canfield	30	27a		felt only by a person lying down
January 09	~ 16:05	15:54	San Bernardino	Caroline Barnes Crosby Diary, 9 January 1857		4a		"very slight"
January 09	16:47	16:41	Oat Mtn., near San Fernando	Letter of Greenwell, dated 24 February 1857	18	15		"another slight shock" *
January 09	17:00	16:53	Los Angeles	Los Angeles *Star*, 17 January 1857	14	12c		"almost as severe as the first"; "followed at intervals by slight motions, till about eleven o'clock, when another heavy one occurred"
January 09			Los Angeles	*El Clamor Público*, 17 January 1857	9	9b		"from the first shock at 10 A.M. until 5 P.M. the earth has been moving constantly, though it required close attention to notice this"
January 09	20:27	20:24	San Buenaventura	Letter of Johnson, dated 19 January 1857	19	16		"slight and momentary"
January 09	20:30	20:26	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"lasted about 1 1/2 minutes, not so severe as the first one of this morning" **
January 09	20:40	20:36	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"lasted about 1 minute, slight" **
January 09	20:45	20:42	Visalia	Letter dated 9 Jan. 1857, appearing in the Stockton *Daily Argus*, 19 January 1857	58	38b		"a slight shock"
January 09	20:45 or 20:50	20:42 or 20:47	San Buenaventura	Letter of Johnson, dated 19 January 1857 Santa Barbara *Gazette*, 15 January 1857	19, 20	16, 17a		"quite violent but momentary," "momentary" Each source reports only one quake around this time. Mr. Johnson apparently reported to the *Gazette* one time, but wrote in his letter another. The two times were off by 5 minutes. See Appendix 2B, Documents 16 and 17a.
January 09	night, before 21:00		San Bernardino	Caroline Barnes Crosby Diary, 9 January 1857		4a		"slight"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
January 09 1857	~ 21:00	20:50	Cajon Pass	Los Angeles *Star*, 17 January 1857, under the heading "FROM THE MOJAVE"	14	12c		"not very severe" note, however, that this was felt by persons *outside*
January 09	22:00	21:56	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"lasted about half a minute, slight" **
January 09	22:25	22:22	Visalia	Letter dated 9 Jan. 1857, appearing in the Stockton *Daily Argus*, 19 January 1857	58	38b		"a slight shock"
January 09	22:20	22:26	Sacramento	Sacramento *Daily Union*, 10 January 1857	65	40a	II-III	"slight" -- the editors of the newspaper did NOT feel this aftershock themselves
January 09	~ 22:30	22:27	Visalia	Letter dated 9 Jan. 1857, appearing in the Stockton *Daily Argus*, 19 January 1857	58	38b	IV-V	"quite a severe [shock]"
January 09	22:36	22:33	San Buenaventura	Letter of Johnson, dated 19 January 1857	19	16	III-IV	"strong but momentary"
January 09	22:40	22:36	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16	IV-V	"the most severe shock of any though much shorter than the first of this morning" **
January 09	~ 23:00	22:50	Cajon Pass	Los Angeles *Star*, 17 January 1857, under the heading "FROM THE MOJAVE"	14	12c	IV	"not very severe" note, however, that this was felt by persons *outside*
January 09	23:00	22:53	Los Angeles	*El Clamor Público*, 17 January 1857	9	9b	IV	"a third shock which lasted 4 seconds"
January 09	~ 23:00	22:53	Los Angeles	Los Angeles *Star*, 17 January 1857	14	12c	IV	"another heavy one"; "during the night several other vibrations were felt"
January 09	evening		Santa Barbara	Letter dated S. Barbara, 9 Jan. 1857, appearing in the San Francisco *Daily Alta California*, 13 January 1857	38	31a		"three [in the] evening, two slight, one heavy"
January 09	night		San Bernardino	R.R. Hopkins, Journal..., entry dated Saturday 10	6	5b		**two events:** "two quite severe shocks, though not so severe as [the mainshock]"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes
January 09 1857			Tejon Canyon, around 20 km NE or ENE of Ft. Tejon	Daily Journal, Tejon Indian Reservation, entry dated 9 January 1857	24	20a		"ten slight shocks during the day"
January 09			Los Angeles	Journal of William A. Wallace, 9 January 1857		13a		"During the day a dozen shocks of less violence than the first have been felt."
January 09-10			Fort Tejon	Letter of Lt. Col. B.L. Beall, dated 9-10 January 1857	23	19		At 8pm on January 9, he wrote that the shocks "have continued with more or less violence, at intervals of five or six minutes, up to this time"; at 9 am on January 10, he wrote that "during the night, and up to this time, the shocks have continued with much violence, at intervals. The buildings have been much damaged since 8 o'clock P.M. of yesterday."
January 09-10			Los Angeles	*El Clamor Público*, 17 January 1857	9	9b		"during the night three more were felt ... though all were brief ... making a total of six that were noticed by most people"
January 10	08:20	08:16	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"slight" **
January 10	~ 23:00	22:53	Los Angeles	Los Angeles *Star*, 17 January 1857	14	12c		"On Saturday several slight shocks occurred — with a severe one about eleven o'clock at night."
January 10			San Bernardino	Los Angeles *Star*, 17 January 1857, under the heading "FROM SAN BERNARDINO"	14	12c		shaking "nearly all day"
January 11	21:40	21:36	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"slight" **
January 11	22:05	22:01	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"quite severe, lasted about 1 1/2 minutes" **
January 11	~ 23:00	22:53	Los Angeles	Los Angeles *Star*, 17 January 1857	14	12c		"a pretty strong vibration"; and then "at intervals throughout the night"
January 11	night		Los Angeles	Wallace Journal, 12 January 1857		13b		"the whole town was again thrown out of doors by the earthquake ... long drawn out [and] followed by a loud concussion"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	## Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes #
January 11 1857			San Bernardino	Los Angeles *Star*, 17 January 1857, under the heading "FROM SAN BERNARDINO"	14	12c		"another shock"
January 12	morning		San Bernardino	Los Angeles *Star*, 17 January 1857, under the heading "FROM SAN BERNARDINO"	14	12c		"quite gentle"
January 12			Los Angeles	Los Angeles *Star*, 17 January 1857	14	12c		"Monday was generally considered free from shocks, although many say they felt them distinctly throughout that day also."
January 13			San Bernardino	R.R. Hopkins, Journal..., entry dated Tuesday 13	6	5c		"the Earth oscillates slightly though perceptible every day"
January 15	~ 00:00	23:59 (on Jan 14)	Santa Barbara	Santa Barbara *Gazette*, 15 January 1857	20	17a		?? "light shock"; date not completely certain
January 15	~ 06:00	05:59	Santa Barbara	Santa Barbara *Gazette*, 15 January 1857	20	17a		?? "strong shock"; date not completely certain
January 15	22:40	22:36	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"slight" **
January 16	00:48	00:44	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"severe, lasted 1 1/2 minutes" **
January 16	00:50	00:46	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"more severe than the last, preceded by a rumbling noise" **
January 16	04:46	04:42	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"slight" **
January 16	~ 16:00	15:59	Santa Barbara	Santa Barbara *Gazette*, 22 January 1857	21	17b	V	"... of brief continuance. No damage ensued therefrom.*** It was sensibly felt throughout the city, and was of sufficient intensity to cause people to leave their houses."
January 16	16:45	16:34	San Bernardino	R.R. Hopkins, Journal..., entry dated Friday 16	6	5d	V	"... a very severe shock of an Earthquake though short. The house shook perceptibly for a minute. The inhabitants of the City fled from the houses to the Street."
January 16	~ 17:00	16:49	San Bernardino	Caroline Barnes Crosby Diary, 16 January 1857		4e	V	"It was the hardest I had witnessed since the first on Friday last."

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
January 16 1857	~ 17:00	16:49	San Bernardino	Letter from Amasa Lyman, dated 18 January 1857		6	V	"... a very severe shock of an earthquake.... The houses shook perceptably for a minute or so. Many of the inhabitants fled from their houses into the street." Note that this is part of a letter, of which *another* excerpt was included in Agnew & Sieh's Appendix, source no. 5.
January 16	17:00	16:53	Los Angeles	*El Clamor Público*, 17 January 1857	9	9b	V-VI	"nearly as strong as the first one but did not last as long"
January 16	17:00	16:53	Los Angeles	Los Angeles *Star*, 17 January 1857	13	12b	V-VI	"a very severe vertical earthquake ... almost as strong as that a week ago"
January 16	17:10	16:58	San Diego	Meteorological Journal of Andrew Cassidy, "Remarks" dated 16th	3	2a	IV	"lasted 1min, 20sec" (Cassidy described the mainshock as lasting 2min, 10sec.)
January 16	afternoon, about when it was felt elsewhere		near Castaic Junction	Santa Barbara *Gazette*, 22 January 1857	21	17b	V-VI	"heavy shock" (more precise location: along the Santa Clara River at the present Los Angeles - Ventura county line)
January 17	19:27	19:23	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"slight" **
January 17 (?)	evening		San Bernardino	Letter from D.M. Thomas, dated 18 January 1857	5	7		"quite a shake of the regular kind" (by *regular*, he means in contrast to the kind with long-period motion, which tends to cause nausea) Comparing this letter with other reports from San Bernardino leads one to believe Mr. Thomas may be mistaken in the date, and that he may actually be talking about the earthquake of 16 January at ~ 5 p.m.
January 17			San Bernardino	R.R. Hopkins, Journal..., entry dated Saturday 17	6	5e		"The Earth quakes slightly throughout the day & night."
January 17			San Bernardino	Letter from Amasa Lyman, dated 18 January 1857		6		"The earth quaked slightly throughout the day and night." Note that this is part of a letter, of which *another* excerpt was included in Agnew & Sieh's Appendix, source no. 5.
January 09-17			Los Angeles	Letter dated 28 Jan. 1857, appearing in the San Francisco *Daily Evening Bulletin*, 3 February 1857	43	32b		"We had five or six shocks during the same day and night [as the mainshock], and within about eight days time we had *twenty* shocks — some violent, some light. Since that time we have had none to speak of."

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
January 18 (or 28?) 1857	~ 02:00	01:56	Sycamore Vly.	Letter of Johnson, dated 19 January 1857	19	16		"a very severe shock" The original text of this letter actually says it occurred on the 28th, although the letter itself was dated the 19th. The previous entry on the list of earthquakes given in the letter was for one on the 17th, and the entry for the "28th" was the final entry on the list. In light of the inconsistency, it is believed that the actual date of this earthquake was January 18th. **
January 18	morning		Santa Barbara	Santa Barbara *Gazette*, 22 January 1857	21	17b		"slight"
January 18			San Bernardino	R.R. Hopkins, Journal..., entry dated Monday 19	6	5f		"several slight earthquakes yesterday and last night"
January 20	08:30		Santa Cruz & Mission San Juan	Townley & Allen (1939)		42	IV	"strong," "smart," Rossi-Forel Intensity V
January 20	morning		Santa Cruz	S. Cruz *Pacific Sentinel*, 24 January 1857	76	28c	IV	not as severe as mainshock, though it caused a general rattling among storekeepers' crockery ware
January 20	morning		San Francisco	Stockton *Daily San Joaquin Republican*, 23 January 1857		39c	III	"slight" -- unclear whether it was felt by the editors of the newspaper in Stockton
January 20	morning		San Francisco	San Francisco (Daily) *Herald*, 21 January 1857		33b	III	"We understand there was a slight shock of an earthquake felt in this city yesterday morning. It must have been very slight."
January 20			Fort Tejon	Los Angeles *Star*, 24 January 1857, under the heading "FROM FORT TEJON"		12d		"a severe shock" Townley & Allen (1939) estimate Rossi-Forel Intensity VI
January 20	15:30		Mission San Juan	Townley & Allen (1939)		42		
January 20	night		Santa Barbara	Santa Barbara *Gazette*, 22 January 1857	21	17b		"moderate"
January 21	~ 07:20 or ~ 19:20	07:25 or 19:25	15-20 miles NW of San Benito	Dr. Canfield's diary		27b		"a slight shock lasting a few seconds" Townley & Allen (1939) estimate Rossi-Forel Intensity III
January 28	~ 01:30	01:29	Santa Barbara	Santa Barbara *Gazette*, 29 January 1857		17d	III	"[a] shock of an earthquake ... It was vibratory, and lasted some 8 or 10 seconds."

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Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
January 09-28 1857			Pasadena / San Marino	Letter of H.R. Myles, dated 28 January 1857	15	14		"about fifty earth-quakes in the last two weeks, three of which rocked the house very much, and cracked the plastering and walls in many places but has done no serious damage..."
January 31	13:10 ??	12:59	San Bernardino	R.R. Hopkins, Journal..., entry dated Saturday 31	6	5g		"severe" with "loud reports in the mountains"; time may be incorrect; it may instead be 01:10
February 01			Fort Tejon	Fort Tejon Meteorological Records		21		shocks
February 02			Fort Tejon	Fort Tejon Meteorological Records		21		shocks
February 03			Fort Tejon	Fort Tejon Meteorological Records		21		shocks
February 04			Fort Tejon	Fort Tejon Meteorological Records		21		shocks
February 05			Fort Tejon	Fort Tejon Meteorological Records		21		shocks
February 07			Fort Tejon	Fort Tejon Meteorological Records		21		"shocks scarcely perceptible"
February 08			Fort Tejon	Fort Tejon Meteorological Records		21		shocks "continued more intensely"
February 09			Fort Tejon	Fort Tejon Meteorological Records		21		shocks
February 10			Fort Tejon	Fort Tejon Meteorological Records		21		shocks
February 11	23:00	22:55	Fort Tejon	Fort Tejon Meteorological Records		21		"very distinct shock"
February 12	during the night		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks
February 19	21:00	20:55	Fort Tejon	Fort Tejon Meteorological Records		21		
February 20	10:00	09:55	Fort Tejon	Fort Tejon Meteorological Records		21		
February 21	day		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks

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Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
February 22 1857	day		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks
February 23	21:00	20:55	Fort Tejon	Fort Tejon Meteorological Records		21		
February 28	during the night		Fort Tejon	Fort Tejon Meteorological Records		21		
February 28	10:00	09:55	Fort Tejon	Fort Tejon Meteorological Records		21		
March 01	day		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks
March 02			Fort Tejon	Fort Tejon Meteorological Records		21		shocks
March 03	20:30	20:25	Fort Tejon	Fort Tejon Meteorological Records		21		"two shocks, one very severe at 8:30 P.M."
March 05	afternoon		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks
March 06	15:40	15:35	Fort Tejon	Fort Tejon Meteorological Records		21		
March 07	04:00	03:55	Fort Tejon	Fort Tejon Meteorological Records		21		
March 08	day		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks
March 11	between 4 and 6 am		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks
March 12	during the night		Fort Tejon	Fort Tejon Meteorological Records		21		three shocks
March 12	11:00	10:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
March 13	during the night		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks

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Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
March 14 1857	~ 03:00	02:59	Santa Barbara and Montecito	Santa Barbara *Gazette*, 19 March 1857		17f	IV	"a hard earthquake shock ... of momentary duration" Townley & Allen (1939) estimate Rossi-Forel Intensity V
March 14	during the night		Fort Tejon	Fort Tejon Meteorological Records		21		three shocks
March 15	05:00	04:55	Fort Tejon	Fort Tejon Meteorological Records		21		
March 17	~ 00:00	23:55 (on Mar 16)	Fort Tejon	Fort Tejon Meteorological Records		21		"very slight" Note that this is listed in the Meteorological Records as being on midnight of March 16. It probably meant the night of the 16th / morning of the 17th, but it is unclear.
March 17	day		Fort Tejon	Fort Tejon Meteorological Records		21		"light"
March 27	15:00	14:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
March 31	forenoon		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks
April 01	03:35	03:40	15-20 miles NW of San Benito	Dr. Canfield's diary		27c		"a severe shock lasting about eight seconds" Townley & Allen (1939) estimate Rossi-Forel Intensity VI
April 03	during the night		Fort Tejon	Fort Tejon Meteorological Records		21		three shocks
April 09	night		San Gabriel and San Jose (Los Angeles Co.)	Stockton *Daily Argus*, 28 April 1857 <originally> *El Clamor Público, L.A.*		38c		"severe" The San Jose mentioned was "nine leagues from Los Angeles" -- probably near San Gabriel. See Appendix 2B, Document 38c, and accompanying Note 4.
April 16	day		Fort Tejon	Fort Tejon Meteorological Records		21		four shocks
April 17	during the night		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks
April 18	evening		Fort Tejon	Fort Tejon Meteorological Records		21		

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April 19 1857	~ 13:00	12:53	Los Angeles	Los Angeles *Star*, 25 April 1857		12e		"slight ... It caused doors and windows to rattle pretty freely, and some people to run out of their houses, but did not create any general alarm."
April 19	afternoon		Fort Tejon	Fort Tejon Meteorological Records		21		two shocks
April 20	04:00	03:55	Fort Tejon	Fort Tejon Meteorological Records		21		
April 22	during the night		Fort Tejon	Fort Tejon Meteorological Records		21		"three light shocks"
April 23	09:30	09:25	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
April 24	11:00	10:55	Fort Tejon	Fort Tejon Meteorological Records		21		
April 24 ??			San Gabriel and San Jose (Los Angeles Co.)	Townley & Allen (1939)		42		The San Jose mentioned was probably in Los Angeles Co. See Appendix 2B, Source 38, Note 4, and Source 42, Note 2.
April 25	morning		Fort Tejon	Fort Tejon Meteorological Records		21		
April 26	during the night		Fort Tejon	Fort Tejon Meteorological Records		21		
April 27	during the night		Fort Tejon	Fort Tejon Meteorological Records		21		
April 28	afternoon		Fort Tejon	Fort Tejon Meteorological Records		21		
May 02	morning		Los Angeles	Townley & Allen (1939)		42		"two shocks"
May 03	22:00	21:53	Los Angeles and El Monte	Townley & Allen (1939)		42		"smart," "violent" Rossi-Forel Intensity VI
May 06	06:00	05:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
May 15	02:30	02:25	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
May 16	11:45	11:40	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"

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Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
May 18 1857	14:00	13:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
May 19	21:30	21:25	Fort Tejon	Fort Tejon Meteorological Records		21		"very severe"
May 20	03:00	02:55	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
May 23 (~)			Fort Tejon	Los Angeles *Star*, 30 May 1857		12f	V	"last week, one or two very severe shocks occurred there, which awoke the sleepers and sent them in a hurry to breathe the fresh air of the parade ground"
May 23			Fort Tejon	Stockton *Daily Argus*, 30 May 1857		38d	V	Townley & Allen (1939) add the description "severe," estimate Rossi-Forel Intensity VI
May 23			Los Angeles	Stockton *Daily Argus*, 30 May 1857		38d		"slight," Townley & Allen (1939) also state that there were "four shocks" at Los Angeles, and they estimate Rossi-Forel Intensity III
May 26	08:15	08:10	Fort Tejon	Fort Tejon Meteorological Records		21		"very severe"
June 02	22:30	22:25	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
June 05	18:30	18:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
June 06	10:00	09:55	Fort Tejon	Fort Tejon Meteorological Records		21		"scarcely perceptible"
June 09	~ 00:00	23:55 (on June 08)	Fort Tejon	Fort Tejon Meteorological Records		21		"two heavy shocks" Note that this is listed in the Meteorological Records as being on midnight of June 8. It probably meant the night of the 8th / morning of the 9th, but it is unclear.
June 10	01:43	01:38	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
June 11	16:30	16:25	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
June 12	17:00	16:55	Fort Tejon	Fort Tejon Meteorological Records		21		"very severe"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
June 14 1857	16:00	15:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
June 15	16:00	15:55	Fort Tejon	Fort Tejon Meteorological Records		21		"scarcely perceptible"
June 18	17:00	16:55	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
July 03	02:00	01:55	Fort Tejon	Fort Tejon Meteorological Records		21		"very severe"
July 03	05:00	04:55	Fort Tejon	Fort Tejon Meteorological Records		21		"very severe"
July 04	05:00	04:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
July 05	16:00	15:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
July 07	14:10	14:05	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
July 09	~ 00:00	23:53 (on July 08)	Los Angeles	Wallace Journal, 10 July 1857		13e	IV	"a very respectable earthquake ... shaking our beds and houses with a good deal of spirit"
July 09	02:00	01:55	Fort Tejon	Fort Tejon Meteorological Records		21	IV-V	"extremely heavy, lasting nearly a minute"
July 10	16:00	15:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
July 10	22:00	21:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
July 12	09:30	09:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
July 13	03:00	02:55	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
July 14	04:20	04:15	Fort Tejon	Fort Tejon Meteorological Records		21		"very severe"
July 15	15:30	15:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
July 15	22:30	22:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
July 16 1857	16:15	16:10	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
July 17	20:30	20:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
July 21	16:00	15:55	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
July 22	01:20	01:15	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
July 26	22:45	22:40	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
July 28	07:30	07:25	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
July 28	20:00	19:55	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
August 03	16:00	15:55	Fort Tejon	Fort Tejon Meteorological Records		21		"two slight shocks"
August 05	02:00	01:55	Fort Tejon	Fort Tejon Meteorological Records		21		"two shocks with heavy rumblings"
August 06	22:00	21:55	Fort Tejon	Fort Tejon Meteorological Records		21		"heavy"
August 07	10:00	09:55	1 mile SW of Fort Tejon	Fort Tejon Meteorological Records		21		"very severe"
August 08	07:45	07:40	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
August 09	12:15	12:10	Fort Tejon	Fort Tejon Meteorological Records		21		"extremely heavy"
August 15	23:45	23:40	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
August 20	02:00	01:55	Fort Tejon	Fort Tejon Meteorological Records		21		"very severe"
August 25	22:35	22:30	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
August 29 1857	09:15	09:10	Fort Tejon	Fort Tejon Meteorological Records		21		"a very severe shock" Townley & Allen (1939) estimate Rossi-Forel Intensity VI at Tejon Reserve, "severe"
August 29	10:27	10:22	Fort Tejon	Los Angeles *Star*, 5 September 1857, under the heading "FROM FORT TEJON"		12g		"a very severe shock" Townley & Allen (1939) estimate Rossi-Forel Intensity VI at Tejon Reserve, "severe"
September 07	11:30	11:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
September 11	05:00	04:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight shock with heavy rumbling"
September 14	02:45	02:40	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
September 22	01:00	00:55	Fort Tejon	Fort Tejon Meteorological Records		21		
September 22	14:00	13:55	Fort Tejon	Fort Tejon Meteorological Records		21		"heavy"
October 02	19:30	19:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
October 03	06:00	05:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
October 06	23:00	22:55	Fort Tejon	Fort Tejon Meteorological Records		21		"heavy"
October 09	00:45	00:40	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
October 19	02:00	01:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
October 22	06:45	06:40	Fort Tejon	Fort Tejon Meteorological Records		21		"heavy"
November 01	14:00	13:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
November 03	18:00	17:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
November 06 1857	04:00	03:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
November 06	21:45	21:40	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
November 09	04:00	03:55	Fort Tejon	Fort Tejon Meteorological Records		21		"four successive shocks"
November 14	15:15	15:10	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
November 20	22:15	22:10	Fort Tejon	Fort Tejon Meteorological Records		21		"heavy"
November 23	14:20	14:15	Fort Tejon	Fort Tejon Meteorological Records		21		"shock with heavy rumblings"
November 29	04:30	04:25	Fort Tejon	Fort Tejon Meteorological Records		21		"heavy"
December 01	22:00	21:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
December 02	~ 01:00	00:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
December 03	20:45	20:40	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
December 09	early morning		San Bernardino	Los Angeles *Star*, 26 December 1857		12i		"Three shocks of an earthquake.... One was very heavy. No damage was done."
December 12	23:30	23:25	Fort Tejon	Fort Tejon Meteorological Records		21		"heavy"
December 15	~ 02:55	02:44	San Bernardino	Caroline Barnes Crosby Diary, 15 December 1857		4g		"light"
December 23	13:00	12:55	Fort Tejon	Fort Tejon Meteorological Records		21		"extremely heavy"
1858								
January 17	22:00	21:55	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
January 21 1858	16:30	16:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
January 26	08:00	07:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
February 02	05:10	05:05	Fort Tejon	Fort Tejon Meteorological Records		21		"heavy"
February 18	03:30	03:25	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
March 27	02:00	01:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight" Note: the Monthly Report lists a shock on Mar 27, but it is not clear which one it refers to.
March 28	00:00	23:55 (on Mar 27)	Fort Tejon	Fort Tejon Meteorological Records		21		Note: the Monthly Report lists a shock on Mar 27, but it is not clear which one it refers to.
March 28	16:00	15:55	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		
March 29	22:15	22:10	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"heavy"
April 03	04:15	04:10	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"heavy"
April 05	21:10	21:05	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"slight" Note that the Monthly Report states the time of this quake as 9:10 A.M.
April 06	06:30	06:25	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"heavy"
April 12	20:10	20:05	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"very heavy" Note that the Monthly Report states the time of this quake as 8:10 A.M.

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
May 18 1858	14:00	13:55	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"heavy"; "severe" Note that the Monthly Report states the time of this quake as 2:40 P.M.
May 19	17:30	17:25	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"slight" Note that the Monthly Report states the time of this quake as 6:10 P.M.
May 27	15:30	15:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
June 14	21:30	21:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
June 15	21:15	21:10	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"very heavy"; "severe ... slightly injuring the Quarters of the Company"
July 21	23:00	22:55	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"slight"
July 21	23:30	23:25	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"very heavy"
August 08	06:45	06:40	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"slight"
August 13	10:30	10:25	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"heavy"
August 13	11:30	11:25	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"heavy"
September 02			Santa Barbara	Townley & Allen (1939)		42		"smart," Rossi-Forel Intensity V
September 06	20:10	20:05	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"slight"
September 07	19:45	19:40	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"slight"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
September 08 1858	19:10	19:05	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"slight"
September 09	18:45	18:40	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"slight" Note that the Monthly Report states the time of this quake as 6:45 A.M.
October 06	11:10	11:05	Fort Tejon	Fort Tejon Meteorological Records		21		
December 15	18:30	18:23	Los Angeles	Los Angeles *Semi-Weekly Vineyard*, 17 December 1858		11a	IV	"slight movements to effect the uprightness of beings and things upon the face of the earth, in this neighborhood, were felt by most of our citizens"
December 15	~ 18:30	18:23	Los Angeles	Los Angeles *Star*, 18 December 1858		12j	IV	"a shock of an earthquake ... it caused quite a shaking of doors and windows"
December 15	~ 19:30	19:19	San Bernardino	Los Angeles *Star*, 25 December 1858, under the heading "FROM SAN BERNARDINO"		12k	V-VI	"[a] shock of an earthquake ... causing men, women and children to make a general rush out into the street, ... cracking the walls of a few houses, and causing doors to fly open, breaking a few dishes and upsetting a few buckets of water. It lasted for about twenty-three seconds." Toppozada, et al (1981) estimate MMI VI at San Bernardino.
December 16	~ 02:00	01:53	Los Angeles	Los Angeles *Star*, 18 December 1858		12j		"a pretty severe shock"
December 16	~ 03:00	02:53	Los Angeles	Los Angeles *Star*, 18 December 1858		12j		"a slight one"
December 16	03:10	02:59	San Bernardino	Los Angeles *Star*, 25 December 1858, under the heading "FROM SAN BERNARDINO"		12k	VII (at S.B.)	"more severe [than that of the night of 15 Dec.], knocking the gable end out of a house ... and tearing the paper from the walls of another house; it lasted half a minute." Continues to say that one house was "shaken down by the earthquake, at Agua Manza," but it is unclear which earthquake (this one or the one earlier that night) was most at fault. Toppozada, *et al.* (1981) estimate MMI VII at San Bernardino and MMI IX at Agua Manza (near San Bernardino).

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	## Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes #
December 16 1858	03:15	03:08	Los Angeles	Los Angeles *Semi-Weekly Vineyard*, 17 December 1858		11a	IV-V	"slight movements to effect the uprightness of beings and things upon the face of the earth, in this neighborhood, were felt by most of our citizens"
December 19	21:00	20:55	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"tremendous shock"; "severe" Note that the Monthly Report states the time of this quake as 9:15 P.M.
December 27	07:45	07:40	Fort Tejon	Ft. Tejon Monthly Report		22		"slight"
1859								
January 22	18:15	18:10	Fort Tejon	Fort Tejon Meteorological Records		21		
January 26	23:00	22:48	San Diego	Agnew, et al (1979); *originally:* Diary of Dr. George McKinstry, entry dated 27 January 1859		3a		
March 08	22:30	22:25	Fort Tejon	Fort Tejon Meteorological Records		21		
March 14	19:30	19:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
March 21	05:20	05:08	San Diego	San Diego *Herald*, 26 March 1859		1a		"We were aroused from our slumbers ... [it] made our dwelling — which is a strong framed, two story structure — creak in every timber and joint. The shock was preceded by no rumbling or other sound, and lasted but a moment. ... across the river, it was much more severe...."
March 21	06:00	05:48	San Diego	Agnew, et al (1979); *originally:* McKinstry Diary, entry dated 21 March 1859		3b		Agnew, et al, estimate intensity IV-V(?). "several more felt that day"

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Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	## Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
March 21 1859	06:18	06:06	San Diego	Letter dated 21 Mar. 1859, appearing in the L.A. *Semi-Weekly Vineyard*, 29 March 1859		11b		"severe ... the first shock seemed to be to the south, with three distinct vibrations, then back to the north, with three more, when it ceased. It was the heaviest shock that I have ever experienced in San Diego."
March 21			San Bernardino	Los Angeles *Star*, 2 April 1859		12l		"a shock of an earthquake" -- unclear which Monday it actually occurred on; it may have been March 28 instead
March 23	03:00	02:55	Fort Tejon	Fort Tejon Meteorological Records		21		"four slight shocks"
March 25			San Diego	Agnew, et al (1979); *originally:* McKinstry Diary, entry dated 25 March 1859		3c		"severe, with ground cracking near Ballena" See note in Agnew, et al.
March 26	14:00	13:48	San Diego	San Diego *Herald*, 2 April 1859		1b		"an earthquake shock, lasting for nearly a minute, was sensibly felt ... it came very near knocking a lot of type in our office into pi"
March 26			San Diego	Agnew, et al (1979); *originally:* McKinstry Diary, entry dated 26 March 1859		3d		possibly felt at Mesa Grande
March 30	10:00	09:48	San Diego	Agnew, et al (1979); *originally:* McKinstry Diary, entry dated 30 March 1859		3e		"slight"
April 01	02:00	01:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
April 22	21:30	21:25	Fort Tejon	Fort Tejon Meteorological Records		21		"severe"
April 22	22:00	21:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
April 23	21:30	21:25	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
May 04	23:30	23:25	Fort Tejon	Fort Tejon Meteorological Records		21	V	"severe, continuing 20 minutes, shaking the hospital fearfully"
June 05	02:00	01:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
July 06 1859	22:00	21:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
August 02	10:00	09:48	San Diego	Agnew, et al (1979); *originally:* McKinstry Diary, entry dated 2 August 1859		3f		
September 08	08:00	07:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
September 20	01:00	00:55	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
October 11	18:35	18:30	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"slight" Note that the Monthly Report states the time of this quake as 6:30 P.M.
October 19	01:00	00:55	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"distinct shock"
October 19	07:30	07:25	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"distinct shock"
November 23	23:30	23:25	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"heavy"; "severe"
November 28	08:00	07:55	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"severe" also heard "heavy rumbling noise in the earth during this night similar to the arrival or departure of a train of railroad cars"
December 01	14:10	13:59	San Bernardino	Townley & Allen (1939)		42		"several successive shocks, some quite heavy"; Rossi-Forel Intensity V
December 02	morning		San Bernardino	Letter dated 6 Dec. 1859, appearing in the Los Angeles *Star*, 10 December 1859, under the heading "CORRESPONDENCE"		12m		"several shocks of an earthquake ... I have not heard of any damage being done."

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Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
1860								
January 13	~ 05:00	04:49	San Bernardino	Los Angeles *Star*, 21 January 1860, under the heading "FROM SAN BERNARDINO"		12n		"some of our citizens were aroused from their slumbers by a slight shake of old mother earth, accompanied by a rumbling noise, like that of distant thunder -- nobody hurt"
January 14	19:23	19:11	San Diego	Meteorological Journal of Andrew Cassidy, "Remarks" dated 14th		2b		"a heavy Earthquake shock, with a rumbling noise ... lasted about 10 seconds"
January 14			San Diego	Agnew, et al (1979); *originally:* Climatological Records of the Weather Bureau, Record Group 27, Microfilm # T-907 (U.S. National Archives)		3g		"violent"
January 27	~ 00:30	00:23	Los Angeles	Los Angeles *Star*, 28 January 1860		12o		"a pretty severe shock ... shaking and rattling doors and windows in the casements ... but a single shock was experienced, accompanied by a rumbling noise; several persons were awoke by the noise, and others by the motion of their beds."
March 26			Los Angeles and So. California	Townley & Allen (1939)		42		"severe," Rossi-Forel Intensity VI
April 02	20:00	20:06	San Juan Bautista	Townley & Allen (1939) *originally:* Sacramento *Union*, 7 April 1860		42		"two severe shocks," Rossi-Forel Intensity VI
April 16	19:00	18:55	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22	III	"slight" Note that the Monthly Report states the time of this quake as 6:30 P.M.
April 16	19:30		San Francisco, Fort Tejon, Santa Barbara	Townley & Allen (1939) *originally:* Sacramento *Union*, 1 May 1860		42		Shocks also on April 17; see Townley & Allen catalogue for these dates
April 16	19:16	19:26	San Francisco	San Francisco *Daily Alta California*, 17 April 1860		31c	III	"... two shocks of an earthquake were felt in nearly all parts of the city. Nobody hurt."
April 16	~ 19:30	19:27	Visalia	Visalia *Weekly Delta*, 21 April 1860		25a	III	"a slight shock"

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Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
April 16 1860			Monterey	Santa Cruz *Pacific Sentinel*, 27 April 1860		28f	V	"frightened the good people of that town out of their propriety"
April 16			Santa Cruz	Santa Cruz *Pacific Sentinel*, 27 April 1860		28f	III-V	"felt"
April 16 and/or 17 (~)			San Francisco	San Jose *Tribune*, 20 April 1860		30b		"Several slight shocks of earthquake were felt in San Francisco last week." Apparently, this was *not* felt in San Jose, especially as it was *not* mentioned in the San Jose Telegraph.
April 17	morning, just before day		Monterey	Santa Cruz *Pacific Sentinel*, 27 April 1860		28f	IV	"lamps were set to ringing, dishes rattled, sleepers were awakened"
April 17	morning, just before day		Santa Cruz	Santa Cruz *Pacific Sentinel*, 27 April 1860		28f		"felt"
May 10	06:30	06:25	Fort Tejon	Ft. Tejon Meteorological Records; *also* Fort Tejon Monthly Report		21, 22		"slight" Note that the Monthly Report states the time of this quake as about 6:10 A.M.
June 06	00:30	00:25	Fort Tejon	Ft. Tejon Monthly Report		22		"slight"
August 02	05:00	04:48	San Diego	Agnew, et al (1979); *originally:* McKinstry Diary, entry dated 2 August 1860		3h		felt at Mesa Grande
August 15			San Diego	Agnew, et al (1979); *originally:* McKinstry Diary, entry dated 15 August 1860		3i		**two events:** lists times as 1:30 & 4:30; unclear if A.M. or P.M. possibly felt at Mesa Grande
September 11	17:45	17:40	Fort Tejon	Fort Tejon Meteorological Records		21		"slight"
September 22	03:00	02:55	Fort Tejon	Fort Tejon Meteorological Records		21		"heavy"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Date Felt	Reported Time	Corrected Time (to PST)	Location Felt	Source	‡‡ Source No. in Appdx to Agnew & Sieh (1978)	Document Number in Appdx 2B to this report	Estimated MMI	Notes ‡
1861								
February 20			Los Angeles	Visalia *Delta*, 2 March 1861		25b		Apparently *not* felt in Visalia. Also, *not* mentioned in Los Angeles *Star*.
December 09	~ 19:00	18:53	Santa Catalina Island	Los Angeles *Star*, 21 December 1861		12p		"one or two severe shocks of earthquake ... the inhabitants were considerably alarmed" -- unclear which Monday it actually occurred on; it may have been December 16 instead
1862								
February 03	morning		San Bernardino	Los Angeles *Star*, 8 February 1862, under the heading "FROM SAN BERNARDINO"		12q		"severe ... no damage done"
February 03	evening		San Bernardino	Letter dated 5 Feb. 1862, appearing in the Los Angeles *Star*, 22 February 1862, under the heading "FROM SAN BERNARDINO"		12r		"a slight shake ... in the southern portion of the city"
February 06	~ 22:00	21:49	San Bernardino	Benjamin Hayes, *Pioneer Notes*; entry dated 6 Feb. 1862		8a		"[a] shock of an earthquake, lasting a second"
April 15 (~)			Cariso Creek (Carrizo Creek, San Diego area?)	Los Angeles *Semi-Weekly Southern News*, 23 April 1862		10a		"severe" (on the desert between L.A. & Yuma); "at Cariso Station, it was severely felt, the few inhabitants were stricken with consternation"

Appendix 1B: Felt Aftershocks of the 9 January 1857 "Fort Tejon" Earthquake

Notes:

The cutoff date for earthquakes has been set at May 26, 1862. This is because, on May 27, 1862, there was a large earthquake in San Diego which had many aftershocks felt all over Southern California. In looking over the current catalogs covering that period, it was observed that no earthquakes occurred in Southern California that were *not* felt in San Diego for the remainder of 1862 (with the exception of one undated quake in Santa Barbara and Goleta). Thus, it is believed that if there were any aftershocks to the "Fort Tejon" quake this late in the sequence, they would have been buried in the San Diego aftershock sequence.

Note that no reports of the mainshock are included in this table. For a list of reported mainshock times, please see Sieh (1978b); for a transcript of the related articles, please see the appendix to Agnew and Sieh (1978).

† Words in quotes in this column are not necessarily quoted word-for-word; they may be paraphrased from the original document instead. Quotes are used in this column to distinguish descriptions taken from the original document from other comments added by the authors of this paper. Where it is desired to know the exact wording of the original document, please refer to Appendix 2B.

†† *If* listed in the Appendix to Agnew and Sieh (1978).

* Note that the Coast Survey San Fernando Station was on a subsidiary peak of Oat Mountain, near San Fernando; the description of the location in the Appendix to Agnew and Sieh (1978) would place this point 7-8 km due west of the interchange of interstates 5 and 210 today. (See Agnew and Sieh, 1978, their Appendix, p. 22.)

** Note that the Coast Survey Camp at Sycamore Valley was probably located in what is now Big Sycamore Canyon, just east of Point Mugu. See Agnew and Sieh (1978); also see Document 17a in Appendix 2B to this paper. In addition, a separate letter of W.M. Johnson describes Sycamore Valley. *(See 1857 Correspondence of the Superintendent, Records of the Coast and Geodetic Survey, Record Group 23, U.S. National Archives microfilm publication M-642, Roll 176, frame 300.)* His description matches the physical and topographic characteristics of Big Sycamore Canyon and of the Conejo Valley at the canyon's "head."

*** Although this newspaper report states that "no damage ensued therefrom," it is not clear how literally that statement should be interpreted. Consider the same newspaper's report of the mainshock: "[The earthquake] passed away without causing material damage to this city. Many walls of buildings were cracked.... The slight damage which ensued therefrom to our dwellings can doubtless be attributed to the great thickness of their 'adobe' walls, and the fact of their being built, with few exceptions, of but one story in height" (Agnew and Sieh, 1978, their Appendix, p.27). -- Although that article reports *no* "material damage" in the city, the next sentence describes damage to buildings. For the mainshock, there is an apparent contradiction within the article, and they may have been downplaying the damage; in the report of the January 16th aftershock, it is possible they did the same. This fact should be considered in assessing an intensity for the January 16th aftershock at this location.

Appendix 2A: List of Primary Sources

Source Number	Source	Number of Citations
1	San Diego *Herald*	2
2	Meteorological Journal of Andrew Cassidy, 1857-1860, San Diego	2
3	Catalog of San Diego Earthquakes (Agnew, et al, 1979)	10
4	Diary of Caroline Barnes Crosby, 1857, San Bernardino **	7
5	Journal of R.R. Hopkins, 1857, San Bernardino	7
6	Letter of Amasa Lyman, 18 January 1857, San Bernardino	1
7	Letter of D.M. Thomas, 18 January 1857, San Bernardino	1
8	Diary of Benjamin Hayes, 6 February 1862, San Bernardino	1
9	Los Angeles *El Clamor Público*	2
10	Los Angeles *Semi-Weekly Southern News*	1
11	Los Angeles *Semi-Weekly Vineyard*	2
12	Los Angeles *Star*	18
13	Journal of William A. Wallace, 1857, Los Angeles **	5
14	Letter of H.R. Myles, 28 January 1857, Pasadena	1
15	Letter of W.E. Greenwell, 24 February 1857, near San Fernando	1
16	Letter of W.M. Johnson, 19 January 1857, Sycamore Canyon	1
17	Santa Barbara *Gazette* **	8
18	Reminiscence of J.F. Dana, ca. 1930-36, Nipomo **	2
19	Letter of Lieutenant Colonel B.L. Beall, 9-10 January 1857, Fort Tejon	1
20	Daily Journal, January 1857, Tejon Indian Reservation, near Fort Tejon	2
21	Meteorological Records from Fort Tejon, 1857-1861	50
22	Monthly Reports from Fort Tejon, 1857-1861	14
23	Letter of John Xántus, 17 September 1857, Fort Tejon	1
24	Reminiscence of Mr. Bell, ca. 1905, Carrizo Plain	1
25	Visalia *Weekly Delta* and *Delta*	2
26	Meteorological Report from Fort Miller, CA, January 1857	1
27	Diary of Dr. C. A. Canfield, 1857, near San Benito	3
28	Santa Cruz *Pacific Sentinel*	6
29	San Jose *Telegraph*	1
30	San Jose *Tribune*	2
31	San Francisco *Daily Alta California*	3
32	San Francisco *Daily Evening Bulletin*	2

Appendix 2A: List of Primary Sources

33	San Francisco *Daily Herald*	2
34	San Francisco *Daily Morning Call*	1
35	San Francisco *Daily Sun*	2
36	San Francisco *Daily Town Talk*	1
37	Letter of George Davidson, 19 January 1857, San Francisco	1
38	Stockton *Daily Argus*	4
39	Stockton *San Joaquin Republican*	3
40	Sacramento *Daily Union*	1
41	Marysville *Herald*	1
42	Townley and Allen Catalog (1939) -- *selected excerpts*	23
43	E.B. Webb: *Indian Life at the Old Missions* (1952) **	2

** *includes a previously unpublished account of the 9 January 1857 mainshock*

Appendix 2B: Primary Documents

1. San Diego *Herald*[1]

1a. 26 March 1859 — page 2, column 4

EARTHQUAKE. — We were aroused from our slumbers on the morning of the 21st instant, at twenty minutes past five o'clock, by the shock of an earthquake, which made our dwelling — which is a strong framed, two story structure — creak in every timber and joint. The shock was preceded by no rumbling or other sound, and lasted but a moment. Sheriff Lyons, whose house is on the flat, across the river, informs us that it was much more severe in that locality than here in town, and that he thought his house was coming down over his head. Mr. Philip Crosthwaite says that it was felt very sensibly at his ranch. We beg that the old granny editors up country, who make it a business to abuse everybody and everything this side of San Francisco, will not make use of these little "shakings up" as an argument against the construction of the Pacific Railroad over the Southern Route!

1b. 02 April 1859 — page 2, column 4

ANOTHER EARTHQUAKE SHOCK. — Last Saturday, the 26th inst., about 2 o'clock in the afternoon, another earthquake shock, lasting for nearly a minute, was sensibly felt in this city. It shook the venerable adobes to the centre, and came very near knocking a lot of type in our office into *pi*. What with earthquakes, cold snaps, west winds and hard times, we are somewhat fearful the town is about "caving in."

Notes:

1. A report of the mainshock is given in the appendix to Agnew and Sieh (1978).

2. Meteorological Journal of Andrew Cassidy, San Diego[1]

Extracts (Cassidy File, San Diego Historical Society & Research Archives, San Diego)

2a. 16 January 1857

16th A shock felt here at 5^{h} 10^{m} p.m. lasted 0^{h} 1^{m} 20^{s}[2] — apparently horizontal motion E. to W.

2b. 14 January 1860

14th 7^{h} 23^{m} p.m. A heavy earthquake shock, with a rumbling noise. Vibration from N. to S. lasted about 10 seconds.

Notes:

1. A report of the mainshock is given in the appendix to Agnew and Sieh (1978).
2. Cassidy described the mainshock as lasting "2 minutes & 10 seconds."

3. Catalog of San Diego Earthquakes

(from Agnew, et al, 1979)

3a. 26 January 1859

11 P.M. [no description given] — McD[1] 1/27/59.

3b. 21 March 1859

6 A.M. Buildings creaked (IV-V?)[2]. Several more felt that day. — McD[1] 3/21/59; SDH[3] 3/26/59, 2:4.

3c. 25 March 1859

Severe, with ground cracking near Ballena. — McD[1] 3/25/59. (Possibly the same as the next shock)[2].

3d. 26 March 1859

2 P.M., sensibly felt. — SDH[3] 4/2/59, 2:4. Possibly also at Mesa Grande. — McD[1] 3/26/59.

3e. 30 March 1859

10 A.M., slight. — McD[1] 3/30/59.

3f. 02 August 1859

10 A.M. — McD[1] 8/2/59.

3g. 14 January 1860

7:23 P.M., "violent," lasted about 10 sec. — CR[4]; Meteorological Journal of Andrew Cassidy[5].

3h. 02 August 1860

5 A.M., Mesa Grande. — McD[1] 8/2/60.

3i. 15 August 1860

1:30 & 4:30. — McD[1] 8/15/60. (Mesa Grande?).

3j. 15 April 1862

Carrizo Creek stage station, all frightened. — Los Angeles *Semi-Weekly Southern News*[6] 4/23/62.

Notes:

1. Extracts from the diaries of Dr. George McKinstry, Serra Museum Library, San Diego. (Note: all files at the Serra Museum Library have since been transferred to the San Diego Historical Society & Research Archives, in San Diego.)

2. Their notes.

3. San Diego *Herald.* See Source #1, this appendix.

4. Climatological Records of the Weather Bureau, Record Group 27, U.S. National Archives. (Microfilm number T907. If no name is given, the records are those for San Diego or New San Diego.)

5. See Source #2, this appendix.

6. See Source #10, this appendix.

4. Diary of Caroline Barnes Crosby, San Bernardino[1]

Extracts (Vault Ms. B-89, Utah State Historical Society, Salt Lake City; transcript also held in the California Room at the San Bernardino Public Library)

4a. 09 January 1857[2]

Frid. 9th of Jan. It was quite fair for the season. At ten minutes or a qr. past 8 o'clock A.M., we were visited with a shock of an earthquake which lasted as near as I could judge about 3 or 4 minutes.

Appendix 2B: Primary Documents

I arose from the breakfast table and went to the kitchen to take another cake in order to finish my meal, got the cakes in my hand when suddenly I felt a dizzyness [sic] in my head, which was succeeded by a sick and nauseous feeling at my stomach. I concluded I had already eaten more than was for my interest and put the cakes in my pocket. I began to stagger and reel like a drunken person, and caught hold of a chair and sat down. By this time I discovered that everything was moving around me, my chair jostled forward and back. I put both hands to my head, and exclaimed Lord have mercy upon us. I arose and went to the door, and discovered bro. McGary, and family out of the house, meditating upon the wonderful phenomena. As I passed the pool of water, between our houses I discovered it was much agitated. I went over there as I was alone at home, Mr. C. having just before left to go to Col. Jackson's, and Alma had gone for a team to get wood. It was the first earthquake of any importance that I have ever witnessed. It caused a sensation similar to seasickness, which I found remained with me sometime after the shock passed away. Some minutes after it was over a certain rumbling sound could be distinctly heard in a northerly directing [sic] resembling distant canon or like the waves of the seas dashing against a rocky shore.

At a few minutes past 4 in the P.M. I discovered another very slight one. Mr. Crosby went to doctor a sick ox belonging to sister Pratt. (Brought home fruit trees from Col. Jackson's, 5 peach trees, two apples, one pear, and one plum tree.) The second shock occurred while he was gone to see the sick ox, the 1st while he was on his way to Col. J.'s.

Evening we retired just before 9 o'clock. Alma was sitting by the fire reading, when another slight shock passed over us. I could not feel materially alarmed for some cause or other. I felt assured that the Lord would do all things right, and did not give myself any great deal of uneasiness.

4b. 12 January 1857

Mon. 12th. Beautiful day. I washed, felt quite well, got through in good season.... Sis. M. said the earthquake made her sick and that she did not seem to recover. I also have several times felt seasick, since frid. 9th of Jan—.[3]

4c. 13 January 1857

Tues. 13th. Very warm and pleasant for the season.

Sister L. P. called, looking very bad, said she had a restless night, and arose with the headache, seemed much cast down and troubled with care, and thinking of the earthquake. Some say that the earth has continued being convulsed since frid. 9th, by turns, untill [sic] now. Some prophesy that the place is going to sink. Say the Spirits have intimated it. Others have had exciting dreams which have caused many fears for the safety of this place....

4d. 15 January 1857

Thurs. 15th. Took a walk with sister Pratt.... On returning called on sis. Hammond. Said she had been much alarmed in consequence of the continued convulsions of the earth, said they had felt a jar every day and evey [sic] night since frid. 9th. They live in an upper room where they can discern the least motion....

4e. 16 January 1857

Frid. 16th. Very warm and pleasant.... Sister P— came in, said she had a very sick night last night, in consequence of a bad cold. While she was in, they sent and informed her that bro. Rich had called to see her, and she immediately left. About 5 o'clock[4] we had another shock of an earthquake. It was the hardest I had witnessed since the first on friday last. Evening Alma spent at his aunt's. Chas. Cox or Bills came in to get a book that told of earthquakes and many other remarkable events....

4f. 13 June 1857

Sat. 13th, this day the comet was expected to come to the earth, but there are no signs of it to my knowledge. Last night I heard a rumbling noise resembling distant thunder, which we thought might be the sound of an earthquake, but we felt nothing.[5] It occured [sic] btween [sic] 12 and 1 o'clock. Quite a cool, comfortable day....

4g. 15 December 1857

Tues. 15th. ... This morning at a few minutes before 3 I felt a light earthquake.

Notes:

1. This diary contains an entry for every single day, beginning 17 Nov. 1855 and continuing until 1 Jan. 1858, on which date the Crosby family left San Bernardino permanently for Salt Lake City. Only those entries (9 Jan. 1857 and later) which made mention of an earthquake are listed above. Note especially that Mrs. Crosby mentions in her entries for 13 Jan. and 15 Jan. 1857 that other people had felt earthquakes which she herself apparently did not. We should not assume, therefore, that the absence of any mention of a particular event in her diary precludes the possibility that such an event was felt in the San Bernardino area.

2. This discussion of the mainshock was *not* published in the appendix to Agnew and Sieh (1978).

3. It is unclear what to make of this description. "Feeling seasick" may be a reference to other earthquakes, but more likely, "feeling seasick" may be simply what it says. People sometimes complain of seasickness even after returning to land from a time at sea. The latter interpretation is taken, and an earthquake is *not* listed in Appendix 1B for this date.

4. From the context, it seems reasonable to assume that this shock occurred at 5 o'clock *in the afternoon*. This time (within margin of error) matches other reported times of the shock.

5. No other report of an earthquake was found for this date, and it is assumed no earthquake occurred. Nothing is listed in Appendix 1B for this date.

5. Journal of R.R. Hopkins, San Bernardino

Extracts from MS Journal of San Bernardino Mission, kept by R.R. Hopkins, official recorder (Catalogue #1421, Historical Department, Church of Jesus Christ of Latter-Day Saints, Salt Lake City)

5a. 09 January 1857

Friday 9 At 25 minutes past 8 o'clock this morning our city was visited with a violent Earthquake....[1] There was two shocks the first lasted two minutes and in about ten minutes there was a second shock not so violent which lasted about one minute.

5b. 10 January 1857

Saturday 10 ... Last night there was two quite severe shocks, though not so severe as yesterday.

5c. 13 January 1857

Tuesday 13 ... The earth oselates slightly though perceptible every day.

5d. 16 January 1857

Friday 16 At 15 minutes of five o'clock p.m. we had a very severe shock of an Earthquake though short. The house shook perceptably for a minute. The Inhabitants of the City fled from the houses to the street.

5e. 17 January 1857

Saturday 17 ... The Earth quakes slightly throughout the day & night.

5f. 19 January 1857

Monday 19 ... There was several slight Earthquakes yesterday & last night.

5g. 31 January 1857

Saturday 31 There was a severe Earth Quake ~~last night~~[2] at 10 minutes past one o'clock pm accompanied with loud reports similar to the discharge of Cannon. The reports were in the mountains

Notes:

1. A full report of the mainshock is given in the appendix to Agnew and Sieh (1978).
2. These words are crossed out in the original.

6. Letter of Amasa Lyman, 18 January 1857, San Bernardino

Portion of a letter from Amasa M. Lyman, 18 January 1857 (In MS "History of San Bernardino," compiled by Andrew Jenson, Historical Department, Church of Jesus Christ of Latter-Day Saints, Salt Lake City)

... We have had a succession of shocks of earthquakes, which have, in our locality, raised more excitement than they have done real damage....

Friday, Jan. 16. About 5 o'clock p.m. a very severe shock of earthquake was felt at San Bernardino. The houses shook perceptably for a minute or so. Many of the inhabitants fled from their houses into the street.

Saturday, Jan. 17. The earth quaked slightly throughout the day and night.

7. Letter of D.M. Thomas, 18 January 1857, San Bernardino

Portion[1] of a letter from D.M. Thomas, 18 January 1857 (In MS "History of San Bernardino," compiled by Andrew Jenson, Historical Department, Church of Jesus Christ of Latter-Day Saints, Salt Lake City)

On Friday morning, the 9 inst., about 8 o'clock, we had a very severe shock of earthquake. The vibration continued about two minutes; the motion was from north to south, and apparently undulating. Many of the people ran out of their houses. It was accompanied with a rumbling noise, and produced a sensation of giddiness, and some were sick similar to sea sickness; every thing (houses, trees, cattle and people) had the appearance of being drunk. I have felt many shocks before but this was different and caused a sensation unlike any I have ever experienced.... There has been more or less vibration every day and night since. On last evening we had quite a shake of the regular kind....

Notes:

1. A more complete discussion of the mainshock is given in the appendix to Agnew and Sieh (1978).

Appendix 2B: Primary Documents

8. Diary of Benjamin Hayes, San Bernardino

Excerpt of diary of Judge Benjamin Hayes, as reprinted in Hayes, 1929, p. 267
(copy held in the California Room at the San Bernardino Public Library)

8a. 06 February 1862

About 10 o'clock P.M. there was the shock of an earthquake, lasting a second, oscillation from east to west.

9. Los Angeles *El Clamor Público*[1]

9a. 10 January 1857 page 3, column 1

At 8 o'clock yesterday morning an earthquake of great strength and duration, lasting about two minutes, was felt here....[2]

Earthquakes seem to be the order of the day. Yesterday afternoon and tonight there have been other tremors of different strengths. Some say that six earthquakes have been felt in less than 24 hours, which has not happened here before.

9b. 17 January 1857

The first shock started at 8 in the morning and lasted between 80 and 90 seconds....[2] A few minutes after 8 there was another earthquake which lasted for a short time. At 11 at night there was a third shock which lasted 4 seconds; during the night three more were felt, making a total of six that were noticed by most people. There is also another phenomenon. From the first shock at 10 A.M. until five P.M. the earth has been moving constantly, though it has required close attention to notice this. There have certainly been more than a few periods, up to 20 minutes long, of almost imperceptible earthquakes....

On the night of the 9th and 10th, three more shocks were felt, though all were brief....[3]

Yesterday at 5 P.M. another earthquake was felt. It was nearly as strong as the first one but did not last as long.

Notes:

1. Translated from Spanish by Agnew and Sieh (1978).
2. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).
3. This appears to be the second reference in this article to the same three shocks.

10. Los Angeles *Semi-Weekly Southern News*

10a. 23 April 1862

EARTHQUAKE. — We learn from J. Jones, Express rider between this place and Fort Yuma, that a severe earthquake was experienced about the 15th inst., on the desert. At Cariso Creek Station its effect was severely felt; the few inhabitants of that vicinity were stricken with consternation.

11. Los Angeles *Semi-Weekly Vineyard*

11a. 17 December 1858 page 2, column 1

Appendix 2B: Primary Documents

SUBTERRANEAN MOVEMENTS. — On Wednesday at 6 $^1/_2$ P.M., and at 3 $^1/_4$ A.M., of Thursday, slight movements to effect the uprightness of beings and things upon the face of the earth, in this neighborhood, were felt by most of our citizens. As for ourself, IDEALINA had for two days previous, belched forth such an eruption of abdominal matter upon our doomed head, that the spasms of mother earth were powerless to effect our crushed and withered nerves.

11b. 29 March 1859 — page 2, column 3

SAN DIEGO, March 21st. 1859

. . . . .

P.S. — We had a severe shock of an earthquake this morning, at 6 o'clock and 18 minutes. From the way that some water in my room was agitated, I think that the shock was from the north to the south. The first shock seemed to be to the south, with three distinct vibrations, then back to the north, with three more, when it ceased. It was the heaviest shock that I have ever experienced in San Diego.

12. Los Angeles *Star*[1]

12a. 10 January 1857[2] — page 2

Yesterday morning, about half-past eight o'clock, a very severe shock of an earthquake was felt here, the vibrations continuing for fully two minutes.... During the day as many as four or five shocks were experienced, but all less intense than the first....

12b. 17 January 1857 — page 2, column 2

At five o'clock yesterday afternoon a very severe vertical earthquake was experienced here. The earth moved from south to north. It was almost as strong as that a week ago.

12c. 17 January 1857[2] — page 2, columns 3-5

. . . . .

On Friday morning, the 9th of January, at twenty-five minutes past eight o'clock A.M., the morning being calm, cool, and clear, the sun shining brightly, a shock of an earthquake was felt here....

In half an hour after, another shock occurred, much less violent; another within an hour from that; and during the day a number of slight vibrations. At five o'clock in the afternoon, a shock occurred almost as severe as the first, which was followed at intervals by slight motions, till about eleven o'clock, when another heavy one occurred. During the night several other vibrations were felt.

On Saturday several slight shocks occurred — with a severe one about eleven o'clock at night.

Sunday was quiet, till about eleven o'clock at night when a pretty strong vibration was felt, and thereafter at intervals throughout the night.

Monday was generally considered free from shocks, although many say they felt them distinctly throughout that day also. Since then the earth has remained quiet....

Under the heading **From Fort Tejon**

FORT TEJON, CAL., Jan. 11th, 1857

.... The first shock took place about thirty minutes past six o'clock, A.M., on Friday, January 9th, which was succeeded, at twenty-seven minutes previous to nine o'clock A.M., by the most terrific shock imaginable....

Appendix 2B: Primary Documents

The shocks and vibrations have continued at regular intervals up to the present time, say five o'clock P.M....

Under the heading **From San Bernardino**

. . . . .

On Saturday [10 January] a plummet was suspended which vibrated nearly all day, sometimes as much as four inches past the centre.

On Sunday another shock was experienced; next morning another, but quite gentle. The people, however, were in a state of continual alarm.

Under the heading **From the Mojave**

. . . . .

At night [on the 9th of January] he camped in the Cajon Pass, when he experienced two more shocks, about nine and eleven o'clock, which were not very severe. He does not know whether these were accompanied by noise, as the wind was high at the time. Next day he arrived at San Bernardino, when he experienced the shocks mentioned by our correspondents.

12d. 24 January 1857 page 2, column 1

Under the heading **From Fort Tejon**

Below will be found a detail of the damage done to the buildings at Fort Tejon, by the shock of the late earthquake. It will thus be seen that the shock must have been very severe. The troops are at present living in tents — the sick are also in tents. On Wednesday the mail rider arrived, [from Fort Tejon] who reported that a severe shock had been experienced there on Tuesday, just previous to his departure, and that vibrations of the earth were of frequent occurrence....[3]

12e. 25 April 1857 page 2, column 2

EARTHQUAKE. — On Sunday last [April 19th], about one o'clock, P.M., a slight shock of an earthquake was felt in this city. It caused doors and windows to rattle pretty freely, and some people to run out of their houses, but did not create any general alarm. We may mention, that earthquake shocks are still of frequent occurrence at Fort Tejon, and of considerable violence.

12f. 30 May 1857 page 2, column 3

EARTHQUAKES. — It appears that old mother earth is still troubled with the consequences of her great convulsion of the 9th of January last. She has not yet recovered her quiet and steady habits, but exhibits the weakness of her internals by shakes, of almost nightly occurrence. Fort Tejon, seems to be the region where her disease is located, for the good people of that Post, are almost nightly entertained with earthquake shocks. Last week, one or two very severe shocks occurred there, which awoke the sleepers and sent them in a hurry to breathe the fresh air of the parade ground. Perhaps the comet that is coming, will be permitted to swallow only that portion of the earth, and has on his prescription, "before taken to be well shaken."

12g. 05 September 1857 page 2, column 1

Under the heading **From Fort Tejon**

. . . . .

A very severe shock of an earthquake was experienced on the 29th ult., at 27 minutes past 10 o'clock, A.M.

Appendix 2B: Primary Documents

12h. 21 November 1857 page 2, columns 2-3

Under the heading **From Fort Tejon**

FORT TEJON, Nov. 12th, 1857

. . . . .

At the Post, we have frequent "shocks," — but no danger is to be apprehended, as they are very slight.

12i. 26 December 1857 page 2, column 3

Three shocks of an earthquake were experienced in San Bernardino, early on the morning of December 9th. One was very heavy. No damage was done.

12j. 18 December 1858 page 2, column 1

EARTHQUAKES — On Wednesday evening [Dec. 15th], at about half past six o'clock, a shock of an earthquake was felt here; it caused quite a shaking of doors and windows. About two o'clock, on Thursday morning, a pretty severe shock occurred, and at three o'clock a slight one.

12k. 25 December 1858 page 2, column 2

Under the heading **From San Bernardino**

. . . . .

EARTHQUAKE. — On Wednesday evening, December 15th, at half past seven o'clock, the good people of this place were aroused from their quiet fire-sides by the shock of an earthquake, causing men, women and children to make a general rush out into the street. I have not heard of any serious damage having been done, more than cracking the walls of a few houses, and causing doors to fly open, breaking a few dishes and upsetting a few buckets of water. It lasted for about twenty-three seconds. The shock was repeated again at ten minutes past three o'clock on Thursday morning. It was more severe, knocking the gable end out of a house belonging to Mr. J. S. Waite, and tearing the paper from the walls of another house; it lasted half a minute. The vibration was north-west to south-east....

Since writing the above, I have been informed that one house was shaken down by the earthquake, at Agua Manza.

12l. 02 April 1859 page 2, column 2

We have been informed that a shock of an earthquake was experienced in San Bernardino, on Monday week.

12m. 10 December 1859 page 2, column 3

Under the heading **Correspondence.**

SAN BERNARDINO, Dec. 6th, 1859

EDITOR STAR — Nothing of much importance has transpired here since my last. On the morning of the 2d, we experienced several shocks of an earthquake; the vibration was from the north-west to the south-east. I have not heard of any damage being done....

12n. 21 January 1860 page 2, column 4

Under the heading **From San Bernardino**

Appendix 2B: Primary Documents

. . . . .

EARTHQUAKE. — On Friday, the 13th inst., about 5 o'clock, A.M., some of our citizens were aroused from their slumbers by a slight shake of old mother earth, accompanied by a rumbling noise, like that of distant thunder — "nobody hurt."

12o. 28 January 1860 page 2, column 2

EARTHQUAKE. — On Friday morning, about half past twelve o'clock, a pretty severe shock of an earthquake was felt in this city — shaking and rattling doors and windows in the casements. The oscillation was from east to west. But a single shock was experienced, accompanied by a rumbling noise; several persons were awoke by the noise, and others by the motion of their beds.

12p. 21 December 1861 page 2, column 3

EARTHQUAKE. — Monday week one or two severe shocks of earthquake were experienced at the island of Catalina, about twenty-five miles off the harbor. The vibrations were from east to west, and were felt about seven o'clock in the evening. The inhabitants were considerably alarmed; and well they might be; for if old mother Earth become [sic] affected in those parts, she may so weaken as to permit the little island to topple over into the domain of Neptune, all too ready to clasp it in his fierce embrace.

12q. 08 February 1862 page 2, column 3

Under the heading **From San Bernardino**

. . . . .

EARTHQUAKE. — On Monday morning last, a severe shock of an earthquak [sic] was experienced in San Bernardino — no damage done.

12r. 22 February 1862 page 2, column 3

Under the heading **From San Bernardino**

SAN BERNARDINO, February 5th, 1862.

. . . . .

EARTHQUAKE. — On the evening of the 3d instant a slight shake of old mother earth was experienced in the southern portion of the city. The vibration was north and south.

Notes:

1. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).

2. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

3. The article then continues by roughly paraphrasing Lt. Col. Beall's letter, Source 23 in the Appendix to Agnew and Sieh, 1978. No additional information is provided in this Los Angeles *Star* article with regard to aftershocks.

13. Journal of William A. Wallace, Los Angeles[1]

Extracts (Beinecke Rare Book and Manuscript Library, Yale University)

13a. 09 January 1857[2] page 39 of bound volume

9— This morning at $8^1/_2$ o'clock, I was walking to Wolfskill's and was near his brick house. Suddenly I felt a sort of vertigo. My legs refused to support me. I swayed too [sic] and fro like a

drunken man. The ground rose up before me, and I reached out my hand to sustain myself against the wall. The wall cracked and rocked. The water which usually runs downhill had doubled upon itself and was rushing with fury towards me. When I saw this, the idea of an Earthquake[3] occurred to me. The ground swayed vertically back and forth, without violence, but with considerable force continuing about 1 $^{1}/_{2}$ minutes. The air also was violently agitated. I passed into the yard and found the whole family of women upon their knees crying to the Virgin[3] with all their lungs for protection. They seemed to be perfectly terror struck. The men were standing about bearheaded [bareheaded] as if they had all rushed outdoors without thought. I returned to town and the whole town were in commotion from the effects produced. During the day a dozen shocks of less violence than the first have been felt. The first was of longer continuance than that of July 1855.

13b. 12 January 1857 page 41

Jan 12.— Last night the whole town was again thrown out of doors by the earthquake. His continuance is not "lengthened sweetness," although it is "long drawn out." So many shocks have taken place that a terror has seized upon the people, the women especially, — and many pass sleepless nights. The last shock was followed by a loud concussion.

13c. 31 January 1857 page 49 (typed article pasted in)

. . . . .

January has past.... The earthquake, which for a time held the people in fear, has subsided, or ceased to frighten everybody; probably fifty shocks have been experienced; many people are very timid, and would rush out of doors night or day. The last shock occurred about 2 A.M., and shook our house severely. D— jumped out of bed, crying to me that "he would be damned if he'd stay in the house anymore;" he seized his pants and made for the door; I turned over and went to sleep. In the morning, D— was asleep in his own bed.

13d. 10 April 1857 page 66 (typed article pasted in)

Under the hand-written heading **Earthquakes**

I was going to write you something about earthquakes—our earthquakes,—but perhaps the subject is too old, or you may be troubled with a weakness of the nerves, at the mention of it—so I will deal gently with your sensibilities. I must say, however, that old Terra is no longer a synonym for firmness. The palsy of age is upon her[4]. From the region of the Tejon, down along, there is still commotion in our mother's bowels. The vent[5] hole from which the gases[6] escape is unapproachable, from the sulfurous atmosphere, and the noise is like that of the escape of steam from a locomotive. The phenomena has ceased to terrify, and it is now watched with curious interest. I was told that at the first great earthquake in January the shock was very severe and loud at Catalina, and that the cattle fled, bellowing with terror, to the tops of the hills. There was also great commotion of the waters, and several large waves rolled upon the shores.

13e. 10 July 1857 page 81 (typed article pasted in)

. . . . .

A very respectable earthquake occurred on Wednesday night, about 12 o'clock, shaking our beds and houses with a good deal of spirit....

Notes:

Appendix 2B: Primary Documents

1. Wallace does NOT make an entry every day -- he sometimes skips several *weeks* between entries. The journal also includes typed articles written by Wallace (Wallace was a correspondent of the *Alta California*) that he pasted into the journal.

2. This discussion of the mainshock was *not* published in the appendix to Agnew and Sieh (1978).

3. Underlined in the original.

4. The word in the original type-set article is "him"; that word is crossed out by Wallace and replaced by the word "her." Wallace was the author of the article and it is presumed that he was correcting a typographical error.

5. The word in the original type-set article is "vast"; that word is crossed out by Wallace and replaced by the word "vent." See note 4.

6. The word in the original type-set article is spelled "gasses," but the second "s" is crossed out by Wallace. See note 4.

14. Letter of H.R. Myles, 28 January 1857, Pasadena

Extracts from a letter of H.R. Myles to Benjamin D. Wilson, 28 January 1857. (Box 6, Benjamin Davis Wilson Papers, Huntington Library, San Marino)[1]

We will finish racking[2] off the wine about the same time, the wine is not very clear that is the most of it owing to two causes. One is many of the casks were closed too tight before the wine was done fermenting, and the other is we have had about fifty earth-quakes in the last two weeks, three of which rocked the house very much, and cracked the plastering and walls in many places but has done no serious damage.... I will take out some brick and a Brick Mason to day to take down and rebuild the South[2] chimney[3].

Notes:

1. This letter was sent from Lake Vineyard, Wilson's ranch. McFarland (1949, p. 289) says that this covered much of what is now Pasadena and San Marino, Wilson's house being in what is now the northwest part of San Marino. (Note of Agnew and Sieh, 1978.)

2. This word is partly illegible and our reading is conjectural. (Note of Agnew and Sieh, 1978.)

3. Much of this letter deals with construction, and it is not certain that this sentence should be read as implying serious earthquake damage to a chimney. (Note of Agnew and Sieh, 1978.)

15. Letter of W.E. Greenwell, 24 February 1857, near San Fernando

Extracts[1] from a letter of W.E. Greenwell to A.D. Bache, 24 February 1857 (pp. 130-133, Vol. 23, 1857 Correspondence of the Superintendent, Records of the Coast and Geodetic Survey, Record Group 23, U. S. National Archives microfilm publication M-642, roll 176, frames 280-282)

Coast Survey Camp
Conejo Station
February 24th 1857

. . . . .

Whilst [I was] occupying the San Fernando station this lower coast was visited by a most fearful earthquake whose centre seemed not far from us. We were encamped in a cañon at the foot of the mountain, my station in full view some 2212 feet above us.[2] I was seated in my tent about 8

o'clk in the morning the wind blowing a gale from the N.W. when we felt the first shock. We started to our feet & ran out. The Earth was in fearful agitation with undulations so quick & rapid as almost to throw me from my feet. The sensation was very much as that felt on the deck on a small vessel in a heavy "chopped sea"....

I send you an extract from my Journal giving the time of the different shocks as felt at our camp....

January 9th

"At 8^h 25^m A.M. had a severe shock of an earthquake which lasted about one minute. Wind N.W. strong.

At 8^h 31^m another slight shock.

At 9^h a very slight shock — At 9^h 31^m another shock similar to the 2nd.

At 4^h 47^m P.M. another slight shock.

Had the above several shocks to day. The wave seemed to travel from East to West."

Notes:

1. The full letter is given in the appendix to Agnew and Sieh (1978).

2. The position given for this triangulation station by Mitchell (1927), who calls it "San Fernando (Old)," places it on a subsidiary peak of Oat Mountain, specifically the one that is at the head of the stream that is the first westerly branch of Limekiln Canyon, counting upstream from Horse Flats. The stated elevation difference puts the camp on the valley floor, probably in Limekiln Canyon or perhaps Wilber Wash. (Note of Agnew and Sieh, 1978.)

16. Letter of W.M. Johnson, 19 January 1857, Sycamore Canyon

Extracts[1] from a letter of W.M. Johnson to A.D. Bache, 19 January 1857 (pp. 139-145, Vol. 23, 1857 Correspondence of the Superintendent, Records of the Coast and Geodetic Survey, Record Group 23, U. S. National Archives microfilm publication M-642, roll 176, frames 294-297)

Camp Sycamore Valley Cal[2]
Jan 19th 1857

. . . . .

On the morning of the 9th inst we experienced the most violent shocks of an earthquake ever remembered to have been felt in this state and should it extend to San Francisco without diminution of its force as felt here, we may expect to hear a melancholy account of the loss of life and property.

The motion to me was vibratory only, though others contend that it was also undulatory, in a direction from SE to NW and was first felt at 24^m past 8 A.M. on the 9th inst and lasted about 2 minutes....

At 34^m after 8 A.M. a second shock, lasted but a few seconds and not so violent as the first: at 36^m after 8 A.M. a third shock quite violent lasted about 10 seconds at 38 past 8 A.M. a fourth shock accompanied by a loud rumbling noise like distant thunder. This was the only sound occasioned by this phenomenon during the whole time. At 12^m of 9 A.M. a fifth shock slight and momentary....

[I] left camp shortly after the last shock for San Buenaventura 30 miles distant....

At San Buenaventura (Jan 9th). This evening the shocks were continued. The first was at 27^m past 8 P.M. slight and momentary, at 15^m of 9 P.M. a second,[3] quite violent but momentary: at 36^m past 10 P.M. a third strong but momentary. To night the people deserted their houses and went into the street, the open country and on the hill-tops back of the mission buildings where they lit camp-fires and passed the night....

During my absence from camp every shock felt was noted in the Journal. The times of their

occurrence may I think be considered as correct but their duration appears to have been judged of more by the recorder's feelings than his watch. The following is transcribed from the Journal

9th	"At 30m past 8 P.M. felt a shock which lasted about 1 1/2 minutes not so severe as the first one of this morning"
	"At 40m past 8 P.M. felt a second shock which lasted about 1 minute. Slight"
	"At 10 P.M. a third shock lasted about half a minute. Slight"
Jan 9th	"At 40m past 10 P.M. felt the most severe shock of any though much shorter than the first of this morning"
Jan 10th	"At 20m after 8 A.M. a slight shock"
Jan 11	"At 40m past 9 P.M. slight shock"
" "	"At 5m past 10 P.M. quite severe lasted about 1 1/2 minutes"
Jan 15th	"At 40m past 10 P.M. a slight shock"
" 16th	"At 48m past 12 A.M. a severe shock, lasted 1 1/2 minutes"
" "	"At 50m past 12 A.M. another more severe than the last, preceded by a rumbling noise"
" "	"At 46m past 4 A.M. a slight shock"
" 17th	"At 27m after 7 P.M. slight shock"
" 28th	"At about 2 o'clock this morning felt a very severe shock"[4]

The two last I recorded myself.

Notes:

1. The full letter is given in the appendix to Agnew and Sieh (1978).

2. Sycamore Valley was probably what is now Big Sycamore Canyon, just east of Point Mugu. See Agnew and Sieh (1978); also see Document 17a in this appendix. In addition, a separate letter of W.M. Johnson describes Sycamore Valley. *(See 1857 Correspondence of the Superintendent, Records of the Coast and Geodetic Survey, Record Group 23, U. S. National Archives microfilm publication M-642, roll 176, frame 300.)* His description matches the physical and topographic characteristics of Big Sycamore Canyon and of the Conejo Valley at the canyon's "head."

3. In his statement to the Santa Barbara *Gazette* (17a), Mr. Johnson gave this time as 8:50.

4. Note that the letter is dated Jan. 19; the date of this entry should probably read Jan. 18 (*not* 28).

17. Santa Barbara *Gazette*[1]

17a. 15 January 1857[2] page 2, columns 2-3

On Friday last, January 9th, this city and adjacent settlements was visited by a succession of earthquake shocks, one of which was the most severe which has been experienced on this coast for a long series of years....

In this city, the morning of the eventful day was ushered in by the same genial sun; the air was tranquil, and no unusual atmospheric phenomena indicated that any sudden danger was so near at hand. At about 10 minutes past 8 o'clock there was a sudden vibration of the earth, which was of brief continuance. By many it was unnoticed, but was distinctly observed by those persons who have felt this peculiar sensation at former periods. At about half past 8, or at 22 minutes past 8 o'clock, according to those who assert that they had the "correct time," the severest shock commenced, and which continued from 40 to 60 seconds. It was universally noticed throughout the city, and was so violent in its vibrations that all the inhabitants fled from their dwellings....

Appendix 2B: Primary Documents

During the evening of the above day some two or three brief "shocks" or vibrations were felt; indeed, throughout the entire day and evening the earth, to us, seemed to be more or less agitated with a tremulous motion, but up to the present period we are happy to chronicle the fact that our beautiful valley continues "in statu quo...."

Through the politeness of Mr. W.M. Johnson, U. S. Coast Surveyor for this District, we are placed in possession of the following interesting account of the earthquake phenomenon which occurred at San Buenaventura and vicinity....[3]

Mr. Johnson's position was some thirty miles southeast of San Buenaventura, in a cañada called Sycamore Valley, (Canada de los Alisas,) sixty miles by land from this city. He noted the following observations: The first shock occurred at 24 minutes past 8 o'clock in the morning; vibrations heavy and violent, and continued 2 minutes. Second shock occurred at 34 minutes past 8. The third at 36 minutes past 8; was quite violent, and continued 10 seconds. The fourth shock took place at 38 minutes past 8; this was accompanied with a loud, rumbling noise, a distinguishing feature, which was observed in no other shocks, either before or afterwards. The fifth shock was noticed at 12 minutes of 9, which was slight, and the sixth at 2 minutes past 9, which was also slight. The vibrations were N.E. and S.W. In the evening of the same day three momentary shocks were distinctly felt, the last one being the most intense. They occurred at 27 minutes past 8, at 10 minutes of 9,[4] and 36 minutes past 10, respectively....

P.S. — We have to record two more "temblores" in this place since writing the above. One light shock occurred about midnight, and another strong shock at about 6 o'clock this morning.

17b. 22 January 1857[2] page 2

On Friday, January 16th, there was another earthquake at or about 4 o'clock, P.M. Fortunately, it was of brief continuance. No damage ensued therefrom. It was sensibly felt throughout the city, and was of sufficient intensity to cause people to leave their houses. There was a slight shock on Sunday morning, the 18th inst., and another moderate shock on the night of the 20th instant....

While on the way hither, when traveling between Cumola and San Francisco Ranchos,[5] some thirty miles distant from San Buenaventura, a heavy shock was felt in the afternoon at the same time that it was noticed here on Friday, January 16th, which we have already above described.

17c. 29 January 1857[6] page 2, column 3

Under the heading **The Latest News from all Quarters**

CALIFORNIA. Latest dates from San Francisco, January 21.

Earthquakes have been felt at Monterey, San Francisco, Benicia, Martinez, Sacramento, Stockton, Visalia (Tulare County), and at Benson's Ferry, on the Moquelumne [sic] river. At Monterey, the vibrating wave seemed to come from the West and North, proceeding to the South and East. It was felt about 7 o'clock on the 9th inst. No harm done. — At San Francisco, it occurred at a quarter past 8 in the morning. The shock seemed to be much more severe in the lower than in the upper part of the city. A slight shock was also felt on the morning of the 20th. — At Benicia, a telegraphic dispatch to the Sacramento Times says, "a severe shock of an earthquake was felt here about 4 o'clock, on the morning of the 18th. It was also felt at Martinez." — At Sacramento, a telegraphic dispatch to the Bulletin states that it was felt at half past 7 o'clock in the morning of the 9th inst. No damage. — At Stockton, the S. J. Republican gives the time at twenty minutes past 8 on the same day, A. M. No damage. — At Visalia, it occurred at fifteen minutes past 8, A. M., on the 9th. Shock very severe, accompanied by a deep rumbling sound "like the grating together of immense rocks." Vibrations from northeast to southwest.

Appendix 2B: Primary Documents

17d. 29 January 1857 page 2, column 4

Under the heading **Notes of the Week**

... — [January] 28th, Another shock of an earthquake occurred this morning — supposed time, about half past 1 o'clock. It was vibratory, and lasted some 8 or 10 seconds.

17e. 05 February 1857 page 2, column 2

Under the heading **Notes of the Week**

... Several slight shocks of earthquakes have been felt, but we can truly say there were no great shakes.[7]

17f. 19 March 1857 page 2, column 2

Along with the weather report

... A hard earthquake shock was felt in this city and Montecito valley about 3 o'clock on the morning of the 14 inst. It was of momentary duration.

17g. 26 March 1857 page 2, column 1

The heavy earthquake which we had on the 9th of January last has done us considerable benefit, although this statement would seem an anomaly. Water is now running in places where before the occurrence it was entirely absent. New springs have been created and the discharge of water increased in others which were previously running.

17h. 23 April 1857 page 3, column 2

By a late arrival from Fort Tejon we learn that the earthquakes are yet in active operation in that section of the country. The earth seems to be in an almost incessant state of agitation and the residents are living in constant alarm.

Notes:

1. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).

2. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

3. The material in this paragraph, being derived from Johnson, is not independent of his letter (16), though it is a little more full in some details.

4. In his letter to A.D. Bache (16), Mr. Johnson gave this time as 8:45.

5. Map 36 in Beck and Haase (1974) shows the latter rancho to be along the Santa Clara River at the present Los Angeles - Ventura county line. (Note of Agnew and Sieh, 1978.)

6. This discussion of the mainshock was *not* published in the appendix to Agnew and Sieh (1978).

7. This is for the week of 29 Jan thru 4 Feb 1857.

Appendix 2B: Primary Documents

18. Reminiscence of J.F. Dana, ca. 1930-36, Nipomo[1]

(from Dana, 1960, pp. 16-17 and 45)[1]

18a. pp. 16-17

. . . . .

Our Casa was not all built at one time as homes are today but additions were made from time to time.... The left wing was used as a kitchen and the right wing was our sitting room. If one looks closely, he will see a crack upon one of the outside walls. This happened in the earthquake of 1857, one of the worst this part of the country ever felt. At this same part of the wall one can see how thick the wall is — over three feet[2] — almost as thick as some of the walls at the old missions.

Not a single nail was used in the building of our home. There was very little iron in California for building use then. Rawhide thongs and morticing were used instead....

18b. p. 45

. . . . .

Through the years we may have had some small earthquakes but the one I remember best was in the year 1857 when I was nineteen years old — just a year before my father died.

It was one of the worst quakes I have ever felt. Our Casa, solidly built as she was, shook for several moments and dust billowed out of the rooms like a sandstorm. Guess the maids dusted extra careful after that! Even an old oak tree which was near the house was so badly shaken that it made quite a hole in the ground. Our adobe houses with walls three to five feet thick were safer than today's modern houses when an earthquake came along, though!

Notes:

1. J. F. Dana lived through the 1857 earthquake as a young man and died in 1936. These memoirs were told to Rocky Dana and Marie Harrington, and were recorded in the 1930s, but they were not put together and published until 1960. These reminiscences are included because they were *not* published in the appendix to Agnew and Sieh (1978).

2. The walls in the house were made of adobe bricks.

19. Letter of Lieutenant Colonel B.L. Beall, 9-10 January 1857, Fort Tejon

Extracts[1] from a letter of Lt. Col. B. L. Beall, 9-10 January 1857
(Letter #B4, Letters Received, 1857, Department of the Pacific, Records of U. S. Army Continental Commands, Record Group 393, U. S. National Archives, Washington, D. C.)

Fort Tehon [sic], California
January 9th 1857.
8 o clock P.M.

. . . . .

I have the honor to report for the information of the Commanding General of this Department, that at about six o'clock this morning, the shocks of an earthquake commenced and have continued with more or less violence, at intervals of five or six minutes, up to this time. The greatest shocks took place at 27 minutes before 9 o.clock A.M. The destruction to property, both public and private, has been immense. Many of the buildings at this Post have been so injured as to be totally uninhabitable....

Fortunately no lives have been lost at the Post. The sick of the command are now in tents,

although the weather is very cold. The shocks have been very extended, and less severe at the Post, than on the Los Angeles road,[2] or in the Tulare valley.[3]

January 10th 9 o.c. AM.

I have the honor to report that during the night, and up to this time, the shocks have continued with much violence, at intervals. The buildings have been much damaged since 8 o clock P.M. of yesterday....

Notes:

1. The full letter is given in the appendix to Agnew and Sieh (1978).

2. In reading this account it should be remembered that at this time the road between Fort Tejon and Los Angeles did not follow the present more direct route. As shown in Williamson (1856), the road ran along the line of the fault from Gorman to Quail Lake, and thence through the Antelope Valley, reentering the mountains at Oakgrove Canyon and following the fault to Elizabeth Lake. It then traversed San Francisquito Pass and went down San Francisquito Canyon to Castaic Junction. (Note of Agnew and Sieh, 1978.)

3. This is probably a reference to the southern San Joaquin Valley. There is no other evidence to support this statement that shaking was indeed stronger in the southern San Joaquin Valley than along the fault; however, if this was the case, it may be explained by the fact that the San Joaquin Valley sits atop layers of sediment, which would have amplified the shaking, whereas Fort Tejon (and the Los Angeles road) lie atop bedrock (K.E. Sieh, personal communication).

20. Daily Journal, January 1857, Tejon Indian Reservation

Portion of MS "Report of Labor on Sebastian Military Reservation[1]"
(Letters Received, California Superintendency, 1857, Records of the Bureau of Indian Affairs, Record Group 75, U. S. National Archives microfilm publication M-234, roll 35, frame 1027)

20a. 09 January 1857

Friday Jan'y 9th — In the morning experienced a tremendous shock of Earthquake, which damaged the greater portion of the houses and threw down one. Ten slight shocks during the day.

20b. 10 January 1857

Saturday Jan'y 10th — Shocks continue.

Notes:

1. The Sebastian Military Reservation (also known as the Tejon Agency, or Tejon Indian Reservation) was located at the mouth of Tejon Canyon, in the southeast corner of the San Joaquin Valley (Boyd, 1972). (Note of Agnew and Sieh, 1978.)

21. Meteorological Records from Fort Tejon

(from Climatological Records, Records of the Weather Bureau, Record Group 27, U. S. National Archives microfilm publication T-907, roll 38)

JANUARY 1857

9 - a severe shock of an earthquake — shocks continued at intervals up to the 31st inst. varying in intensity & frequency

Appendix 2B: Primary Documents

FEBRUARY 1857

1 - shock continued
2 - continued
3 - continued
4 - continued
5 - continued
7 - shocks scarcely perceptible
8 - continued more intensely
9 - continued
10 - continued
11 - a very distinct shock at 11 P.M.
12 - two shocks during the night
19 - a shock at 9 P.M.
20 - a shock at 10 A.M.
21 - two shocks during the day
22 - two shocks during the day
23 - a shock at 9 o'c P.M.
28 - a shock at 10 o'c A.M., also during night

MARCH 1857

1 - two shocks during the day
2 - shocks continue
3 - two shocks, one very severe at 8:30 P.M.
5 - two shocks in the afternoon
6 - one shock at 3:40 P.M.
7 - one shock at 4 A.M.
8 - two shocks during the day
11 - two between 4 and 6 o'clock A.M.
12 - three shocks during the night, one slight shock at 11 A.M.
13 - two shocks during the night
14 - three shocks during the night
15 - one shock at 5 A.M.
16 - a very slight shock about midnight
17 - one light shock during the day
27 - a slight shock at 3:00 P.M.
31 - two shocks during the forenoon

APRIL 1857

3 - three shocks during the night
16 - four shocks during the day
17 - two shocks during the night
18 - one shock in the evening
19 - two shocks during the afternoon

20 - one shock at 4 A.M.
22 - three light shocks during the night
23 - a severe shock at 9:30 A.M.
24 - 1 shock at 11 A.M.
25 - 1 shock in the morning
26 - one shock during the night
27 - one shock during the night
28 - one shock in the afternoon

MAY 1857

6 - a slight shock of earthquaque at 6 A.M.
15 - severe shock at 2:30 A.M.
16 - a slight shock at 11:45 A.M.
18 - a slight shock at 2 P.M.
19 - a very severe shock at 9:30 P.M.
20 - a severe shock at 3 A.M.
26 - a very severe shock at 8:15 A.M.

JUNE 1857

2 - a severe shock of earthquaque at 10 $^1/_2$ P.M.
5 - a slight shock at 6 $^1/_2$ P.M.
6 - a scarcely perceptible shock at 10 A.M.
8 - two heavy shocks about midnight
10 - a severe shock at 17 minutes to 2 A.M.
11 - a severe shock at 4 $^1/_2$ P.M.
12 - a very severe shock at 5 P.M.
14 - a slight shock at 4 P.M.
15 - a scarcely perceptible shock at 4 P.M.
18 - a severe shock at 5 P.M.

JULY 1857

3 - very severe shock at 2 A.M., & 5 A.M.
4 - slight shock at 5 A.M.
5 - slight shock at 4 P.M.
7 - slight shock at 2:10 P.M.
9 - an extremely heavy shock at 2 A.M., lasting nearly a minute
10 - slight shock at 4, & 10 P.M.
12 - a slight shock at 9:30 A.M.
13 - a severe shock at 3 A.M.
14 - a very severe shock at 4:20 A.M.
15 - a slight shock at 3 $^1/_2$ & 10 $^1/_2$ P.M.
16 - a slight shock at 4:15 P.M.
17 - a slight shock at 8:30 P.M.

21 - severe shock at 4 P.M.
22 - a ~~very~~[1] severe shock at 1:20 A.M.
26 - a severe shock at 10:45 P.M.
28 - a severe shock at 7:30 A.M. & 8 P.M.

AUGUST 1857

3 - two slight shocks at 4 P.M.
5 - two shocks with heavy rumblings at 2 A.M.
6 - a heavy shock at 10 P.M.
7 - a very severe shock at 10 A.M. a mile SW of the Post
8 - a slight shock at 7:45 A.M.
9 - an extremely heavy shock at 12:15 P.M.
15 - a slight shock at 11:45 P.M.
20 - a very severe shock at 2 A.M.
25 - a slight shock at 10:35 P.M.
29 - a very severe shock at 9:15 A.M.

SEPTEMBER 1857

7 - a slight shock at 11:30 A.M.
11 - a slight shock with heavy rumbling at 5 A.M.
14 - a slight shock at 2:45 A.M.
22 - a shock at 1 A.M., a heavy shock at 2 P.M.

OCTOBER 1857

2 - a slight shock of earthquaque at 7:30 P.M.
3 - a slight shock at 6 A.M.
6 - a heavy shock at 11 P.M.
9 - a slight shock at 12:45 A.M.
19- a slight shock at 2 A.M.
22 - a heavy shock at 6:45 A.M.

NOVEMBER 1857

1 - a slight shock of earthquaque at 2 P.M.
3 - a slight shock at 6 P.M.
6 - a slight shock at 4 A.M.; &, 9:45 P.M.
9 - four successive shocks at 4 A.M.
14 - a slight shock at 3:15 P.M.
20 - a heavy shock at 10:15 P.M.
23 - shock with heavy rumblings at 2:20 P.M.
29 - a heavy shock at 4:30 A.M.

DECEMBER 1857

1 - a slight shock of earthquaque at 10 P.M.
2 - a slight shock about 1 A.M.
3 - a slight shock at 8:45 P.M.

12 - a heavy shock at 11:30 P.M.
23 - an extremely heavy shock at 1 P.M.

JANUARY 1858
17 - severe shock of earthquaque at 10 P.M.
21 - slight shock at 4:30 P.M.
26 - slight shock at 8 A.M.

FEBRUARY 1858
2 - a heavy shock of earthquaque at 5:10 A.M.
18 - severe shock of earthquaque at 3:30 A.M.

MARCH 1858
27 - a slight shock of earthquaque at 2 A.M.
a shock of an earthquaque at 12 M[idnight] March 28
28 - shock of earthquaque at 4 P.M.
29 - a heavy shock at 10:15 P.M.

APRIL 1858
3 - a heavy shock of earthquaque at 4:15 A.M.
5 - a slight shock at 9:10 P.M.
6 - a heavy shock at 6:30 A.M.
12 - a very heavy shock at 8:10 P.M.

MAY 1858
18 - a heavy shock of earthquaque at 2 P.M.
19 - a slight shock at 5:30 P.M.
27 - a slight shock at 3:30 P.M.

JUNE 1858
14 - a slight shock of earthquaque at 9:30 P.M.
15 - a very heavy shock at 9:15 P.M.

JULY 1858
21 - a shock of earthquaque at 11 P.M., and another very heavy at 11:30 P.M.

AUGUST 1858
8 - a slight shock of earthquaque at 6:45 A.M.
13 - a heavy shock at 10:30, and 11:30 A.M.

SEPTEMBER 1858
6 - a slight shock of earthquaque at 8:10 P.M.
7 - a slight shock at 7:45 P.M.
8 - a slight shock at 7:10 P.M.
9 - a slight shock at 6:45 P.M.

OCTOBER 1858
6 - a shock of earthquaque at 11:10 A.M.

Appendix 2B: Primary Documents

NOVEMBER 1858
NO EARTHQUAKES

DECEMBER 1858
19 - tremendous shock of earthquaque at 9 P.M.

JANUARY 1859
22 - shock of earthquake at 6:15 P.M.

FEBRUARY 1859
RECORDS MISSING

MARCH 1859
8 - shock of earthquake 10:30 P.M.
14 - slight shock of earthquake 7:30 P.M.
23 - four slight shocks at 3 A.M.

APRIL 1859
1 - slight shock of earthquake at 2 A.M.
22 - severe shock of earthquake at 9 $^{1}/_{2}$ P.M., slight at 10 P.M.
23 - slight shock at 9 $^{1}/_{2}$ P.M.

MAY 1859
4 - a severe shock of earthquake at 11 $^{1}/_{2}$ P.M., continuing 20 minutes shaking the hospital fearfully

JUNE 1859
5 - slight shock of earthquake at 2 A.M.

JULY 1859
6 - slight shock of earthquake at 10h P.M.

AUGUST 1859
NO EARTHQUAKES

SEPTEMBER 1859
8 - slight shock of earthquake at 8 o'c A.M.
20 - slight shock earthquake at 1 o'c A.M.

OCTOBER 1859
11 - slight shock of earthquake at 25 m to 7 P.M.
19 - two distinct shocks of E.quake at 1 o'c & 7:30 A.M.[2]

NOVEMBER 1859
23 - heavy shock of earthquake at 11:30 P.M.
28 - heavy rumbling noise in the earth during this night similar to the arrival or departure of a train of railroad cars[3]
severe shock of E.quake at 8 A.M.

DECEMBER 1859
NO EARTHQUAKES

Appendix 2B: Primary Documents

JANUARY 1860
NO EARTHQUAKES

FEBRUARY 1860
NO EARTHQUAKES

MARCH 1860
NO EARTHQUAKES

APRIL 1860
16 - slight shock of earthquake at 7 P.M.

MAY 1860
10 - slight shock of earthquake 6:30 A.M.

JUNE 1860
RECORDS MISSING

JULY 1860
RECORDS MISSING

AUGUST 1860
NO EARTHQUAKES

SEPTEMBER 1860
11 - slight shock of earthquake at 5:45 P.M.
22 - heavy shock of earthquake at 3 A.M.

OCTOBER 1860
NO EARTHQUAKES

NOVEMBER 1860
NO EARTHQUAKES

DECEMBER 1860
NO EARTHQUAKES

JANUARY 1861
NO EARTHQUAKES

FEBRUARY 1861
NO EARTHQUAKES

MARCH 1861
NO EARTHQUAKES

APRIL 1861
NO EARTHQUAKES

MAY 1861[4]
NO EARTHQUAKES

Appendix 2B: Primary Documents

Notes:

1. Crossed out in the original.

2. It appears that it originally ended as "7.30 p.m." but was corrected to read "7.30 a.m."

3. This could very well be a landslide in the mountains surrounding Fort Tejon. It had been raining extremely heavily for the previous three days. It could also be describing distant thunder.

4. Records end May 1861; the next Meteorological Report is dated September 1863.

22. Monthly Reports from Fort Tejon

(from Record Group 94, U. S. National Archives microfilm publication M-617, roll 1257)

JANUARY 1857 *

The Post was visited by several severe shocks of an earthquake on the 9th. inst. which have continued at intervals of a few hours up to the present time, damaging the buildings more or less.

FEBRUARY 1857 thru FEBRUARY 1858 *

RECORD OF EVENTS section left blank, or no mention of earthquakes.

MARCH 1858 *

A slight shock of an Earthquake felt at this Post on the 27th another on the 28th and a heavy one on the 29th.

APRIL 1858 [1]

There was a heavy shock of an Earthquake at this Post at 4.15 A.M. on the 3rd inst. a slight one at 9.10 A.M. on the 5th a heavy one at 6.30 A.M. on the 6th and a very heavy one at 8.10 A.M. on the 12th.

MAY 1858 [2]

There was a severe shock of an Earthquake at this Post at 2.40 P.M. on the 18th inst. — and a slight one at 6.10 P.M. on the 19th.

JUNE 1858 [3]

A severe shock of an Earthquake was felt at this Post at 9.15 P.M. on the 15th instant slightly injuring the Quarters of the Company.

JULY 1858 [4]

A slight shock of an Earthquake was felt at 11 o'clock P.M. and a very heavy one at 11.30 P.M. on the 21st inst.

AUGUST 1858 *

A slight shock of an Earthquake was felt at this Post at 6.45 A.M. on the 8th inst. and a heavy one at 10.30 and 11.30 A.M. on the 13th inst.

SEPTEMBER 1858 [5]

A slight shock of an Earthquake was felt at this Post at 8.10 P.M. on the 6th — one at 7.45 P.M. on the 7th — one at 7.10 P.M. on the 8th — and one at 6.45 A.M. on the 9th.

Appendix 2B: Primary Documents

OCTOBER 1858 and NOVEMBER 1858 *

RECORD OF EVENTS section left blank, or no mention of earthquakes.

DECEMBER 1858 [6]

A severe shock of an Earthquake was felt at this Post at 9.15 P.M. on the 19th and a slight one at 7.45 A.M. on the 27th.

JANUARY 1859 thru SEPTEMBER 1859 *

RECORD OF EVENTS section left blank, or no mention of earthquakes.

OCTOBER 1859 [7]

A slight shock of an Earthquake at 6.30 P.M. on the 11th inst and 2 distinct ones on the 19th at 1 and 7.30 A.M.

NOVEMBER 1859 [8]

There was a severe shock of an Earthquake at 11.30 P.M. on the 23d and another severe one at 8 A.M. on the 28th inst .

DECEMBER 1859 thru MARCH 1860 *

RECORD OF EVENTS section left blank, or no mention of earthquakes.

APRIL 1860 [9]

A shock of an Earthquake was observed at this post at 6.30 P.M. April 16 1860.

MAY 1860 [10]

A slight shock of an Earthquaqe was observed at this post about 10 minutes past 6 A.M. May 10 1860.

JUNE 1860 [11]

A slight shock of an earthquake was observed at this post at 12.30 A.M. on the 6th inst.

JULY 1860 thru MAY 1861 * [12]

RECORD OF EVENTS section left blank, or no mention of earthquakes.

Notes:

* There is NO additional information (in addition to information already in the *Meteorological* Records, Source #21) given here in the monthly reports, for these months.

1. The Meteorological Records for this month list the times of the earthquakes, successively, as 4:15 A.M., 9:10 P.M., 6:30 A.M., and 8:10 P.M.; the inconsistencies are noted in Appendix 1B.

2. According to the Meteorological Records, the shock of 18 May was at 2 P.M. and was "heavy," and the shock of 19 May was at 5:30 P.M.; the inconsistencies are noted in Appendix 1B. There was also a shock on 27 May.

3. The description here in the Monthly Report for the 15 June earthquake is more descriptive than that in the Meteorological Records; both descriptions appear in Appendix 1B. There was also a shock on 14 June.

4. The description here of "slight" for the 11 P.M. quake does not appear in the Meteorological Records, but it will be included in Appendix 1B.

5. According to the Meteorological Records, the shock of 9 Sept was at 6:45 P.M.; the inconsistency is noted in Appendix 1B.

6. According to the Meteorological Records, the shock of 19 Dec was at 9 P.M. and was "tremendous"; the inconsistencies are noted in Appendix 1B. The shock of 27 Dec was not mentioned in the Meteorological Records, but it will be listed in Appendix 1B.

7. According to the Meteorological Records, the shock of 11 Oct was at 6:35 P.M.; the inconsistency is noted in Appendix 1B.

8. According to the Meteorological Records, the shock of 23 Nov was "heavy"; both descriptions are included in Appendix 1B.

9. According to the Meteorological Records, the shock of 16 Apr was at 7:00 P.M.; the inconsistency is noted in Appendix 1B.

10. According to the Meteorological Records, the shock of 10 May was at 6:30 A.M.; the inconsistency is noted in Appendix 1B.

11. The Meteorological Records for June 1860 are missing. The earthquake mentioned here, in June's Monthly Report, will be included in Appendix 1B.

12. Records end May 1861; the next Monthly Report is dated August 1863.

23. Letter of John Xántus, 17 September 1857, Fort Tejon

(from Xántus, 1986, p. 48)[1]

Fort Tejon, Cala.
Sept. 17 1857

. . . . .

Since a month we experienced very few Earthquaque shocks, & their intensity decreases from time to time. They come some time yet, with heavy rumblings (like a passing of a railroad car over a bridge), but the vibration is generally very slight, & and almost always vertical; this is a great change their nature, as formally [sic] the rumblings were slight, the shocks very heavy, & invariably oscillatory. Our buildings were considerably injured this spring, some of them perfectly ruined, but since their repairation [sic] not even a crack is seen on them.

Notes:

1. The volume also contains several letters discussing the mainshock, however, no information could be gained from those letters which was not already discussed in the sources included in the appendix to Agnew and Sieh (1978).

24. Reminiscence of Mr. Bell, ca. 1905, Carrizo Plain

(As retold by geologist Harry R. Johnson, in a letter[1] to H. O. Wood, 22 May 1944)

A year or so before the 1906 San Francisco earthquake I learned that a Mr. Bell had experienced the 1857 disturbance whilst herding cattle in the Cariso Plains. I visited Bell in Bakersfield and he informed me that at the time of the earthquake he and a couple of other men working with him

thought at first that the disturbance was due to a stampede among the cattle. According to Bell the earthquake occurred in the early morning hours, before daybreak,[2] and when it became light enough he and his helpers started a search for their cattle, which of course had been badly frightened. Bell noticed considerable dust in the air along the foot of the Temblor Range and assumed it to have been raised by his stock on the run. It is possible of course that this may have been due to fine material thrown into the air along the rift at the moment of displacement....

Notes:

1. A more complete version of the letter, with descriptions of damage probably related to the mainshock, is given in the appendix to Agnew and Sieh (1978), and in Wood (1955), p. 63.

2. As Wood (1955) and Sieh (1978, pp. 1747-1748) pointed out, it is very likely that, when Mr. Bell recounted his experiences on the morning of the earthquake, some 50 years after the fact, the details were somewhat nebulous and perhaps rearranged in his mind. Undoubtedly, he is in error in stating that the main earthquake occurred "before daybreak." Nevertheless, he does remember that his cattle stampeded before daybreak, and he had to wait until it was light enough to round them up, so this activity was probably associated with one of the early-morning shocks prior to sunrise. If he was indeed near the epicenter of the dawn foreshock, it would be reasonable that the intensity felt at his location (on the Carrizo Plain) was sufficient to stampede cattle.

25. Visalia *Weekly Delta* and *Delta*[1]

25a. 21 April 1860 — page 3, column 1

On Monday evening last, about half past 7 o'clock, a slight shock of an earthquake was felt in Visalia.

25b. 02 March 1861 — page 2, column 1

A shock of an Earthquake was felt in Los Angeles on the 20th ult.[2]

Notes:

1. A description of effects of the mainshock is given in the appendix to Agnew and Sieh (1978).

2. Note that this does not appear to have been reported from any Los Angeles sources.

26. Meteorological Report from Fort Miller, CA,[1] January 1857

(from Climatological Records, Records of the Weather Bureau, Record Group 27, U. S. National Archives microfilm publication T-907, roll 38)

JANUARY 1857

Three distinct and very perceptible shocks of the earth ~~was~~[2] felt this morning (the 9th) at 8 A.M. a slight tremor occured during the night previous at 2 $^1/_2$ A.M.

Notes:

1. The site of Fort Miller is now beneath Lake Millerton Reservoir, on the boundary of Fresno and Madera Counties. Whiting and Whiting (1960) give the coordinates of Fort Miller as (37.01°N, 119.67°W). (Note of Agnew and Sieh, 1978.)

2. This word is crossed out in the original.

Appendix 2B: Primary Documents

27. Diary of Dr. C. A. Canfield, 1857, near San Benito

(from Holden, 1898)

27a. 09 January 1857

... 15 or 20 miles N. W. of San Benito, Dr. Canfield's Diary[1] says 3 shocks, the first about sunrise [which was at 7.23 a. m.],[2] lasting not over 5 seconds, accompanied by noise. The second about 8 a. m., "very much more violent — pieces of mortar fell from the walls — I was almost thrown from my seat — this lasted for a minute or two and I then went out of doors, when the oscillation returned and lasted perhaps a minute, but was quite gentle." The direction was S. to N. A person lying down reported a shock at 10 a. m., which was not felt by persons in motion.

27b. 21 January 1857

15 or 20 miles N. W. of San Benito. About 7h. 20m. a.m.? p.m.? a slight shock lasting a few seconds.[3]

27c. 01 April 1857

15 or 20 miles N. W. of San Benito. About 3.35 a. m. a severe shock lasting about 8 sec.[3]

Notes:

1. Holden (1898, p. 3) specifies this more fully as the diary of "Dr. C. A. Canfield, who lived 15 or 20 miles northwest of San Benito, Monterey County." We have not been able to locate this document, or any more precise reference to Canfield's location. (Note of Agnew and Sieh, 1978.)

2. Holden's note.

3. Holden did not quote directly from Dr. Canfield's diary.

28. Santa Cruz *Pacific Sentinel*[1]

28a. 10 January 1857[2] page 2, column 1

Yesterday morning was experienced two severe shocks of an earthquake, the first between 5 and 6 o'clock A.M., and the other about 8 o'clock A.M., which lasted for several seconds, and caused a shaking of things generally. As yet, we have heard of no damage resulting from them.

28b. 17 January 1857[2,3] page 2, column 5

On the morning of the 9th there were three earthquake shocks. The first was felt about 4 A.M., and was quite severe, causing buildings to tremble considerably and accompanied with a noise resembling a heavy wind. A second was felt a few minutes before 7, and was not as severe as the first or third. The third took place about 7-1/2, and was so severe that clocks were stopped, cradles and chairs set in rapid motion, and the undulatory motion of the earth caused many to feel dizzy, a cracking and shaking of buildings, waving and bowing of trees as if by a heavy wind....

28c. 24 January 1857 page 2, column 2

A shock of an earthquake was very seriously felt on Tuesday morning last, it was not so severe as that of the 9th inst., though our store keepers say it caused a general rattling among their crockery ware.

Appendix 2B: Primary Documents

28d. 31 January 1857[2,3] page 1, column 5

The shock of earthquake ... was felt in the counties of Santa Cruz and Monterey, on Friday morning, the 9th inst.... We understand from other parties that shocks were felt also at one o'clock A.M., and another at 8 o'clock A.M.

28e. 31 January 1857[2,3] page 2, column 1

The Earthquake or Wave of the 9th of January

Our readers will find to-day, on our first page, the most corrected accounts yet published. It appears from what we have observed of the phenomena and the observation of our friends in Monterey county, that three distinct shocks were experienced — the first at one o'clock A.M., the second which was the sharpest, at seven A.M., and the third at 8 A.M.... In taking into consideration the exact time of the visitation of these earthwaves, and the great discrepancy in the accounts of the different observers throughout the State, it must be borne in mind, that out of San Francisco, and Sacramento, (where there are proper chronometers corrected daily for science and navigation) there are not two watches which keep the same time — generally they differ by fifteen minutes, and often half an hour.

28f. 27 April 1860 page 2, column 1

EARTHQUAKE. — We have advices from Monterey, to the effect that the shock of an earthquake there, on Monday, 16th instant, frightened the good people of that town out of their propriety, and caused them to think very strongly that old mother earth, in one of her spasmodic throes would land them "on the other side of Jordan." On the following morning just before day, another shock was experienced. Lamps were set to ringing, dishes rattled, sleepers were awakened. The same shocks, at the same time, were felt at this place.

Notes:

1. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).

2. The reported times in the *Sentinel* for the earthquakes on the morning of 9 January 1857 should regarded especially carefully, as the *Sentinel* appears to be ambivalent about the earthquake times it reports. Ironically, their initial report (28a, 10 January) appears to be the most accurate. But Alexander S. Taylor, a Monterey correspondent of the San Francisco *Bulletin*, reports in the issue of 12 January (Document 32a) that the mainshock was felt in Monterey at "about 7 o'clock." This report seems to have convinced the editors of the Santa Cruz *Pacific Sentinel* that their own observations of an 8 o'clock mainshock were in error (Sieh, 1978b, pp. 1745-1748). By the 17 January edition of the *Sentinel* (28b), the editors had changed the time to 7:30 a.m., and by the edition of 31 January (28e), the mainshock is reported at 7:00 a.m., with a lighter shock at 8 a.m. The editors of the *Sentinel* even realize (and admit?) in the edition of the 31st (28e) that there may be uncertainties in the reported earthquake times given in their paper.

3. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

29. San Jose *Telegraph*

29a. 13 January 1857[1] page 2, column 3

On Friday morning at about five minutes past eight o'clock, a severe shock of an earthquake was felt in this city.... It is said that at five o'clock, and again at about six, of the same morning, very distinct shocks of an earthquake were felt, but the motions were short and quick.

Appendix 2B: Primary Documents

Notes:

1. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

30. San Jose *Tribune*

30a. 14 January 1857[1] page 2, column 2

At about four o'clock on Friday morning last, Jan. 9th., a pretty severe shock of an earthquake was felt in this city, and a still stronger one on the same morning at about half past eight....

30b. 20 April 1860 page 2, column 2

Several slight shocks of earthquake were felt in San Francisco last week.

Notes:

1. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

31. San Francisco *Daily Alta California*[1]

31a. 13 January 1857[2,3] page 1, column 1

This day will long be remembered by the people of Santa Barbara. We have had six shocks of an earthquake up to this minute, two since I commenced writing, consequently my nerves are not in as good order as usual. The first shock was at six in the morning, the second at nine, one and a half minutes in duration, the most severe shock ever felt in this part of the country.... Third shock at ten, slight — the three last this evening, two slight, one heavy. If we have many more, we shall begin to think we are going elsewhere.

31b. 28 January 1858[2,4] page 1, columns 5-6

SANTA BARBARA. — The morning of the 9th January, was ushered in with a clear sky and cool atmosphere. First shock of earthquake felt at 8:10 A. M. It was brief and passed unnoticed by many. At 8:22 A. M., the heavy shock occurred and continued from 40 to 60 seconds....

SACRAMENTO. — The *Sacramento Union* says: "The earthquake of Jan. 9th was felt at 2:15 A. M. and 8:15 A. M.[5] The last shock was of few seconds duration, but sufficient in force to cause chandeliers to vibrate about a foot from the centre, and to create a rattling among crockery and other wares...."

Respectfully yours,

C. H. Randall

31c. 17 April 1860 page 1, column 4

EARTHQUAKE. — At sixteen minutes past seven o'clock last evening, two shocks of an earthquake were felt in nearly all parts of the city. Nobody hurt.

Notes:

1. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).
2. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).
3. This is from a letter of R. E. Raimond, of Santa Barbara, dated 9 January 1857.

4. It should be noted that C. H. Randall, the author of this account, was also an editor of the Santa Barbara *Gazette* (see the *Gazette*, 15 January 1857), so that this account is not independent of those in that newspaper, reprinted here as Source #17.

5. The original account (40a) says $10^{1}/_{4}$ A.M.

32. San Francisco *Daily Evening Bulletin*[1]

32a. 12 January 1857[2] page 2, column 2

Our regular Los Angeles correspondent ... writes:

"A severe shock of an earthquake was felt here this morning [Friday, 9th January][3] at half past eight o'clock.... Almost an hour later another shock was felt.

"'A.S.T.'[4] of Monterey ... writes...:

"'A smart shock of earthquake ... was felt in Monterey about 7 o'clock in the morning of Friday, the 9th inst. It shook some of the oldest adobe buildings in the town, but did no harm whatsoever to things animate or inanimate. The earth seemed moved with the motion of a heaving, rolling wave. It was certainly a horizontal movement, and not a vertical one. Many people in the town, who were about their occupation, did not experience the sensation in the slightest degree; while those who were in bed felt it distinctly.'"

32b. 03 February 1857[2]

Los Angeles, January 28, 1857

... The great earthquake felt here on the morning of the 9th inst. was rather more extensive in its operations than we at first anticipated; it did some appalling execution in various localities in this vicinity....

We had at Los Angeles five or six shocks during the same day and night, and within about eight days time we had *twenty* shocks — some violent, some light. Since that time we have had none to speak of. For about a week we were "well shaken" and expected to be "taken," as the doctors phrase it. Reports were constantly coming in of the doings of the first great *temblor* in the sections of the country about us, interspersed with "lesser shakes" of the earth, so that the public nerves were kept up to rather an uncomfortable tension....

Notes:

1. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).
2. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).
3. The bracketed material is in the original.
4. Alexander S. Taylor, California historian and bibliographer.

33. San Francisco *Daily Herald*[1]

33a. 10 January 1857[2] page 2, column 2

At five o'clock, yesterday morning, and again at fifteen minutes after eight o'clock, the earth was shaken to its centre by the throes which seem to have become a part of the peculiarities of our State....

Appendix 2B: Primary Documents

33b. 21 January 1857 page 2, column 2

EARTHQUAKE. — We understand there was a slight shock of an earthquake felt in this city yesterday morning. It must have been very slight.

Notes:

1. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).

2. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

34. San Francisco *Daily Morning Call*

34a. 10 January 1857[1]

At about half-past five o'clock yesterday morning, a slight shock of an earthquake was felt, and at eight o'clock, another much more severe....

Notes:

1. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

35. San Francisco *Daily Sun*[1]

35a. 10 January 1857[2] page 2

On just such a morning as that of yesterday, on the 15th of February, now nearly one year, our city was visited by a most severe shock of earthquake.... Within the last twenty-four hours we have again felt the upheaving of Earth's foundations, and although the shock, or rather tremors, were not very severe, yet they were sufficiently so to cause much agitation to some persons. They seem to have been more severely felt in the lower portion of the city. The first shock was at 11 o'clock and 20 minutes, P.M.; the second at 1 o'clock and 33 minutes, A.M.; the third at 4 o'clock and 15 minutes; the fourth at 6 o'clock and 8 minutes; the fifth at 7 o'clock precisely, and the sixth at 8 o'clock and 14 minutes. The tremors of the fifth shock, four in number, produced a circular motion of the pendulum, and in the other five, the oscillations were apparently from northeast to southwest. The last shock was much the strongest, and created considerable alarm....

35b. 20 January 1857 page 2

The agent of the Pacific Express Company, at Mokelumne Hill, has kindly given us some valuable information in regard to the shocks of earthquake experienced at that place on the night of the 8th inst. He says:

So firmly are we fixed upon the bosom of mother Earth, that severe indeed must be the shock which can disturb our equanimity, or in fact, our equilibrium; but on the night in question, we were suddenly aroused and many seriously alarmed by a rapid succession of slight shocks, which caused our windows and doors to rattle as if they were breaking. The shocks were accompanied, at intervals, by flashes of light, from east to west. These were witnessed by many persons, who were aroused from their slumbers, and had assembled in small knots to speculate on the unusual occurrence. A committee was appointed, including many of our scientific and professional citizens to investigate the phenomenon, and in a few minutes it was ascertained that a jubilee had been declared for the election of our esteemed friend, Mr. Broderick.[3]

This was all we saw, heard or felt of earthquakes, until the arrival of the Stockton stages on the day following.[4]

Notes:

1. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).

2. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

3. David C. Broderick. Bancroft (1888, pp. 705-706) gives the details of his election as Senator. Though not actually elected by the legislature until 9 January, he had been nominated by them in caucus before, so a celebration on the night of the 8th and 9th is perfectly comprehensible. (Note of Agnew and Sieh, 1978.)

4. The jocular tone of this piece makes it hard to tell if any earthquakes were felt or not. From this sentence, it appears that the mainshock was not felt. (Note of Agnew and Sieh, 1978.)

36. San Francisco *Daily Town Talk*

36a. 10 January 1857[1] page 2, column 4

The prevalent cold weather has had an effect on Mother Earth, who, during the night of Thursday and early yesterday morning, evidenced the power of the chills. At eleven o'clock on Thursday night the first shock occurred, a moderate one ensued, and we suppose the old lady took a tissane and retired. The effects of the Thompsonian cure, however, passed off by sunrise yesterday, and at seven o'clock the paroxysm returned, being followed by a severer one at twenty minutes past eight. All three shocks were perceptibly felt in our vicinity, and the latter traveled as far as Sacramento. The vibrations of the second shock were north and south, those of the third, three in number, were more violent in effect, and moved from east to west....

Notes:

1. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

37. Letter of George Davidson, 19 January 1857, San Francisco

Portion[1] of a letter from George Davidson to Alexander Dallas Bache, San Francisco, 19 January 1857 (Vol. 16, Superintendent's Correspondence for 1857, Records of the Coast and Geodetic Survey, Record Group 23, U. S. National Archives microfilm publication M-642, roll 169, frames 164-165)

We had an earthquake here on the morning of the 9th. 1st shock about $7^1/_4$ A.M. second and more violent about $8^1/_4$ A.M....

Notes:

1. A more complete discussion of the mainshock is given in the appendix to Agnew and Sieh (1978).

38. Stockton *Daily Argus*[1]

38a. 16 January 1857[2] page 2, column 1

We learn from Mr. Canaday, who arrived in this city yesterday in charge of an express from Fort Tejon, that the earthquake which was felt in this city on the 9th inst., was remarkably severe at that place. A light shock was observed in the morning at about 6 o'clock[3] which was scarcely

perceptible. At about 8½ o'clock, a second shock occurred which lasted from three to five minutes, and resembled in sound the rumbling of a train of cars....

At the Fort, no one was injured and no accident occurred, beyond the falling of houses and trees. Shocks were felt throughout the day at short intervals, which kept the people on the qui vive, expecting every moment more serious results....

38b. 19 January 1857[2] page 2, column 2

Visalia, Jan. 9th, 1857

EDITOR ARGUS — Sir: This morning about sun-rise a slight shock of an earthquake was felt at this place. Fifteen minutes after 8 o'clock a very severe shock was felt which lasted for a number of minutes....

Slight shocks have been felt during the day and evening. At fifteen minutes of 9 o'clock at night, a slight shock — at twenty five minutes after ten, a slight shock — followed in a few minutes by quite a severe one. No damage has been done as we can learn. Should I be able to gather any more particulars in reference to this matter, I will forward them by the first opportunity....

38c. 28 April 1857 page 2, column 3

EARTHQUAKE IN THE SOUTH. — *El Clamor Publico* says that on the night of April 9th a severe shock of an earthquake was felt at San Gabriel. At San Jose, nine leagues from Los Angeles,[4] a trembling of the earth was also apparent on the same night.

38d. 30 May 1857 page 2, column 5

A slight shock of earthquake occurred at Los Angeles on the 23d inst., at which time a shock was also felt at Fort Tejon.

Notes:

1. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).

2. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

3. In his statement to the *San Joaquin Republican* (39b), Mr. Canaday gave this time as 6:30.

4. Gudde (1969, p. 287) lists a San Jose Creek, Hills, Peak, and Wash as places in Los Angeles County, and he states that "these features were so named because they are partly on the territory of the San Jose grant, dated April 15, 1837, and March 14, 1840." San Jose Creek and Hills lie in the San Dimas and El Monte 7.5-minute U.S.G.S. quadrangles in Los Angeles County, along the southern margin of the San Gabriel Valley. The San Jose referred to in this article was probably in this vicinity. This inferred location for San Jose is especially attractive, as it would be in close proximity to San Gabriel, the other place an earthquake was felt that night.

39. Stockton *San Joaquin Republican*[1]

39a. 10 January 1857[2] page 2, column 1

Many of our citizens experienced a severe shock of an earthquake yesterday, at about twenty minutes past eight o'clock A.M.... One gentleman informs us that he felt a shock similar to the one mentioned above, about six o'clock, but being engaged out of doors at the hour first named, he did not feel it at that time. If his statement is correct, there must have been two separate shocks, at 6 and 8 o'clock....

39b. 16 January 1857[2] page 2, column 1

From Mr. Canaday, who arrived in this city yesterday afternoon from Fort Tejon, we learn that the earthquake which occurred on the 8th inst., was felt in that vicinity with great severity.

The first shock, which was very slight, and barely perceptible, occurred at $6^1/_2$ o'clock[3] in the morning, and second at $8^1/_2$ o'clock. The second lasted from three to five minutes, throwing down some of the walls of unfinished adobe houses, and prostrating most of the chimneys in the vicinity of the Fort....

Up to the time our informant left the Fort, — Saturday morning — slight shocks were felt with more or less frequency. No indications of an earthquake were observed during the trip to this city.

39c. 23 January 1857 page 2, column 2

A slight shock of an earthquake was felt at San Francisco on the morning of the 20th.

Notes:

1. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).

2. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

3. This article, being drawn from Mr. Canaday's statements, is not independent of (38a), which is taken from the more full account. (Compare Sources 57 and 61 in the appendix to Agnew and Sieh, 1978.) In his statement to the *Daily Argus*, Mr. Canaday gave this time as 6:00.

40. Sacramento *Daily Union*[1]

40a. 10 January 1857[2] page 2, column 4

The vibrating motion incident to an earthquake was observed distinctly, though slightly, in this city about $2^1/_4$ A.M. yesterday — more sensibly at $10^1/_4$ A.M.[3] and again, slightly (we are informed) at 10:20 P.M. The shock at $10^1/_4$ A.M. created some consternation in many localities, although in others it was wholly unnoticed. It was but of a few seconds in duration, but sufficient in force to cause chandeliers to vibrate about a foot from the center, to create a rattling among the crockery and other wares of our dealers, to rock several of the hulks at the levee and impart to many a sense of motion produced by some general unseen cause....

Notes:

1. Full reports of the mainshock are given in the appendix to Agnew and Sieh (1978).

2. A more complete version of this article is given in the appendix to Agnew and Sieh (1978).

3. This time is exceptionally bad, and may be an editorial error. Another article on the same date of the same paper described the mainshock as occurring at 8 A.M. (See Source 66 in the appendix to Agnew and Sieh, 1978.)

41. Marysville *Herald*

41a. 13 January 1857 page 2, column 2

On the night of Thursday and the morning of Friday last, several shocks of an earthquake were felt in San Francisco, Sacramento, Stockton and also slightly in this city.

Appendix 2B: Primary Documents

42. Selected Excerpts[1] from Townley and Allen (1939)

1857 January 16. 5 p.m. V. Los Angeles. Severe shock.—B.MS.—Perrey.

1857 January 17. Night. Los Angeles? Two shocks; **January 18, 8 a.m.**—Perrey.

1857 January 20. 8:30 a.m. V. Santa Cruz and Mission San Juan. Strong shock.—J.B.T. [Trask calls this a "smart" shock, not a "strong" shock.—*Proc. Cal. Acad. Sci.*, **1**, 121]

1857 January 20. VI. Fort Tejon. Severe shock.—B.MS.—*Los Angeles County History*, p.545.

1857 January 20. 3:30 p.m. Mission San Juan.—Perrey.

1857 January 21. About 7:20 a.m.? p.m.? III. Fifteen or twenty miles northwest of San Benito. A slight shock lasting a few seconds.—Dr. Canfield's diary.

1857 March 14. 15h [3 p.m.] V. Santa Barbara and Montecito. Severe shocks.—J.B.T.

1857 April 1. 3:35 a.m. VI. Fifteen or twenty miles northwest of San Benito. A severe shock lasting about eight seconds.—Dr. Canfield's diary.

1857 April 24? San Gabriel and San Jose.—Perrey. [~~Must have been two distinct shocks.~~][2]

1857 May 2. Morning. Los Angeles. Two shocks.—B.MS.

1857 May 3. 22h [10 p.m.] VI. Los Angeles and El Monte. Smart shock.—J.B.T. "Violent shock."—Perrey.

1857 May 23. VI. Fort Tejon. Severe shock. Slight shock at Los Angeles (III).—J.B.T. "Four shocks at Los Angeles."—B.MS.

1857 August 29. VI. Tejon Reserve. Severe shock.—J.B.T.

1858 September 2. V. Santa Barbara. Smart shock.—J.B.T.

1859 March 21. 5:20 a.m. San Diego.—Perrey.

1859 December 1. 14h 10m [2:10 p.m.] V. San Bernardino. Several successive shocks, some quite heavy.—J.B.T. 2:10 p.m.—Perrey.

1860 January 26-27. Night. Los Angeles.—Perrey.

1860 March 26. VI. Los Angeles and Southern California. Severe.—B.MS.

1860 April 2. 8 p.m. VI. San Juan, Monterey [San Benito since 1874] Co. Two severe shocks.—B.MS.—*Sacramento Union*, April 7, 1860.

1860 April 16. 7:30 p.m. San Francisco, Fort Tejon, Santa Barbara.—B.MS.—*Sacramento Union*, May 1, 1860.

7 p.m. Severe shocks at San Francisco. (VI)—Perrey. April 17? About this time shocks during several hours at Washoe, Nevada.—Perrey. [Probably at least three shocks listed under this date.]

1861 March ? Tejon.—B.MS.

1861 December 9. Santa Catalina Island.—B.MS.

1862 March. Tejon.—B.MS.

Appendix 2B: Primary Documents

Notes:

1. All earthquakes listed in Townley and Allen (1939), between 10 January 1857 and 26 May 1862, for Monterey, San Benito, and Fresno Counties and to the southeast; additional earthquakes included when they coincided temporally with an earthquake (possibly the same event) that was reportedly felt within the specified region.

All intensities are given on the Rossi-Forel Intensity scale.
Words in brackets added by Townley and Allen.
Source codes used are as follows: "B. MS." = H. H. Bancroft's MS notes; "J.B.T." = J. B. Trask.
For further information on original sources or on the Rossi-Forel scale, consult Townley and Allen (1939), pp. 6-9 and 11-12, respectively.

Dr. Canfield's diary entries also appear in this appendix under Source #27.

2. See Source #38, Note 4. Townley and Allen were probably unaware of this San Jose in Los Angeles County. There was probably only one earthquake, in Los Angeles County, and the San Jose in Santa Clara County was probably not affected.

43. E. B. Webb: *Indian Life at the Old Missions* (1952)[1]

43a. pp. 133-134

This [Santa Cruz][2] mission's story for the next seven years [following a series of "earth tremors" in autumn of 1825][2] is one of struggle to repair and strengthen the damaged buildings.... In 1832 a buttress of stone was built on the cemetery side of the church which was in a ruinous condition.

In 1840, an "abundance of waters" (tidal wave?)[3] destroyed the tower. There is in the Padre's report no mention of the earthquake which Bancroft says preceded the tidal wave, or flood. Two of the bells hanging in the tower were broken. Ernest Massey, visiting Santa Cruz in 1850, wrote in his Diary: "Today the church is in ruins. Only the nave, dilapidated both outside and in, is still standing; it is still used for holding services. The tower has fallen, and the bells, fastened to a few crude beams, are lying in the debris."

On the morning of January 9, 1857, an earthquake ... destroyed the much buffeted and battered church of Santa Cruz. A portion of the building was later repaired with boards and used as a stable for horses and storage place for hay.

43b. p. 135

Its[4] tiled roof had been destroyed by the earthquake of 1857.

Notes:

1. These discussions of the mainshock were *not* published in the appendix to Agnew and Sieh (1978).

2. Information in these brackets is included by us to put the text into context.

3. Note of E. B. Webb.

4. Regarding Mission San Buenaventura's church.

APPENDIX 3A: MODIFIED MERCALLI SCALE
(Wood and Neumann, 1931; Toppozada *et al.*, 1981)

Items added by Toppozada et al. (1981) are enclosed in brackets.

I Not felt -- or, except rarely under especially favorable circumstances.
Under certain conditions, at and outside the boundary of the area in which a great shock is felt:
sometimes birds, animals, reported uneasy or disturbed;
sometimes dizziness or nausea experienced;
sometimes trees, structures, liquids, bodies of water, may sway -- doors may swing, very slowly.

II Felt indoors by few, especially on upper floors, or by sensitive or nervous persons.
Also, as in grade I, but often more noticeably:
sometimes hanging objects may swing, especially when delicately suspended;
sometimes trees, structures, liquids, bodies of water, may sway, doors may swing, very slowly;
sometimes birds, animals, reported uneasy or disturbed;
sometimes dizziness or nausea experienced.

III Felt indoors by several [a number, some], motion usually rapid vibration.
Sometimes not recognized to be an earthquake at first.
Duration estimated in some cases.
Vibration like that due to passing of light, or lightly loaded trucks, or heavy trucks some distance away.
Hanging objects may swing slightly.
Movements may be appreciable on upper levels of tall structures.
Rocked standing motor cars slightly.

IV Felt indoors by many, outdoors by few.
Awakened few, especially light sleepers.
Frightened no one, unless apprehensive from previous experience.
Vibration like that due to passing of heavy, or heavily loaded trucks.
Sensation like heavy body striking building, or falling of heavy objects inside.
Rattling of dishes, windows, doors; glassware and crockery clink and clash.
Creaking of walls, frame, especially in the upper range of this grade.
Hanging objects swung, in numerous instances.
Disturbed liquids in open vessels slightly.
Rocked standing motor cars noticeably.
[Frightened a few or several.]

APPENDIX 3A: MODIFIED MERCALLI SCALE
(Wood and Neumann, 1931; Toppozada *et al.*, 1981)

V Felt indoors by practically all, outdoors by many or most: outdoors direction estimated.
Awakened many, or most.
Frightened few [many] -- slight excitement, a few [or some] ran outdoors.
Buildings trembled throughout.
Broke dishes, glassware, to some extent.
Cracked windows -- in some cases, but not generally.
Overturned vases, small or unstable objects, in many instances, with occasional fall.
Hanging objects, doors, swing generally or considerably.
Knocked pictures against walls, or swung them out of place.
Opened, or closed, doors, shutters, abruptly.
Pendulum clocks stopped, started, or ran fast, or slow.
Moved small objects, furnishings, the latter to slight extent.
Spilled liquids in small amounts from well-filled open containers.
Trees, bushes, shaken slightly.
[Minor cracking of plaster.]
[Felt by most at an hour when most would be asleep.]
[Rang very small bells, i.e. door bells.]

VI Felt by all, indoors and outdoors.
Frightened many [most or all], excitement general, some alarm, many [or all] ran outdoors.
Awakened all.
Persons made to move unsteadily.
Trees, bushes, shaken slightly to moderately.
Liquid set in strong motion.
Small bells rang -- church, chapel, school, etc.
Damage slight in poorly built buildings.
Fall of plaster in small amount.
Cracked plaster somewhat, especially fine cracks, chimneys in some instances.
Broke dishes, glassware, in considerable quantity, also some windows.
Fall of knick-knacks, books, pictures.
Overturned furniture in many instances.
Moved furnishings of moderately heavy kind.
[Some brick walls cracked slightly.]
[A few loose bricks knocked from walls.]
[Many plaster walls cracked.]

VII Frightened all -- general alarm, all ran outdoors.
Some, or many, found it difficult to stand.
Noticed by persons driving motor cars [or horse drawn carriages].
Trees and bushes shaken moderately to strongly.
Waves on ponds, lakes, and running water.
Water turbid from mud stirred up.
Incaving to some extent of sand or gravel stream banks.
Rang large church bells, etc.
Suspended objects made to quiver.

APPENDIX 3A: MODIFIED MERCALLI SCALE
(Wood and Neumann, 1931; Toppozada *et al.*, 1981)

Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary buildings, considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc.
Cracked chimneys to considerable extent, walls to some extent.
Fall of plaster in considerable to large amount, also some stucco.
Broke numerous windows, furniture to some extent.
Shook down loosened brickwork and tiles.
Broke weak chimneys at the roof-line (sometimes damaging roofs).
Fall of cornices from towers and high buildings.
Dislodged bricks and stones.
Overturned heavy furniture, with damage from breaking.
Damage considerable to concrete irrigation ditches.
[Fall of a few fire walls.]

VIII Fright general -- alarm approaches panic.
Disturbed persons driving motor cars.
Trees shaken strongly -- branches, trunks, broken off, especially palm trees.
Ejected sand and mud in small amounts.
Changes: temporary, permanent; in flow of springs and wells; dry wells renewed flow; in temperature of spring and well waters.
Damage slight in structures (brick) built especially to withstand earthquakes.
Considerable in ordinary substantial buildings, partial collapse, racked, tumbled down, wooden houses in some cases [those on stilts]; threw out panel walls in frame structures, broke off decayed piling.
Fall of walls.
Cracked, broke, solid stone walls seriously.
Wet ground to some extent, also ground on steep slopes.
Twisting, fall, of [most or all] chimneys, columns, monuments, also factory stacks, towers.
Moved conspicuously, overturned, very heavy furniture.
[Moved frame structures on their foundations.]
[Weak adobe buildings may collapse.]

IX Panic general.
Cracked ground conspicuously.
Damage considerable in (masonry) structures built especially to withstand earthquakes:
threw out of plumb some wood-frame houses built especially to withstand earthquakes;
great in substantial (masonry) buildings, some collapse in large part [partial collapse of a number of buildings or a few buildings largely collapsed or both]; or wholly shifted frame buildings off foundations; racked frames; serious to reservoirs; underground pipes sometimes broken.

APPENDIX 3A: MODIFIED MERCALLI SCALE
(Wood and Neumann, 1931; Toppozada *et al.*, 1981)

X Cracked ground, especially when loose and wet, up to widths of several inches: fissures up to a yard in width ran parallel to canal and stream banks.
Landslides considerable from river banks and steep coasts.
Shifted sand and mud horizontally on beaches and flat land.
Changed level of water in wells.
Threw water on banks of canals, lakes, rivers, etc.
Damage serious to dams, dikes, embankments.
Severe to well-built wooden structures and bridges, some destroyed.
Developed dangerous cracks in excellent brick walls.
Destroyed most masonry and frame structures, also their foundations.
Bent railroad rails slightly.
Tore apart, or crushed endwise, pipe lines buried in earth.
Open cracks and broad wavy folds in cement pavements and asphalt road surfaces.

XI Disturbances in ground many and widespread, varying with ground material.
Broad fissures, earth slumps, and land slips in soft, wet ground.
Ejected water in large amount charged with sand and mud.
Caused sea-waves ("tidal" waves) of significant magnitude.
Damage severe to wood-frame structures, especially near shock centers.
Great to dams, dikes, embankments, often for long distances.
Few, if any (masonry), structures remained standing.
Destroyed large well-built bridges by the wrecking of supporting piers or pillars.
Affected yielding wooden bridges less.
Bent railroad rails greatly, and thrust them endwise.
Put pipe lines buried in earth completely out of service.

XII Damage total -- practically all works of construction damaged greatly or destroyed.
Disturbances in ground great and varied, numerous shearing cracks.
Landslides, falls of rock of significant character, slumping of river banks, etc., numerous and extensive.
Wrenched loose, tore off, large rock masses.
Fault slips in firm rock, with notable horizontal and vertical offset displacements.
Water channels, surface and underground, disturbed and modified greatly.
Dammed lakes, produced waterfalls, deflected rivers, etc.
Waves seen on ground surfaces (actually seen, probably, in some cases).
Distorted lines of sight and level.
Threw objects upward into the air.

APPENDIX 3B: ALTERED MODIFIED MERCALLI SCALE
(For 19th Century Earthquake Reports -- from Toppozada *et al.*, 1981)

When we assigned values of intensity based on the reported earthquake effects, we altered the Modified Mercalli scale of Wood and Neumann (1931) to make it more applicable to the limited information given in newspaper articles. Our most significant alteration of the intensity scale concerns the quality of 19th Century building construction. It is assumed that damaged structures are of the poorest quality construction; Masonry D of Richter (1958): "weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally." This has led to the following modifications:

V Minor cracking of plaster (It is felt that cracking of plaster is a lower intensity than fall of plaster particularly when the reported cracks may have predated the earthquake and were either enlarged by the earthquake or were noticed for the first time after the earthquake.)

VI Fall of plaster (same as MM scale); minor cracks in masonry walls (when it is stated that walls were cracked without specifying whether it was the plaster or the masonry which was cracked an intensity of V-VI, meaning V or VI, is assigned); a few loose bricks fell from the top of walls or chimneys (it is assumed the shaking required to dislodge loose bricks is about the same that is required to knock items from shelves).

VII One or more chimneys fell or were badly damaged (it is assumed that all damaged chimneys were weak); moderate damage to masonry walls such as large cracks or fall of bricks, tilework; fall of cornices from high buildings and towers; fall of some firewalls (nonstructural unreinforced brick walls usually one brick thick).

VIII Partial collapse of masonry walls, frame houses shifted on their foundations, collapse of weak adobe buildings; all chimneys twisted or knocked down.

IX Partial collapse of a number of masonry buildings or total collapse of a few masonry buildings; wood frame buildings shifted off of their foundations. (Richter (1958) states that Masonry D "weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally" is destroyed at this intensity. For this reason, we assign no higher intensity than IX. When most masonry buildings are destroyed a IX+ is assigned recognizing that the intensity could be higher, but we have no evidence that the structures were stronger than Masonry D.)

Further clarification was also needed in understanding the effects of earthquakes on people. Newspaper writers of the nineteenth century had a tendency to exaggerate or romanticize the response of the populace. For this reason, statements that people were frightened were treated with skepticism unless substantiated by other evidence such as people rushing out of buildings. The system used to assign intensities, based on the response of the populace, is as follows: A few people were frightened at IV; many were frightened and a few ran outside at V; most or all were frightened and many ran outside at VI. When it was uncertain whether few or many people ran out, as in "People ran out", intensity V-VI was assigned, meaning V or VI. When people found it difficult to stand, intensity VII was assigned. No higher intensities were assigned based on the effects of earthquakes on people.

APPENDIX 3B: ALTERED MODIFIED MERCALLI SCALE
(For 19th Century Earthquake Reports -- from Toppozada *et al.*, 1981)

The final items, which we have modified in our application of the scale, are those items dealing with ground effects or ground failure such an landslides, changes in springs or cracks in the ground. It has been our experience that the intensities derived from these effects, using the intensity scale as written, are often much higher than those indicated by structural damage in the same area. Landslides, rockfalls, and ground cracking due to slumping sometimes occur without being triggered by earthquakes, so their use as indications of ground shaking is suspect. We have found that these features generally occur within the intensity VI zone. Consequently, we assign an intensity of VI+, meaning VI or larger, to these effects.

APPENDIX 4:
A DISCUSSION ON CONFIDENCE PARAMETERS
as taken from Bakun and Wentworth (1997)

The values in Table 1 are actually *not* the values that appear in the version of the article by Bakun and Wentworth that went to press, but are instead from an earlier version of their work. In this appendix, we discuss the reasoning for choosing the earlier values.

In the final version of their paper, Bakun and Wentworth discuss a distance correction, which would preferentially weight intensity observations from reporting sources near the epicentral region. This would seem a logical correction, they argued, because intensity observations near an assumed epicenter are particularly sensitive to an error in its location, whereas intensity observations farther away are less sensitive. Comparing the "original" (values computed *without* distance corrections) and "revised" (values computed *with* distance corrections) tables of rms values associated with various confidence levels appropriate for different numbers of intensity observations, we see that, indeed, in cases where there are 50 or more intensity observations, the distance corrections improve the confidence of the rms contours; however, for fewer than 50 observations, that is not necessarily the case, and for fewer than 20 observations, the *opposite* holds true: the distance corrections actually decrease the confidence of the rms contours. Most likely this is because, in cases where there are so few reporting localities, there may not be any localities near the epicenter, and such a correction would tend to skew the plotted epicenter toward the reporting localities, thereby biasing said epicenters toward population centers.

But no matter the reason, for our purposes (for the earthquakes we are looking at, we have, at most, seven reporting localities) the distance corrections are not appropriate to use; *we therefore did not use distance corrections in any of our plots or computations*, and we use the "original" table to determine the relationship between confidence levels and rms values for a particular number of intensity observations. Both the "original" and the "revised" tables are included in this appendix; the values for which the "original" or "revised" method is "better" are in italic type in the appropriate table. Table 1A in the main portion of this article is the top four rows of data from the "original" table.

Note that the uncertainties in magnitude (Table 1B in the main portion of this article) were *unaffected* by the presence or absence of the distance corrections.

APPENDIX 4

"Original" Table (WITHOUT Distance Corrections):

# of MMI	rms [M_I] contour				
Confidence Parameter:	95%	90%	80%	67%	50%
5	*0.507*	*0.417*	*0.313*	*0.227*	*0.152*
10	*0.311*	*0.245*	*0.175*	*0.122*	*0.076*
15	*0.232*	*0.182*	*0.128*	*0.086*	*0.054*
20	*0.187*	*0.145*	*0.102*	*0.068*	*0.042*
25	*0.159*	*0.125*	*0.087*	*0.059*	0.037
30	*0.142*	*0.110*	*0.078*	0.052	0.033
40	*0.117*	*0.093*	0.065	0.045	0.028
50	*0.106*	0.084	0.059	0.040	0.026
60	0.097	0.076	0.055	0.038	0.025
70	0.091	0.071	0.051	0.036	0.024
80	0.087	0.067	0.049	0.034	0.023
90	0.082	0.064	0.047	0.033	0.022
100	0.079	0.062	0.045	0.033	0.022
110	0.076	0.060	0.044	0.032	0.021
120	0.073	0.059	0.043	0.031	0.020
130	0.071	0.057	0.042	0.030	0.020
150	0.068	0.055	0.041	0.029	0.020
170	0.067	0.054	0.040	0.029	0.020

"Revised" Table (WITH Distance Corrections):

# of MMI	rms [M_I] contour				
Confidence Parameter:	95%	90%	80%	67%	50%
5	0.589	0.469	0.352	0.259	0.179
10	0.387	0.303	0.217	0.152	0.098
15	0.287	0.221	0.152	0.102	0.062
20	0.226	0.169	0.113	0.074	0.044
25	0.188	0.138	0.093	*0.059*	*0.035*
30	0.156	0.118	*0.078*	*0.050*	*0.030*
40	0.124	*0.093*	*0.062*	*0.040*	*0.024*
50	*0.106*	*0.079*	*0.053*	*0.034*	*0.021*
60	*0.095*	*0.072*	*0.048*	*0.031*	*0.019*
70	*0.087*	*0.066*	*0.045*	*0.028*	*0.017*
80	*0.080*	*0.061*	*0.041*	*0.026*	*0.016*
90	*0.076*	*0.059*	*0.039*	*0.025*	*0.015*
100	*0.072*	*0.056*	*0.038*	*0.024*	*0.014*
110	*0.070*	*0.054*	*0.036*	*0.023*	*0.014*
120	*0.068*	*0.052*	*0.035*	*0.022*	*0.013*
130	*0.066*	*0.051*	*0.034*	*0.021*	*0.013*
150	*0.063*	*0.049*	*0.032*	*0.020*	*0.013*
170	*0.060*	*0.047*	*0.031*	*0.019*	*0.012*

Appendix 5: 1857 Calendar

January

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

February

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

March

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

April

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

May

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

June

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

July

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

August

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

September

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

October

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

November

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

December

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		