DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

The Intensity of the July 21, 1986, Chalfant Valley, California, Earthquake

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by

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ABSTRACT

On 21 July 1986 at 14:42 UTC Chalfant Valley, California was rocked by a strong earthquake with a magnitude of 6.5M_L (BRK). The hypocenter (37.537°N., 118.447°W., with a depth of 9 km) is about 8 km northwest of the town of Chalfant, a small desert community about 15 km north of Bishop, California. Considerable foreshock activity began approximately 3 weeks prior to the mainshock. The largest foreshock occurred on 20 July 1986, at 14:29 UTC, with a magnitude of 5.9M_L (BRK) (Cockerham and Corbett, 1987). The Chalfant Valley earthquake had a maximum Modified Mercalli (MM) Intensity of VI. The strongest acceleration recorded was .46 *g* about 14 km north of the epicenter. The most severe damage was sustained at Chalfant. The earthquake was felt over approximately 202,000 km2 of land area in California, Nevada, Utah, and Arizona (see fig. 1). High rise buildings were swayed in Los Angeles, San Francisco, and Salt Lake City. Official estimates of damage exceed $2.7 million (Southern California Earthquake Preparedness Project, 1986). Surface fracturing that occurred along 15.5 km of the north-trending White Mountain fault zone (east of the epicenter and Chalfant) indicate displacement along the fault is right-lateral oblique.

INTRODUCTION

This report shows the geographic intensity pattern, estimated from ground shaking, during the July 21, 1986, Chalfant Valley event. Intensity information was collected by a 550-km-radius mail canvass, a field survey (conducted by a team from NEIC on July 23, 1986--of the epicentral area), and press reports. The isoseismal map (fig. 1) shows the intensity pattern for the entire felt area. The description of ground shaking (in the epicentral area) includes photographs of intensity damage to different types of structures at different distances from the epicenter, and the acceleration data obtained from the earthquake. The acceleration data is found in Appendix A (p. 24). In addition, the seismic history of the Chalfant area is found in Appendix B (p. 25).

Intensities are rated using the Modified Mercalli Intensity Scale of 1931 (Wood and Neumann, 1931). The maximum intensity VI at Chalfant was based on the intense shaking but lack of structural damage to permanent structures (press report). The non-structural damage to these permanent structures included: bricks loosened from chimneys, broken windows, and stucco damage. This damage to permanent structures was sustained by just a few buildings. However, a large number of mobile homes, were thrown off their foundations and one mobile home was irreparably damaged. It is noted by Bryant and others (1986) that many of the mobile home supports were not reinforced and were ungrouted.

General Geology

The Chalfant area is located in a seismically active part of the western Basin and Range. Chalfant Valley, between the White Mountains and the Volcanic Tablelands, (Cockerham and Corbett, 1987) is located in a graben between the eastern Sierra Nevada Mountains and the White Mountains to the east. Bishop, the Volcanic Tableland, and the Long Valley caldera are all located in this graben (DePolo and Ramelli, 1987). Chalfant is located on valley fill deposits. The epicenter of the 21 July 1986 earthquake is located about 8 km northwest of Chalfant in the Volcanic Tableland (see fig. 2). This Volcanic Tableland was formed by the eruption of the Long Valley caldera (Cockerham and Corbett, 1987).

The Mammoth Lakes earthquakes of 1980 are thought to have been caused by magma rising or moving beneath the Long Valley caldera (Kahle and others, 1986). Many seismologists are skeptical that the Chalfant earthquake also was caused by similar movement of magma. Rather, the Chalfant event is thought to be a tectonic earthquake, due to tectonic stresses causing shifting along a fault.

Surface Rupture and Fault Movement

On the day of the Chalfant earthquake, fresh surface ruptures were found southeast of the epicenter along the north-trending White Mountain fault zone (a frontal fault zone at the western boundary of the White Mountains) (Bryant and others, 1986). Discontinuous surface fracturing occurred along 15.5 km of the fault (DePolo and Ramelli, 1987). The Chalfant Valley main shock is thought to have occurred either along the White Mountain fault zone or along a northwest-trending splay of the White Mountain fault zone (DePolo and Ramelli, 1987). Slip directions and fracture patterns in the White Mountain fault zone suggest right-lateral oblique displacement (DePolo and Ramelli, 1987). Rupture is described as discontinuous zones of north-trending cracks and fissures, many showing clear left-stepping patterns and right-lateral slip (Kahle and others, 1986).

In the Volcanic Tableland, elements of several prominent zones of tension cracks were found in an area about 9.6 km wide by 22.8 km long. These fissures, that coincide with NNW trending faults, are thought to be an indication of tectonic extension in the epicentral area. (Bryant and others, 1986).

The preferred focal mechanism solution determined from first-motion readings at University of California, Berkeley, University of Nevada, and the National Earthquake Information Center (NEIC fault plane, see fig. 2) has a fault plane striking N28°W with a dip of 72° to the west and a rake (slip angle) of 168°. The fault plane solution corresponds to right-lateral, strike-slip faulting with a small normal component (east side up) (Bryant and others, 1986).

Geologic Effects

In the Mammoth Lakes area a rockslide rumbled down Mammoth Mountain after the earthquake. Also, a Sierra Club trail crew was briefly stranded by a rockslide that blocked an access road near Pine Lake (32 km west of Bishop). Some rockslides were also reported in the Fish Lakes area in Nevada (press report).

Numerous rockfalls were reported in Chidago Canyon and the canyons of the White Mountains; spectacular dust clouds were associated with these rockfalls. Rockfalls were also observed, during our NEIC survey, all along Fishslough Road (see fig. 3) Some roads were temporarily blocked by boulders; however, no thoroughfares were blocked.

The Hot Creek bathing area 64 km north of Bishop was closed when inspectors found additional hot water coming through fissures (press report).

Strong Motion

The highest horizontal and vertical peak accelerations of .46 *g* and .35 *g*, respectively, were recorded at the Zack Brothers Ranch (see fig. 3) (Bryant and others, 1986). For a complete list of acceleration data obtained (in the epicentral area) from the earthquake see Appendix A (p. 24)

A First-Hand Observation of Ground Motion

On the morning of the July 21, 1986, Kenneth Smith was in Chalfant Valley with two geology students from the University of Nevada (Smith, 1987). They were about 6 km north of the epicenter (see fig. 3) and were able to observe the earthquake effects first-hand. Smith summarized the event as occurring in four episodes:

1-- An initial long-period heave 1-2 seconds before any high frequency shaking; this first motion was up and the wave front was observed approaching from the south with dominant vertical motion.

2-- A 5-second build-up of high frequency horizontal ground motion.

3-- Strong shaking for 15-20 seconds; the strongest accelerations were horizontal, and apparently significantly less than 1 *g* -- this motion quickly fell off.

4-- Long-period vertical motion for about 20 seconds that diminished gradually.

THE ISOSEISMAL MAP

Description Of Ground Shaking Effects On Manmade Structures In The Epicentral Area

Three intensity MM VI values were assigned (see fig. 1) at: Chalfant, Bishop, and the Owens River Gorge plant system.

A landslide occurred in 25 m of roadfill, on the Pleasant Valley Dam Road, over a marshy area in the Owens River Valley southeast of Lake Crowley (Bryant and others, 1986) (see figs. 3 and 7). The slide occurred about 16 km south of the epicenter and about 10.5 km northeast of Bishop. It temporarily stranded campers and overturned a camper trailer located at the head of the slide--no injuries were reported. Inspection by one geologist indicates that the landslide was caused by liquefaction of saturated alluvial soils at the base of the roadfill (Kahle and others, 1986). Another observer noted that the soil failure involved both fill and underlying saturated soft clayey sediment. Mud was extruded and flowed along the toe of the slide (Bryant and others, 1986). During the NEIC survey, we noted that a portion of the slide was at the intersection of the road and a presently unused irrigation ditch which possibly could have been a catchment for runoff, aiding in the saturation of soils (see fig. 8).

Rockslides caused the Upper- and Middle-Gorge hydro-electric plants, in the Owens River Gorge, to be inaccessible following the earthquake; the only seismic effects to Upper-Gorge and Middle-Gorge plants involved disconnected switches that required minor repairs. The Control-Gorge plant sustained some switchyard damage; a wire was pulled from a transformer, causing all three plants to go off-line. The plants were back on-line within 7 days (Bryant and others, 1986).

An **intensity MM VI** was assigned to damage of pipe supports. During the earthquake, part of a 19.2-km-long, 2.4-m-diameter pipe sustained support damage. The pipe is the portion of the Los Angeles aqueduct that connects the Gorge plants (see fig. 3). This pipe has pin supports that allow longitudinal movement from thermal expansion. The earthquake caused the pins to slide laterally as much as 51 mm. In some locations, it caused set bolts to shear. The reinforced concrete footings for these pin supports cracked and spalled, and anchor bolts pulled (Bryant and others, 1986). Five or six of these concrete footings along the pipe were damaged in this way (see figs. 9 and 10). This damage is attributed to lateral movement (Duane Buckholtz, personal communication).

An **intensity MM VI** was assigned the the town of Chalfant (pop. about 400), which is the closest population center to the earthquake epicenter. Shaking effects included: skewed roofs, cracked mobile home roofs, cracked mobile home skirts, broken sewer lines, muddied wells supplying homes with ground water, and minor injuries to two people from falling objects. Most of the damage was related to horizontal shifting of the mobile homes off jacks and block foundations. As mentioned earlier no permanent dwellings sustained structural damage.

All of Chalfant's 145 structures (mainly one-family residence mobile homes) sustained damage to their contents (many items were thrown off shelves and glass items broken). Of these structures, 53 mobile homes (single and double width) were shaken off their foundations. Most of these mobile home foundations were hollow, concrete block masonry; some were tripods. Only one home in Chalfant was damaged irreparably; the double width mobile home, on Mountain View Avenue, that was thrown off its supports (press report) (see figs. 13 and 14).

Figures 11 to 22 show the damage observed during our NEIC field survey. Most of the mobile homes had been releveled on their foundations at this time but most skirts had not yet been repaired or replaced. We saw no other evidence of damage to permanent dwellings in Chalfant other than a few bricks loosened from chimneys, and a few places where windows had broken and subsequently were cleaned up and boarded over. In addition, Bryant and others (1986) observed fallen chimneys.

An **intensity MM VI** was assigned to the town of Bishop (pop. about 4,000). Most of this damage consisted of fallen and broken glassware. Grocery stores, liquor stores and restaurants lost many glass items. Building damage was not structural and consisted of loosened bricks, a few broken windows, a few buildings with chimney damage (no chimneys had fallen, however).

Bishop's structures are composed mainly of one-story wooden and brick, residential buildings. There are a few two- and three-story buildings, which are mainly businesses or public buildings. Figures 23 to 26 show the damage found during the survey of Bishop. The following is a list of additional damage found by Bishop building inspector Ottie Bear:

Sears and Roebuck Co.-- Mortar cracked (old block building).
Perry Motors-- One window cracked.
RASCO-- One window broke.
J. C. Penny's-- A new back section, with no reinforcing, separated slightly.
Masonic Temple (three story)-- Plaster fell from the third floor ceiling.
City Hall-- A parapet wall cracked and pulled apart around the front door of the main building; a few suspended ceiling tiles also fell.
Burger King-- A few ceiling tiles fell.

The mail canvass questionnaires indicate the following effects in Bishop:

Highways or streets sustained large cracks. Many items were thrown from store shelves; light furniture or small appliances overturned; many glassware items and dishes broke; many small objects overturned and fell; many windows broke; hanging pictures fell; windows, doors, dishes rattled loudly. The Bishop Sheriff, in a personal communication, said that most items thrown off shelves were thrown off of north walls.

The following damage descriptions are from towns within our field survey area and within the MM V isoseismal (see fig. 1):

Benton-- No apparent damage from field survey: two old, one-room buildings on about 1.5 m supports (poor supports) had apparently not collapsed (see fig. 27); about 2.5 km south of town part of a stack of bailed hay had fallen over (see fig. 28). The mail canvass reports we received indicate that: A few windows cracked; hanging pictures fell; a few objects fell. People had difficulty standing or walking. Trees and bushes shook strongly. Elevated water tanks cracked and many water wells were damaged.

Considering most of the effects, or lack of effects in Benton, it's questionable whether water tanks cracked and water wells were damaged significantly. If they had been, comparable effects would have been observed, in our field survey, in the same mail canvass or in press reports.

Big Pine-- No apparent damage from field survey. The mail canvass reports we received indicate that: a few small objects overturned and fell and a few items were thrown from store shelves.

Crowley Lake-- No apparent damage from field survey. The mail canvass reports we received indicate that: A few glassware items and dishes broke; a few items were thrown from store shelves; hanging pictures were moved out of place;

windows, doors, and dishes rattled loudly. People had difficulty walking or standing. Trees and bushes shook moderately.

Mammoth Lakes-- No apparent damage from field survey. The mail canvass reports that we received indicate that: A few small objects overturned and fell and windows, doors, and dishes rattled loudly. Trees and bushes shook moderately.

Rovana-- There was no apparent damage from field survey. A mail questionnaire was not received from this locality.

Tom's Place-- There was no apparent damage from field survey. A mail questionnaire was not received from this locality.

Anomalous Intensity Values Outside the Epicentral Area

Locations of anomalously high intensity values within the MM IV isoseismal include:

California-- Bass Lake, Coalinga, Corcoran, Farmersville, Firebaugh, Fresno (Tower), Ivanhoe, Madera, North Fork, O'Neals, Orange Cove, Porterville, San Joaquin, Sonora, and Wawona.

Nevada-- Carson City and Lake Tahoe.

The majority of the above anomalies occur within the Great Valley; most of these are located along the margins of the Valley. The rest of the anomalies are mainly next to lakes and creeks in the Sierra Nevada Mountains.

Locations of anomalously high intensity values within the MM II-III isoseismal include:

California-- Bethel Island, Ceres, Keyes, Linden, Merced, and Sacramento.

All of the above anomalies occur within the Great Valley.

Locations of anomalously high intensity values outside the isoseismals include:

Intensity MM IV--

Los Angeles, California area-- Carson, Colton, Hawthorne, Pasadena, Stanton.

The above anomalies occur adjacent to the San Bernardino Mountains, the San Gabriel Mountains, and near coastal areas.

Intensity MM III--

Los Angeles, California area-- Arcadia, Burbank, Glendale, Los Alamitos, and San Pedro.

The above anomalies occur adjacent to the San Gabriel Mountains or near coastal areas.

San Diego area-- Lemon Grove, Oceanside, Santee, and Spring Valley.

The above anomalies occur in valley areas in the San Diego area and near the coastline.

Intensity MM II--

Indio, California (Coachella Valley).
Elko, Nevada (Humbolt River area).

General Trend of the Isoseismal Map

The most prominent trend of the isoseismal map is a general northwest southeast orientation. This direction roughly follows the strike of the preferred fault plane, the trend of the Sierra Nevada and the White Mountains and thus, the trends of valleys adjacent to these ranges.

FINAL COMMENTS

The damage caused by in the July 21, 1986 earthquake, that could have been most easily mitigated, was to the inadequately anchored mobile homes, in Chalfant, that were located on valley fill deposits.

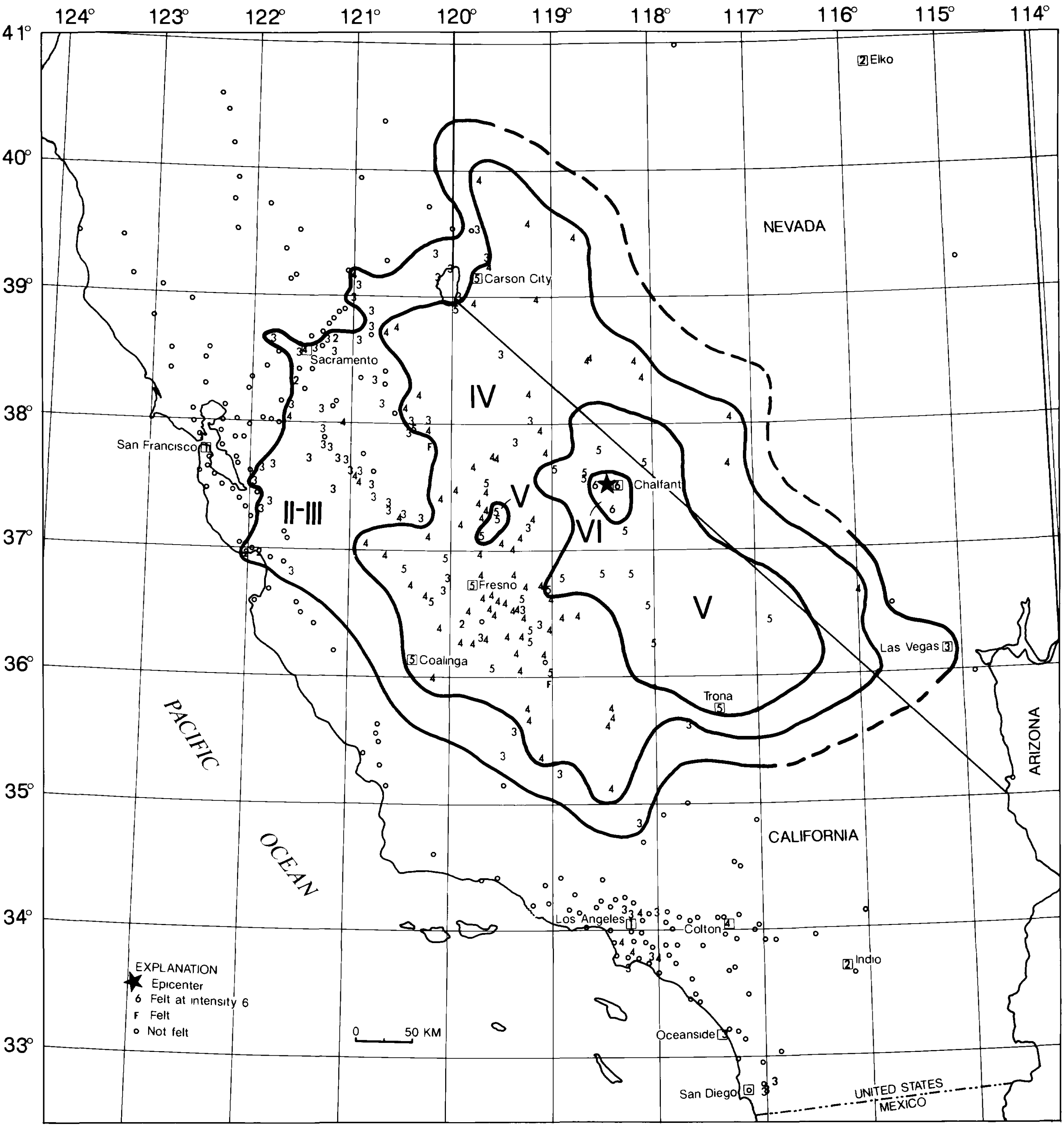

Figure 1. Isoseismal map for the Chalfant Valley earthquake of 21 July 1986, 14 42 26.6 UTC. Roman numerals represent Modified Mercalli intensities between isoseismals; arabic numerals are used to represent these intensities at specific sites. Felt indicates, felt only, at specific sites.

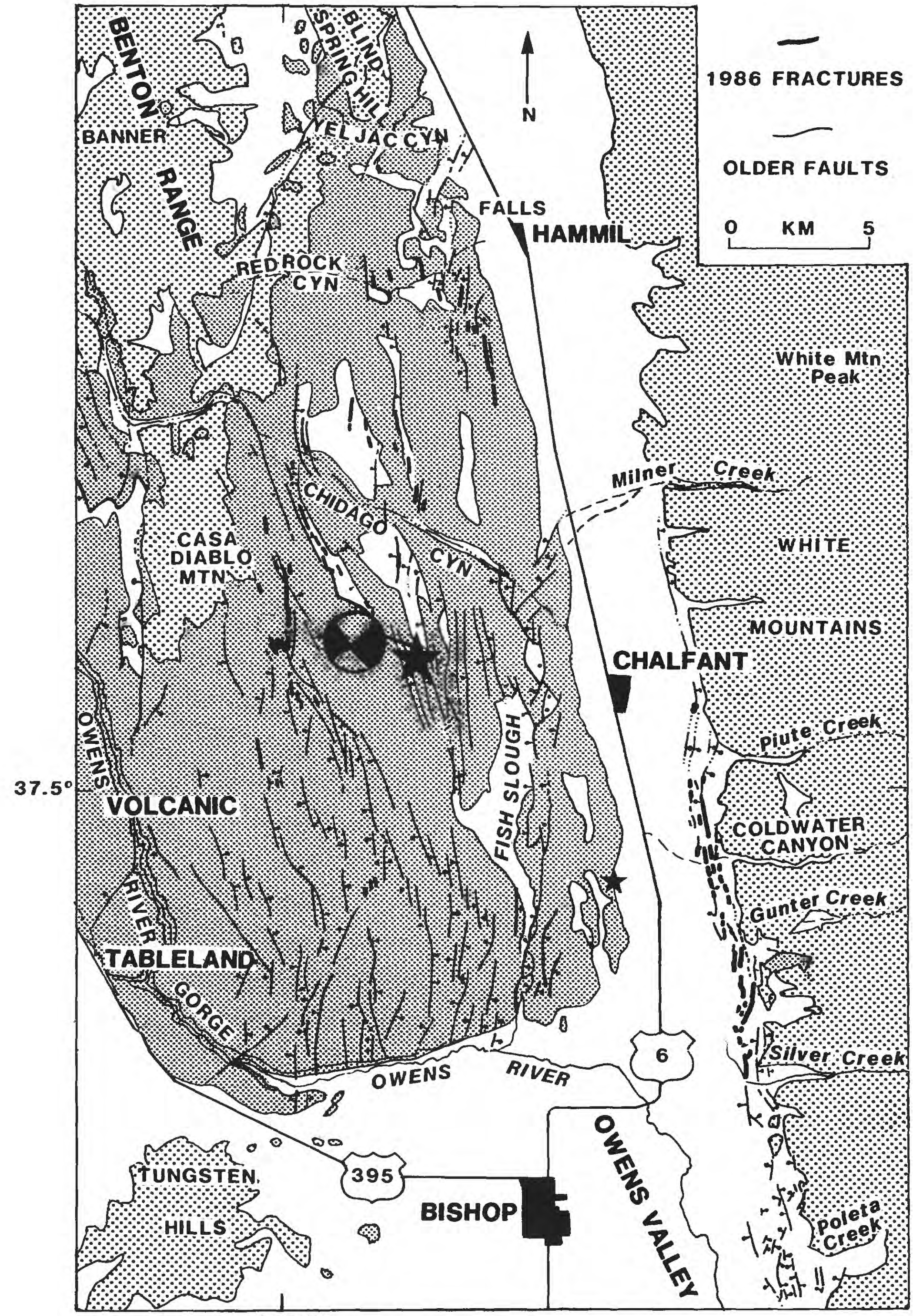

Figure 2. Geologic map of the Chalfant Valley area. Smaller stippling indicates Bishop Tuff (Volcanic Tableland); larger stippling is older bedrock; unshaded areas indicate Quaternary alluvium, including fan gravels. Large star is the epicenter of the, 21 July 1986, main shock and small star is largest aftershock (31 July 1986). The map is from Lienkaemper and others (1987). The main shock focal mechanism is from NEIC (Preliminary Determination of Epicenters, Monthly Listing, 1986).

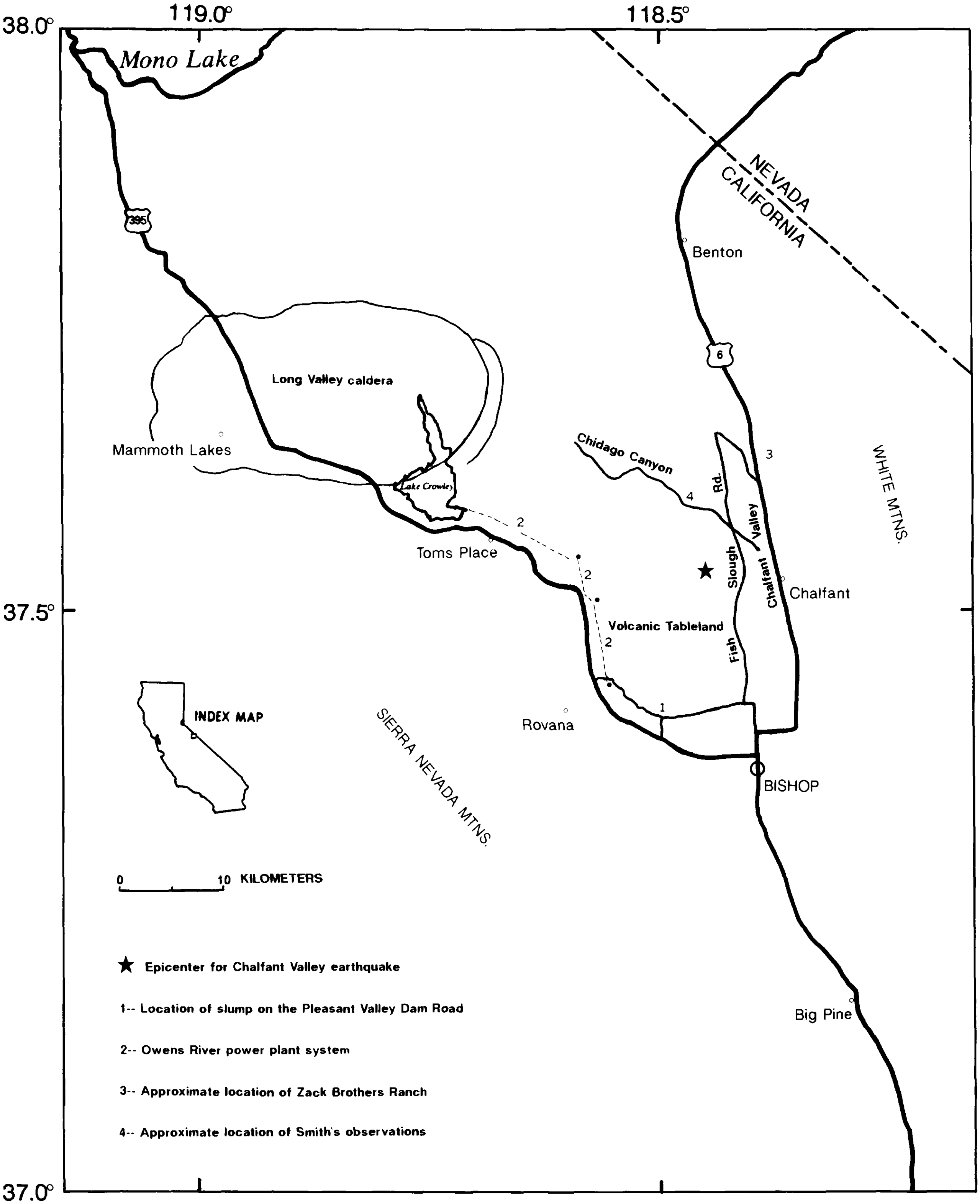

Figure 3. Schematic diagram showing points where there were shaking effects of special interest. Numbers correspond to those in the lower left-hand corner.

Figure 4. A road blocked by a boulder in the Chalfant Valley after the Chalfant event (photo from Kahle and others, 1986).

Figure 5. Dust rising out of canyons, in the White Mountains caused by rockslides and rockfalls during the Chalfant event (photo from Kahle and others, 1986).

Figure 6. Rockfall along Fish Slough Road.

Figure 7. Landslide which occurred in 25 m of roadfill on the Pleasant Valley Dam Road (photo from press report).

Figure 8. After picture of the Pleasant Valley Dam Road; shows intersection of road with an old irrigation ditch.

Figure 9. The 19.2-km-long pipe connecting the Owens Gorge power plant system (photo from Bryant and others, 1986).

Figure 10. Concrete supports for the pipe (photo from Bryant and others, 1986).

Figure 11. Permanent dwelling, in Chalfant, on Mountain View Drive. A few bricks have been loosened from the chimney.

Figure 12. Mobile home, in Chalfant, on Mountain View Drive and Chase Avenue. It has been releveled back on its supports.

Figure 13. Mobile home, in Chalfant, off its supports (irreparably damaged) on Mountain View Avenue.

Figure 14. Close up of above photo.

Figure 15. Mobile home, in Chalfant, across from the town park. The supports are leaning.

Figure 16. The other side of the above mobile home. Porch supports are torqued.

Figure 17. Mobile home, in Chalfant, on Chase Avenue off of its supports.

Figure 18. Virginia Avenue in Chalfant. The fence is bent by cement slabs which have slid.

Figure 19. Fallen cinderblock fence, in Chalfant, on Chase Avenue.

Figure 20. Fallen cinderblock fence, in Chalfant, on Chase Avenue.

Figure 21. Two gate posts in Chalfant. The one on the right fell; the one on the left, supported by the fence, did not.

Figure 22. Wooden fence broken, in Chalfant, on Chase Avenue.

Figure 23. First Sierra Bank in Bishop (Main Street and Line Street). There was cracking and separating of brick facade.

Figure 24. Western Auto (Main Street) in Bishop; the window was broken and subsequently reboarded.

Figure 25. Realty World (178 E. Line Street). A chimney was broken just above the roofline.

Figure 26. A residence in Bishop (Home Street and Pine Street). The chimney separated about 35 mm from the house.

Figure 27. These houses on supports, just south of Benton, apparently didn't fall during the earthquake.

Figure 28. A haystack, just south of Benton, with a few stacks out of kilter.

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Appendix A---Strong Motion

The following is a list of strong motion records from the California Strong Motion Instrumentation Program. The records were recovered following the 21 July 1986, Chalfant Valley earthquake.

	Station Name	Geographic Coordinates Lat.(o)	Long.(o)	Epicentral Distance (km)	Azimuth	Maximum Acceleration
1.	Chalfant— Zack Brothers Ranch	37.662N.	118.398W.	14	17	0.46g H*, 0.35g V*
2.	Bishop— Paradise Lodge	37.481N.	118.602W.	16	244	0.18g H, 0.14g V
3.	Bishop— Main Street Office Bldg.	37.370N.	118.396W.	20	168	Ground— 0.25g H, 0.17g V Structure— 0.40g H
4.	Bishop— LAWP	37.360N.	118.396W.	21	169	0.25g H, 0.14g V
5.	Long Valley Dam— (Crowley Lake)	37.588N.	118.705W.	24	282	Crest— 0.21g H, 0.10g V Abutment— 0.34g H, 0.11g V Downstream Ground 0.10g H, 0.05g V
6.	Crowley Lake— Shehorn Residence	37.561N.	118.743W.	27	274	0.16g H, 0.09g V
7.	Benton	37.818N.	118.475W.	31	355	0.21g H, 0.13g V
8.	Convict Creek	37.614N.	118.831W.	35	283	0.08g H, 0.03g V
9.	Mammoth Lakes Sheriff Substation	37.638N.	118.892W.	41	285	0.05g H, 0.03g V
10.	Mammoth Lakes High School Gym FF	37.641N.	118.963W.	47	283	0.04g H, 0.03g V

Distance is relative to the earthquake epicenter 37.544N., 118.442W. (USGS). Azimuth from the earthquake epicenter to the station is clockwise from north, 0-360(o).
H* - horizontal, V* - vertical.
(Table taken from Bryant and others, 1986)

Appendix B---Seismic History

The following is a chronological list of hypocenters, that occurred between 1800–1987 (including the Chalfant event) within an approximately 20 km radius of the Chalfant epicenter. The list includes MM intensities of VI or comparable magnitudes to the 21 July 1986 event.

	Date	Origin time (UTC) hr min sec	Geographic Coordinates Lat(°)	Long(°)	Depth (km)	Magnitude	MM Intensity	Remarks
1.	1872 Apr. 11	19 00 00.00	37.500N.	118.500W.		6.6(CDMG)	IX	Epicentral uncertainty ≥100 km.
2.	1938 Dec. 03	17 42 52.60	37.453N.	118.603W.	10	5.5ML(BRK) 5.7ML(PAS)	VI	Felt over an area ≈ 24,000 mi.^{2} in California and Nevada. MM about VI in Owens Valley Region. Felt in San Joaquin Valley as far north as Stockton and to Bakersfield on the south. West of Bishop, there was a report of a 6 ft. diameter boulder crashing into a house and causing considerable damage. In the Owens River Gorge, reports of rocks loosened, buildings damaged, and pipelines damaged. In San Joaquin Valley, in the Fresno area, pictures fell from walls. MM VI Del Piedra, Independence, Terra Bella, Visalia.
3.	1947 Jan. 11	11 57 48.00	37.600N.	118.430W.		4.4ML(BRK) 4.4ML(PAS)	VI	Felt strongest at Owens River Gorge.
4.	1951 Dec. 28	02 49 27.00	37.567N.	118.583W.		5.1ML(BRK) 5.2ML(PAS)	VI	Felt over an area of ≈10,000 mi.^{2}. MM VI at Long Valley Reservoir.
5.	1959 June 18	00 29 40.00	37.550N.	118.567W.		4.7ML(BRK) 4.7ML(PAS)	VI	Felt over an area of ≈3,000 mi.^{2}, mainly in the region southeast of Yosemite National Park. MM VI Mammoth Lakes, where plaster cracked.
6.	1963 Dec. 06	08 34 21.57	37.537N.	118.425W.		4.7ML(BRK) 4.7ML(PAS)	VI	Felt over an area of ≈10,000 mi.^{2} of California, and Nevada. MM VI. Plaster cracked in Bishop and in the Paradise area; a 230 KV transformer bushing cracked at Bishop.
7.	1978 Oct. 04	16 42 48.60	37.530N.	118.630W.	9	5.8ML(BRK) 5.8ML(PAS)	VI	Felt over an area of ≈105,000 km^2 of California and Nevada. In the Bishop area: grocery stores had considerable amounts of canned and bottled goods shaken from shelves; pictures knocked off walls; boulders rolled unto roads. Landslides occurred near Bishop, Mammoth Lakes, and Yosemite National Park. MM VI at Benton, Bishop, Easton, Friant, Mammoth Lakes, and Paradise Camp.
8.	1984 Nov. 23	18 08 25.51	37.458N.	118.605W.	12	6.1ML(BRK) 6.2ML(PAS)	V	Felt over an area of ≈114,000 km^2 of California and Nevada. M_o=5.3*10**24(BRK).
9.	1986 July 21	14 42 26.60	37.537N.	118.447W.	9	6.5ML(BRK) 6.0ML(PAS)	VI	Felt throughout a large area, ≈ 202,000 km^2, of California, Nevada, and Arizona. Felt in high-rise buildings as far away as Los Angeles, San Francisco, California, and Salt Lake City, Utah. M_o=3.5*10**24(BRK).