CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

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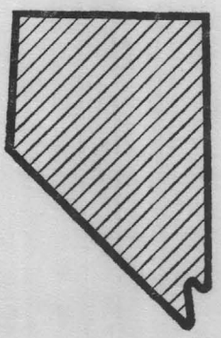
EARTHQUAKE EPICENTERS

NEVADA BUREAU OF MINES
MAP 29

EARTHQUAKE EPICENTER MAP OF NEVADA

By

David B. Slemmons, James I. Gimlett, Austin E. Jones,
Roger Greensfelder, and James Koenig



MACKAY SCHOOL OF MINES
UNIVERSITY OF NEVADA
1965

Price 75 cents

NEVADA BUREAU OF MINES MAP 29

The Mackay School of Mines is one of the several colleges of the University of Nevada. The School consists of three divisions: the academic departments of instruction, the Nevada Bureau of Mines, and the Nevada Mining Analytical Laboratory. The Mackay School of Mines is thus the State of Nevada's educational, research, and public service center for the mineral industry.

The Nevada Bureau of Mines and the Nevada Mining Analytical Laboratory serve the public as State agencies to assist in developing Nevada's mineral resources. They identify, analyze, and evaluate minerals, rocks, and ores found in Nevada. They conduct field studies on Nevada geology and mineral deposits, including metallic and industrial minerals as well as oil and gas. They pursue laboratory and library research in mineral beneficiation, extractive metallurgy, and economic problems connected with the mineral industry of Nevada.

For information concerning the mineral resources and mineral industry of Nevada, write to: Director, Nevada Bureau of Mines, University of Nevada, Reno, Nevada.

Mackay School of Mines
University of Nevada
Reno, Nevada

EARTHQUAKE EPICENTER MAP OF NEVADA

By

David B. Slemmons*, James I. Gimlett**, Austin E. Jones*,
Roger W. Greensfelder* and James B. Koenig*.

Prepared for the
Air Force Office of Scientific Research

TECHNICAL REPORT NUMBER 5

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* Mackay School of Mines, University of Nevada
** Hycon Manufacturying Company, Monrovia, California

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UNIVERSITY OF NEVADA
RENO, NEVADA

MACKAY SCHOOL OF MINES
SEISMOGRAPHIC STATION

February 24, 1965

Colonel William Best, Retired
Geophysics Division
Air Force Office of Scientific Research
Office of Aerospace Research
Washington, D. C. 20333

Dear Colonel Best:

Enclosed is one copy of a report, "Earthquake Epicenter Map of Nevada" by James I. Gimlett (Hycon Manufacturing Company, Monrovia, California), Austin E. Jones, Roger W. Greensfelder, James B. Koenig, and myself. The original copy of this report has been submitted to the Nevada Bureau of Mines for publication as Map 29 in their map series.

The epicenter map and the related brief text is mainly a condensation of our Technical Report No. 3, which will be published in the April issue of the Bulletin of the Seismological Society of America. The principal difference in this publication is that it will make available the epicenter map at a 1/1,000,000 scale, which is much more suitable for seismological and earthquake engineering studies. The text includes basic definitions of seismological terms and emphasizes geological aspects, since this publication series is designed for a different professional audience than the catalog. The final map will include the topographic base for Nevada, as well as the enclosed text and the table of Destructive and Near-Destructive Earthquakes.

Preparation of this map was accomplished under our Grant No. AF-AFOSR-646-64, APC No. 4810, AO No. 292-64, in the amount $104,646.00.

Sincerely yours,

David B. Slemmons

David B. Slemmons
Principal Investigator

DBS:ak

Enclosure

EARTHQUAKE EPICENTER MAP OF NEVADA by David B. Slemmons, James I. Gimlett, Austin E. Jones, Roger W. Greensfelder and James B. Koenig.

INTRODUCTION

Nevada earthquake epicenters for the period from about 1852 to 1961 are plotted on the accompanying map. During this period 1,173 earthquakes with Nevada epicenters were felt, 586 others with Richter magnitudes above 4.0 were recorded and were probably felt by some residents, and approximately 220 were reported in non-specific terms (e.g. "several aftershocks were felt"). High seismicity of this region is indicated by the fact that on an equal-area basis, during the period 1934-1960, Nevada had the highest incidence of earthquakes of any of the conterminous United States.

This research was supported by Grant No. AF-AFOSR-62-285 of the Air Force Office of Scientific Research as part of the Advanced Research Project Agency's VELA UNIFORM Project, and by the G. K. Gilbert Award of the Carnegie Institution of Washington.

Data for this epicenter map is condensed from Slemmons, Jones, and Gimlett (1965).

TERMINOLOGY

Epicenter: The point on the earth's surface directly above the focus or origin of an earthquake. Accurate determination of an earthquake epicenter depends both on the number of seismographic stations which are located within the epicentral region, and on the accuracy of knowledge of the structure of the earth's crust in the same region. For larger earthquakes, it is possible to determine an approximate epicenter by outlining areas of greatest damage or areas where the earthquake was most strongly felt. Most of the epicenters plotted on this map have possible location errors of 5 to 15 miles; for this reason, epicenters for adjoining states are shown on the map only if they are within 20 miles of the Nevada boundary.

Intensity: A number assigned to each place where an earthquake is reported felt or does damage. The intensity at any point is indicative of the way in which the earthquake was felt, of the amount of damage it did to man-made structures, or of geological effects (e.g. surface faulting, landsliding) of the earthquake at that location. The most widely used scale is the Modified Mercalli scale, 1956 version which follows.

Richter magnitude: A measure of the amount of energy released during an earthquake; it is normally calculated from measurements on recordings made with calibrated seismographs. The highest magnitude for any recorded earthquake is just under 9; the highest for any Nevada epicenter is 7.75 for the 1916 Pleasant Valley earthquake. Earthquakes with magnitudes above about 5 or 5.5 are potentially destructive at the epicenter.

MODIFIED MERCALLI INTENSITY SCALE OF 1931, REVISED 1956 VERSION

I. Not felt. Marginal and long-period effects of large earthquakes.

II. Felt by persons at rest, on upper floors, or favorably placed.

III. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.

IV. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV wooden walls and frame creak.

V. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and weak masonry and adobe cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle).

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to weak masonry and adobe, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry of ordinary quality. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

VIII. Steering of motor cars affected. Damage to masonry of ordinary quality, some damage to good masonry not designed to resist lateral forces, but none to well-constructed masonry designed to resist lateral forces. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

IX. General panic. Weak masonry destroyed; masonry of ordinary quality heavily damaged, sometimes with complete collapse; good masonry, not designed to withstand lateral forces seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.

X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown out on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

XI. Rails bent greatly. Underground pipeline completely out of service.

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

EPICENTRAL DISTRIBUTION

On this map, epicenters are divided into two groups -- pre-1932 and post-1932 -- in order to distinguish between early historic events with poor epicentral locations, and modern events with better epicenters based on instrumental information. A search of the data for periodicity or sequential relationships of activity within the province or with respect to adjoining provinces, has not revealed any conclusive trends of earthquake strain release in space or time, other than a distinct, but statistically inadequate tendency for a 20-year cycle of activity, with peaks at about 1852?, 1872, 1894, 1916, 1932-33, and 1954 (Slemmons, Jones and Gimlett, 1965).

Felt reports are naturally biased toward population centers. Except for Las Vegas, most of the larger towns (and even the old mining camps) are in western Nevada. Until recently most of the seismographic stations in the area have been on the west side of the State. During the late 1880's and early 1890's the Weather Bureau operated a pendulum seismograph in Carson City. The epicenters are biased toward Carson City for this period. Because of the Wiechert seismograph at the University of Nevada, epicenters are strongly slanted toward Reno for the period 1916-1932. A very large number of small events were felt and recorded at Boulder City during the late 30's and early 40's. Earthquakes began to be felt near Boulder City after Lake Mead had first filled up to an elevation of 1,025 feet above sea level from a Colorado River level of 650 feet (Jones, 1944) and this activity has continued through the 1950's.

It is quite obvious that this map cannot be complete. However, it is believed that no events of magnitudes over 6.0 have been missed since approximately 1860. The epicenters include all known events with felt reports and instrumentally-determined events over 4.0 magnitude.

The general pattern for both periods of time is similar, with the exception of new, unusual activity near Lake Mead following the reservoir loading in 1936. The earlier events have a more rectilinear, grid-like distribution, due to epicenter locations which were rounded-off to nearest degree, half-degree, or quarter-degree. The distribution of epicenters is very uneven with a strong tendency for most of the activity to be in belts or areas of high activity with larger, intervening areas of weak seismic activity. The largest area of low earthquake activity is in eastern Nevada-western Utah. There is an anomalous relationship for parts of this area, for many fresh-appearing geologically young faults and steep and rugged fault-block mountain ranges are present in this region. Evidently, the one-hundred year period of earthquake observation is statistically a very poor sample of the longer-term seismic activity of this region.

The epicenter map for Nevada shows a strong concentration of activity into the following three seismic zones, the first two of which cross each other in the Cedar Mountain-Excelsior Mountain area:

(1) Western Nevada-Eastern California Seismic Zone: This is a broad zone of about 50-100 miles width bounded on the west by the Sierra Nevada and on the east by faults at the eastern edge of Walker Lane. The zone is structurally relatively narrow at the northern end near Reno, and broadens southward into two main sub-parallel structural branches, the Fish Lake Valley-Furnace Creek-Death Valley fault systems, and the Walker Lane (The Pyramid Lake-Walker Lake-Las Vegas Valley alignment). This zone has been especially active during both the pre- and post-1932 periods. It has been the site of at least 6 of 21 historic earthquakes which have produced surface faulting during the period 1932 to the present. Although the heavier concentration of population in cities and towns located on or near the Walker Lane tends to bias felt reports toward this region, the concentration in the zone, both of very large earthquakes and instrumentally-determined epicenters, indicates that earthquake frequency and

strain release are actually quite high in this region (see also Niazi, 1964). Although few fault-plane solutions are available for earthquakes in this region, the data from the Fairview Peak and Fallon-Stillwater earthquakes of 1954, and the direction of horizontal components of offset during the Cedar Mountain earthquake of 1932 and the Excelsior Mountain earthquake of 1934, indicate that many earthquakes in this zone have major strike-slip components of displacement that are right-lateral (dextral) on northerly to northwesterly trending faults and left-lateral (sinistral) on northerly to northeasterly trending faults. The southeastern part of the zone between Goldfield and Las Vegas has a much lower intensity of activity, which indicates that recent tectonic activity there is mainly in the western part of this zone on the Sierra Nevada fault zone, and the Fish Lake Valley-Furnace Creek-Death Valley fault zones. Most of this area of activity is well within California and is not shown on this epicenter map of Nevada (see Calif. Dept. of Water Resources, 1964). This zone contains most of the Pleistocene volcanics of the region (note, for example, the Nevada distribution of cinder cones (Horton), 1964).

(2) The 118° Meridian Seismic Zone: This zone of activity includes the Owens Valley-Sierra Nevada fault zone (with surface faulting in 1872), and the Excelsior Mountain zone of 1934, the Cedar Mountain zone of 1932, the two Rainbow Mountain fault zones of 1954, the Fairview Peak and Dixie Valley earthquakes of 1954, the Wonder earthquake of 1903, and the Pleasant Valley zones of 1915. This zone is marked by strong strike-slip components of faulting at and near the Walker Lane and mainly normal faulting with subordinate strike-slip faulting at the north end of the zone. It includes 9 of 21 examples of historic surface faulting in the conterminous United States and must be ranked as one of the country's most active seismic zones.

This zone, at least in part, follows the boundary between Sierra Nevada type granitic basement terrains to the west and the mainly metamorphic terrains

to the east. In the Walker Lane area it is related to a marked thickening of the earth's crust which extends westward toward the Sierra Nevada. It is also near zones of intense mercury (Lawrence and Wilson, 1962) and antimony (Lawrence, 1962) mineralization. This suggests that the high level of seismic activity may be part of a long-term crustal instability that also influenced the distribution of the geologically-young mercury and antimony mineralization.

(3) The Southern Nevada Transverse Zone: This zone crosses southern Nevada on a structural line that begins on trend with the Garlock fault zone and curves northeastward to connect with the active earthquake belt in central Utah. This zone is of lower seismic intensity, except for a region near Lake Mead which became seismically active after reservoir loading commenced in 1936. Geologically, there is evidence for strong strike-slip components that are similar to the left-lateral faulting of the Garlock zone in east-west trending zones and right-lateral along trends parallel to the Walker Lane.

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DESTRUCTIVE AND NEAR-DESTRUCTIVE EARTHQUAKES WITH NEVADA EPICENTERS

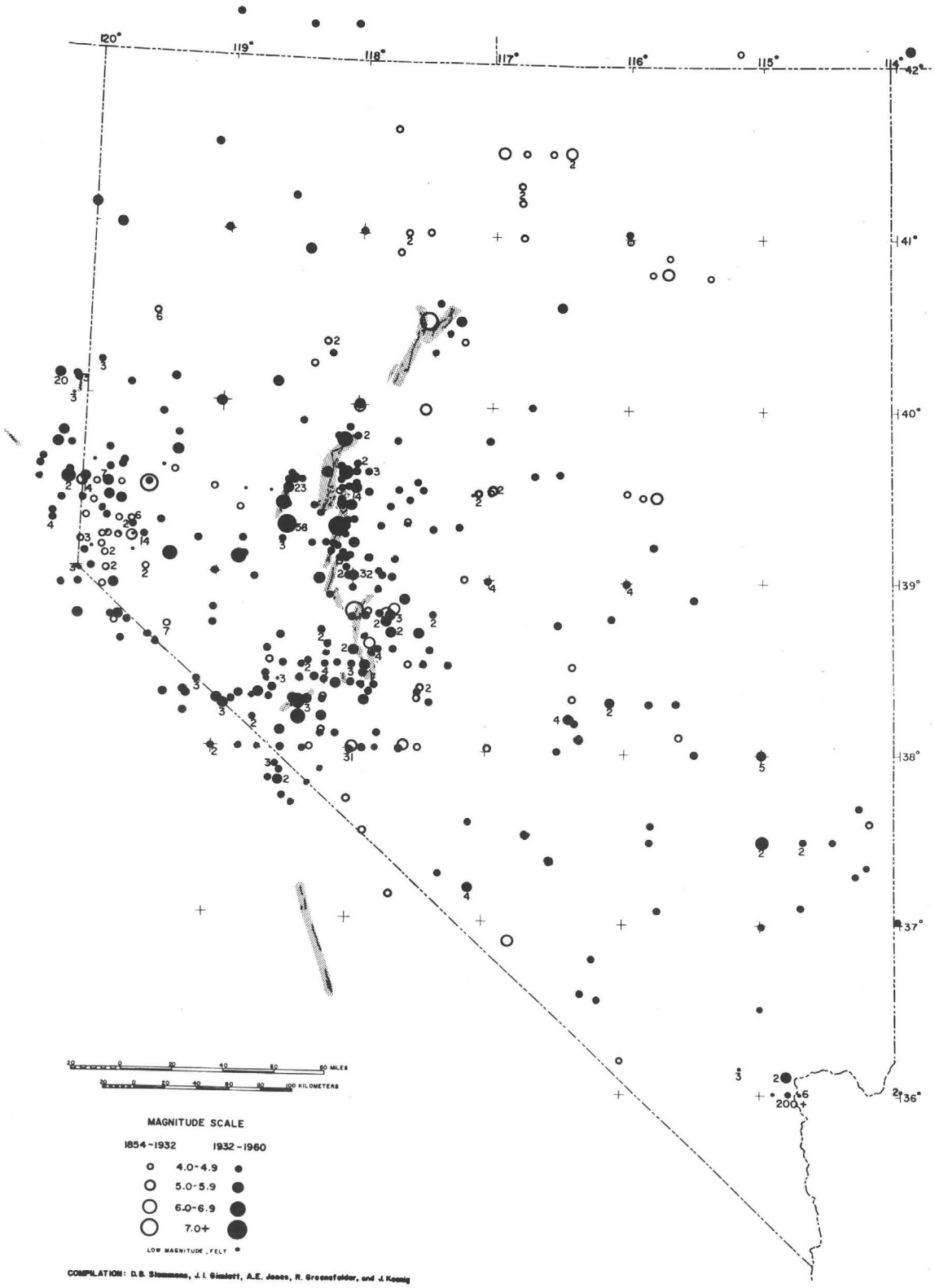
Date Year-Mo-Day	P.S.T. Hr-Min-Sec	N Lat	W Long	Mag	Remarks
1852		39.5	119.5		Paiutes report quake near Pyramid Lake 13 years ago. Great cracks opened from which water spouted 100 feet high. Large landslide on Slide Mountain.
1860-03-15	10:45:			7.	Widely felt from California (Sacramento-Yreka) to Utah. Very violent in Carson City. First known event in Virginia City. Felt area over 250,000 sq. mi.
1868-05-29	21:11:	39.5	120.	6.	Maximum intensity of VII in Virginia City area. Several aftershocks. Felt area of at least 40,000 sq. mi. Double shock.
1869-12-26	17:30:	39.5	120.		Maximum intensity of IX. Three shocks at Gold Hill. N-S motion felt underground in Virginia City mines. Brick buildings damaged. Felt in Camptonville, Sacramento, Stockton, Chico, Truckee. Buildings damaged in Downieville, California. 26 aftershocks felt at Virginia City.
1869-12-26	21:50:	39.5	120.		Maximum intensity of VII. 3 aftershocks of 12-26. E-W motion at Gold Hill. Felt at Nevada City, Calif. Not as strong as main shock. Epicenter may be in California.
1869-12-27	01:40:	39.5	120.		Maximum intensity of VIII. Aftershock of 12-26. E-W motion at Gold Hill, Nevada. Strong at Marysville, California. Epicenter may be to NW of 12-26.
1872-03-23	13:41:	40.0	117.5	5.5	Maximum intensity of VII at Austin. Felt in Unionville & Winnemucca. Violent shock at Austin, E to W motion. Shook brick walls, part of plaster in courthouse fell. Felt area over 12,000 sq. mi.
1872-11-12				6.	Light at Stockton, California & sharp at Austin. Felt area over 50,000 sq. mi.
1873-11-05	09:00:	40.0	118.	5.5	Heavy at Unionville, 4 shocks at Virginia City. 8 shocks in 2 days at Carson Sink. Waters agitated. Felt area over 10,000 sq. mi.

1875-04-01	18:00:	39.5	115.8		Maximum intensity of VII at Eureka. Shock of 3-6 sec. Frightened many. Buildings seriously damaged, E-W motion, Eureka.
1887-06-03	02:48:	39.2	119.8		Maximum intensity of VII in Carson City, very severe for 6 or 7 sec, rotary motion, noise like thunder before shock. Stone and brick walls cracked.
1894-11-18	02:49:	39.2	119.5		VII at Virginia City with cracked plaster, some damaged walls and many broken windows. N-S motion. III at Carson City, E-W motion. This is probably the main shock. Over 100 shocks were felt in Virginia City within week.
1896-01-27	13:01:	39.1	119.8		VI at Carson City. Mainly vertical with SW to NE, large crack in side of government building and plaster fell in county building, Carson City.
1897-05-15	11:04:	39.3	119.7		Intensity V, severe 3 sec shock in Carson City. NE to SW motion. Plaster broken in many buildings.
1901-07-26	14:20:	40.8	115.7	5.0	Intensity VII in Elko. Series of heavy shocks, N to S vibrations, dishes broken, new brick school and other buildings damaged. At Deeth goods shaken from shelves (V), felt in Carlin. Felt area 3,500 sq. mi.
1903?		39.5	118.1		Wonder, Nevada. Historic faulting on at least 3 miles length along the Gold King fault. Year of earthquake is uncertain.
1910-11-21	15:23:	38.	118.		Intensity VIII. Duration Tonopah Jctn 2 min. Broke windows. Threw watchman's car from track.
1914-02-18	10:17:	39.5	119.8	6.	Intensity VII in Truckee Meadows area 2 distinct shocks lasting from 6 to 30 sec. Cracked buildings. Felt area 50,000 sq. mi. Palisades to Downieville, California, as far S as Tonopah.
1914-04-24	00:34:	39.5	119.8	6.4	Intensity VIII in Reno. Heaviest shock in Reno since 1868 and in U.S. this year. Lasted 10 sec., toppled chimneys. Felt area ca. 100,000 sq. mi. Intensities at Winnemucca, Stockton, Susanville were IV.
1915-10-02	17:49:	40.5	117.5		Intensity VIII in a strong Pleasant Valley foreshock. Felt 200 mi. away in Camptonville, California. Felt 45-50 sec. in Reno - no damage.

1915-10-02	22:53:	40.5	117.5	7.8	Maximum intensity X in Great Pleasant Valley shock. Felt from Wash. to Mexican border & from Pacific Ocean to Mont., Colo., & Ariz., over 500,000 sq. mi. Surface fault up to 15 feet high extending 20 miles along and near foot of Tobin Range. Destructive in sparsely settled country.
1916-02-02	21:03:04	41.	117.8	5.9	Maximum intensity over VI. Origin probably somewhat N of Pleasant Valley quake. Felt in Gerlach (VI), Rebel Creek (IV to V), Fallon (III), Amos & Winnemucca (IV). Felt area ca. 30,000 sq. mi.
1916-08-03	05:50:	41.5	116.5	5.6	Intensity over IV. Felt Elko, Winnemucca, lasted 12 seconds.
1916-08-03	06:21:	41.5	116.5	5.8	Intensity over III. Northern Nevada reported from Winnemucca, McDermitt & Rebel Creek.
1916-11-10	01:11:	35.5	116.0	6.1	Intensity over V. Southern Nevada. May have originated east of Death Valley.
1932-12-20	22:10:04	38.80	117.98	7.2	Maximum intensity X in western Nevada in Basin between Gabbs Valley Range and Pilot Mountains on west and Paradise Range and Cedar Mountain on east. Major event. Recorded 2,000 aftershocks, accompanied by formation of a group of tension faults or rifts in the epicentral area 38 miles long by 4-9 miles wide. Felt in Reno.
1933-01-04	22:51:	38.77	117.74	5.9	Intensity IV. Felt Mina, Potts & Wabuska. Aftershock of 12-21.
1933-02-13	14:09:	38.	118.	5.5	Intensity IV at Benton, III at Reno, Mina & Austin, Nevada.
1933-06-25	12:45:	39.1	119.3	6.0	Intensity VII near Wabuska & Yerington. Felt area 40,000 sq. mi., including Sacramento, Stockton, Tahoe City, Reno, Fallon.
1934-01-30	11:24:	38.3	118.4	5.6	Intensity VII at Mina. Strong foreshock of later one same day; did slight damage - cracked plaster & courthouse wall. Slighter foreshock 6 min. later felt at Fallon, Hawthorne, Ione. One 16 minutes later.
1934-01-30	12:16:35	38.28	118.37	6.3	Maximum intensity VIII. Severe quake, felt widely over Nevada & parts of Utah and Calif. Damaged several buildings in Mina. Many small aftershocks were felt; fault developed on Excelsior Mtn. up to 3 inches wide; & vertical displacement up to 5 inches on main scarp. Some left lateral displacement.

1934-01-30	12:30:	38.3	118.4	5.7	In Hawthorne. Aftershock of medium intensity. Lasted 15 sec. Not felt at Bishop.
1934-02-09	01:21:	38.3	118.4	5.5	Intensity IV. Epicenter western Nevada.
1939-05-11	10:40:	38.6	117.8	5.5	Maximum intensity of VI in west central Nevada, from Beatty to Lovelock & Reno to Eureka. Felt area 38,000 sq. mi. Two foreshocks 33 min. earlier were felt in Reno.
1942-12-03	01:44:42	39.7	119.3	5.9	Intensity VI at Fernley, Fallon & Reno, where small objects fell. One & one half min. at Fernley. Felt by and awakened many at Minden. Windows rattled. Felt over 24,000 sq. mi.
1943-08-08	21:30:04	38.2	118.2	5.5	Maximum intensity VI. Felt over an area of 34,000 sq. mi. in east-central Calif. & western Nevada. 4 large aftershocks.
1948-12-29	04:53:27	39.5	120.1	6.0	Maximum intensity VII at Verdi. Strong quake affected a 40,000 sq. mi. area, with epicenter apparently in Verdi Fault; many were awakened & frightened; the 1st & strongest shock lasted 5 to 20 sec.; damage was minor, except in Verdi--walls, windows, & dishes were cracked & broken here; every one of the town's 75 houses were damaged. Over 200 aftershocks with average magnitude of about 3 were recorded at Reno in the next few weeks.
1950-12-14	05:24:19	40.08	120.07	5.6	Intensity VII at Herlong, Calif. Main shock, felt over an area of 20,000 sq. mi. in NE Calif. and western Nevada. Considerable damage was done at Herlong & Doyle, Calif., and plaster was cracked at Flanigan, Nevada.
1953-09-25	19:34:29	39.53	119.98	5.5	Maximum intensity VI. 8 miles west of Reno. Shock felt over approximately 12,000 sq. mi. of western Nevada & NE California. Minor damage at Reno. Maximum intensity VI at Olinghouse Canyon, Reno & Vista. In Reno at least two chimneys toppled, dishes rattled, chandeliers swung. Near Vista the temblor caused an earthslide partly blocking U.S. Hiway 40.
1954-07-06	03:13:20	39.42	118.53	6.8	Maximum intensity IX E of Fallon. The epicenter was assigned to the main fault zone on the east edge of Rainbow Mt. in the Stillwater Range, 15 miles SE of Fallon. Felt over ca. 130,000 sq. mi. Principal damage was to the canal & drainage system of the Newlands Project--estimated at $200,000. Hiway 50 east of Fallon was cracked & buckled.
1954-07-06	03:49:00	39.42	118.53	5.7	Felt at Fallon.

1954-07-06	14:07:41	39.3	118.5	6.0	Fallon aftershock. Frame store creaked at Baxter, Calif. Aftershock at 15:57:07 felt at Wabuska.
1954-08-31	14:20:32	39.6	118.2	5.8	Intensity VII at Dixie Valley. Felt very strongly in the Stillwater Mtns. In the vicinity of Job Peak.
1954-12-16	03:07:11	39.28	118.12	7.3	Maximum intensity X at Frenchmans Station. Felt over 200,000 sq. mi. Maximum intensity X assigned to surface faulting. 50-foot section of Hiway 50 dropped 5.5 feet E of Frenchmans, 3,000 dollars in store goods lost. Other damage in Fallon, Carson City, Elko, Sacramento, Calif. ca. 50 miles of normal faulting occurred on Fairview Peak, and along the Clan Alpine Range to E. Displacements were mainly vertical, maximum exceeded 20 feet with the mountain rising relative to the valley.
1954-12-16	03:11:34	39.8	118.1	6.9	Maximum intensity X in Dixie Valley.
1954-12-16	06:16:57	39.5	118.0	5.8	Aftershock with surface faulting on W side of Dixie Valley at E side of Stillwater Range.
1954-08-23	21:51:32	39.42	118.53	6.8	VIII. Fallon. Second major Fallon earthquake. Felt over 150,000 sq. mi. Additional vertical surface movement, west side uplifted, occurred in the same rupture zone as July 6, with the extension of breakage 11 miles to the North. Rogers Dam was considerably damaged. Instances of more severe damage than with main shock.
1959-03-22	23:10:20	39.60	118.07	6.3	Intensity VI in Dixie Valley. Slight plaster cracks reported at Frenchmans Station and Carson City. Reports from Dixie Valley indicate shock had rolling motion and was not too strong. Felt over an area of ca. 50,000 sq. mi.
1959-04-01	10:18:28	39.7	120.2	5.8	Intensity VII Doyle, Calif. Felt from Reno to San Francisco. Damage amounted to $5,000 at Loyalton, where chimneys toppled, merchandise was knocked from shelves, windows cracked; an old stone building near Vinton collapsed; a crack appeared in Sacramento City Hall.
1959-06-23	06:35:02	39.08	118.82	6.3	Intensity VI at Schurz. Main shock of series. One foreshock and 2 aftershocks. Felt over ca. 35,000 sq. mi., including Reno, Fallon, Lovelock, Carson City, and Hawthorne in Nevada; felt in Turlock, Calif. Principal effects in Schurz, where a road embankment cracked.



COMPILATION: D.B. Slemmons, J.I. Gimlett, A.E. Jones, R. Greensfelder, and J. Koenig

Research supported by grant no. AF-AFOSR-62-285 of the Air Force Office of Scientific Research

INTRODUCTION

Nevada earthquake epicenters for the period from about 1852 to 1961 are plotted on the accompanying map. During this period 1,173 earthquakes with Nevada epicenters were felt, 586 others with Richter magnitudes above 4.0 were recorded and were probably felt by some residents, and approximately 220 were reported in non-specific terms (e.g. "several aftershocks were felt"). High seismicity of this region is indicated by the fact that on an equal-area basis, during the period 1934-1960, Nevada had the highest incidence of earthquakes of any of the conterminous United States.

This research was supported by Grant No. AF-AFOSR-62-285 of the Air Force Office of Scientific Research as part of the Advanced Research Project Agency's Vela Uniform Project, and by the G. K. Gilbert Award of the Carnegie Institution of Washington.

Data for this epicenter map is condensed from Slemmons, Jones, and Gimlett (1965).

TERMINOLOGY

Epicenter: The point on the earth's surface directly above the focus or origin of an earthquake. Accurate determination of an earthquake epicenter depends both on the number of seismographic stations which are located within the epicentral region, and on the accuracy of knowledge of the structure of the earth's crust in the same region. For larger earthquakes, it is possible to determine an approximate epicenter by outlining areas of greatest damage or areas where the earthquake was most strongly felt. Most of the epicenters plotted on this map have possible location errors of 5 to 15 miles; for this reason, epicenters for adjoining states are shown on the map only if they are within 20 miles of the Nevada boundary.

Intensity: A number assigned to each place where an earthquake is reported felt or does damage. The intensity at any point is indicative of the way in which the earthquake was felt, of the amount of damage it did to man-made structures, or of geological effects (e.g. surface faulting, landsliding) of the earthquake at that location. The most widely used scale is the Modified Mercalli scale, 1956 version, which is given below.

Richter magnitude: a measure of the amount of energy released during an earthquake; it is normally calculated from measurements on recordings made with calibrated seismographs. The greatest magnitude for any recorded earthquake is just under 9; the greatest for any Nevada epicenter is 7.75 for the 1916 Pleasant Valley earthquake. Earthquakes with magnitudes above about 5 or 5.5 are potentially destructive at the epicenter.

MODIFIED MERCALLI INTENSITY SCALE OF 1931, REVISED 1956 VERSION

I. Not felt. Marginal and long-period effects of large earthquakes.

II. Felt by persons at rest, on upper floors, or favorably placed.

III. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.

IV. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV, wooden walls and frame creak.

V. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., fall off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and weak masonry and adobe cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle).

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to weak masonry and adobe, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry of ordinary quality. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

VIII. Steering of motor cars affected. Damage to masonry of ordinary quality, some damage to good masonry not designed to resist lateral forces, but none to well-constructed masonry designed to resist lateral forces. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

IX. General panic. Weak masonry destroyed; masonry of ordinary quality heavily damaged, sometimes with complete collapse; good masonry, not designed to withstand lateral forces seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames cracked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.

X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown out on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

XI. Rails bent greatly. Underground pipeline completely out of service.

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

EPICENTRAL DISTRIBUTION

On this map, epicenters are divided into two groups -- pre-1932, and 1932 to the present -- in order to distinguish between early historic events with poor epicentral locations, and modern events with better epicenters based on instrumental information. A search of the data for periodicity or sequential relationships of activity within the province or with respect to adjoining provinces, has not revealed any conclusive trends of earthquake strain release in space or time, other than a distinct, but statistically inadequate tendency for a 20-year cycle of activity, with peaks at about 1852?, 1872, 1894, 1916, 1932-33, and 1954 (Slemmons, Jones and Gimlett, 1965).

Felt reports are naturally biased toward population centers. Except for Las Vegas, most of the larger towns (and even the old mining camps) are in western Nevada. Until recently most of the seismographic stations in the area have been on the west side of the State. During the late 1880's and early 1890's the Weather Bureau operated a pendulum seismograph in Carson City. The epicenters are biased toward Carson City for this period. Because of the Wiechert seismograph at the University of Nevada, epicenters are strongly slanted toward Reno for the period 1916-1932. A very large number of small events were felt and recorded at Boulder City during the late 30's and early 40's. Earthquakes began to be felt near Boulder City after Lake Mead had first filled to an elevation of 1,025 feet above sea level from a Colorado River level of 650 feet (Jones, 1944), and this activity has continued into the 1950's.

It is quite obvious that this map cannot be complete. However, it is believed that no events of magnitudes over 6.0 have been missed since approximately 1860. The epicenters include all known events with felt reports, and all instrumentally-determined events over 4.0 magnitude.

The general pattern for both periods of time is similar, with the exception of new, unusual activity near Lake Mead following the reservoir loading in 1936. The earlier events have a more rectilinear, grid-like distribution, due to epicenter locations which were rounded-off to nearest degree, half-degree, or quarter-degree. The distribution of epicenters is very uneven with a strong tendency for most of the activity to be in belts or areas of high activity with larger, intervening areas of weak seismic activity. The largest area of low earthquake activity is in eastern Nevada and western Utah. There is an anomalous relationship for parts of this area, for many fresh-appearing geologically young faults and steep and rugged fault-block mountain ranges are present in this region. Evidently, the one-hundred year period of earthquake observation is statistically a very poor sample of the longer-term seismic activity of this region.

The epicenter map for Nevada shows a strong concentration of activity into the following three seismic zones, the first two of which cross each other in the Cedar Mountain—Excelsior Mountain area:

(1) Western Nevada-Eastern California Seismic Zone: This is a broad zone, about 50 to 100 miles wide, bounded on the west by the Sierra Nevada and on the east by faults at the eastern edge of the Walker Lane. The zone is structurally relatively narrow at the northern end near Reno, and broadens southward into two main sub-parallel structural branches, the Fish Lake Valley—Furnace Creek—Death Valley fault systems, and the Walker Lane (The Pyramid Lake—Walker Lake—Las Vegas Valley alignment). The zone has been especially active during the entire period for which records are available, and has been the site of at least 6 of 21 historic earthquakes which have produced surface faulting in the period from 1932 to the present. Although the heavier concentration of population in cities and towns located on or near the Walker Lane tends to bias felt reports toward this region, the concentration in the zone, both of very large earthquakes and instrumentally-determined epicenters, indicates that earthquake frequency and strain release are actually quite high in this region (see also Niazi, 1964). Although few fault-plane solutions are available for earthquakes in this region, the data from the Fairview Peak and Fallon—Stillwater earthquakes of 1954, and the direction of horizontal components of offset during the Cedar Mountain earthquake of 1932 and the Excelsior Mountain earthquake of 1934, indicate that many earthquakes in the zone have major strike-slip components of displacement that are right-lateral (dextral) on northerly to northwesterly trending faults, and left-lateral (sinistral) on northerly to northeasterly trending faults. The southeastern part of the zone, between Goldfield and Las Vegas, has a much lower intensity of activity, which indicates that recent tectonic activity there is mainly west of this zone on the Sierra Nevada fault zone, and on the Fish Lake Valley—Furnace Creek—Death Valley fault zones. Most of this area of activity is well within California (see Calif. Dept. of Water Resources, 1964) and is not shown on this map. The area contains most of the Pleistocene volcanics of the region. Note, for example, the Nevada distribution of cinder cones (Horton, 1964).

(2) The 118° Meridian Seismic Zone: This zone of activity includes the Owens Valley—Sierra Nevada fault zone (with surface faulting in 1872), and the Excelsior Mountain zone of 1934, the Cedar Mountain zone of 1932, the two Rainbow Mountain fault zones of 1954, the Fairview Peak and Dixie Valley earthquakes of 1954, the Wonder earthquake of 1903, and the Pleasant Valley zones of 1915. This zone is marked by strong strike-slip components of faulting at and near the Walker Lane, and mainly by normal faulting with subordinate strike-slip faulting at the north end of the zone. It includes 9 of 21 examples of historic surface faulting in the conterminous United States, and must be ranked as one of the country's most active seismic zones.

This zone, at least in part, follows the boundary between Sierra Nevada type granitic basement terrains to the west, and the mainly metamorphic terrains to the east. In the Walker Lane area it is related to a marked thickening of the earth's crust which extends westward toward the Sierra Nevada. It is also close to zones of intense mercury (Lawrence and Wilson, 1962) and antimony (Lawrence, 1962) mineralization. This suggests that the high level of seismic activity may be part of a long-term crustal instability that also influenced the distribution of the geologically-young mercury and antimony mineralization.

(3) The Southern Nevada Transverse Zone: This zone crosses southern Nevada on a structural line that begins on trend with the Garlock fault zone in the west, and curves northeastward to connect with the active earthquake belt in central Utah. This zone is of lower seismic intensity, except for a region near Lake Mead which became seismically active after reservoir loading commenced in 1936. Geologically, there is evidence for strong strike-slip components in east-west trending zones that are similar to the left-lateral faulting of the Garlock zone, and for right-lateral faulting along trends parallel to the Walker Lane.

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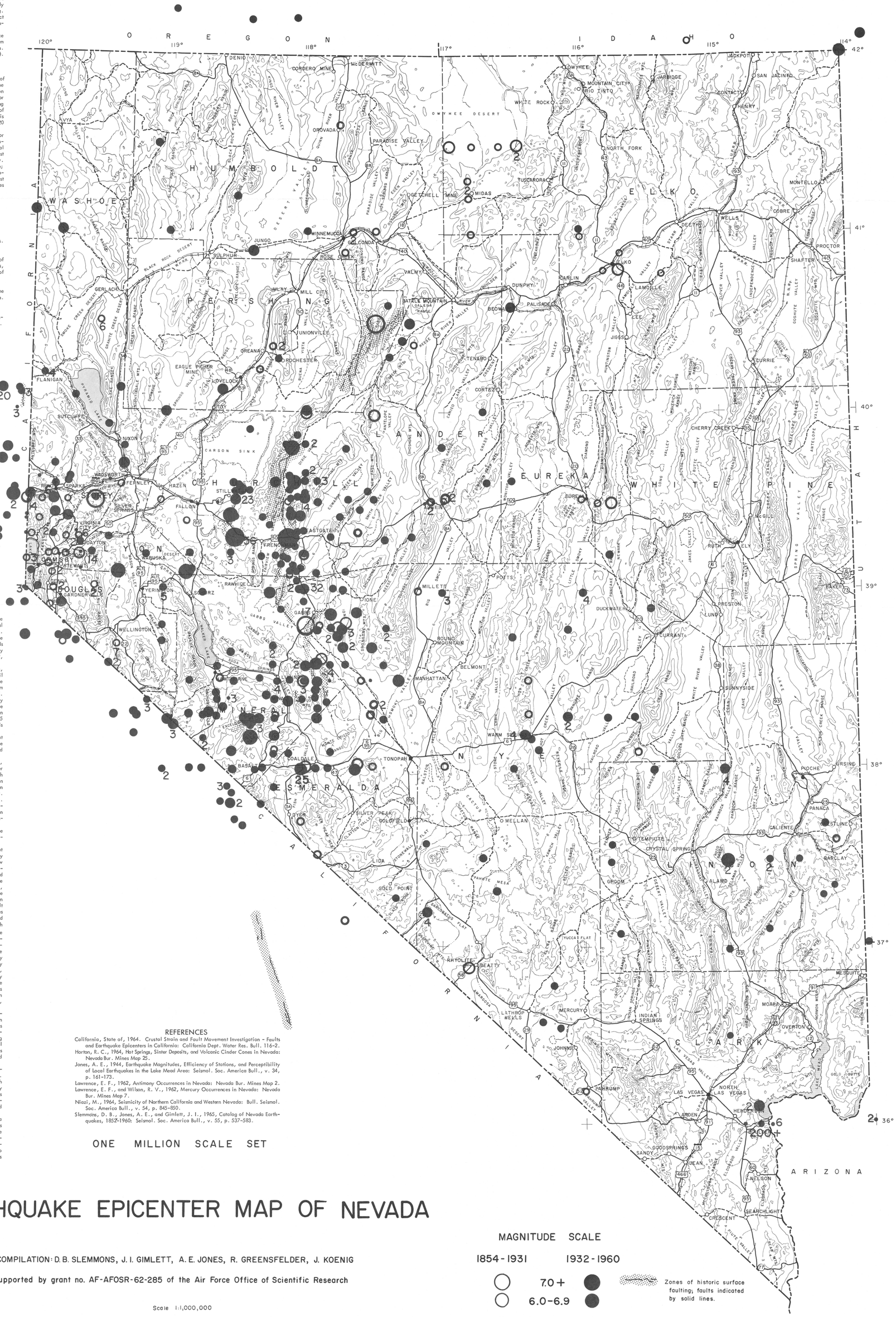
ONE MILLION SCALE SET



DESTRUCTIVE AND NEAR-DESTRUCTIVE EARTHQUAKES WITH NEVADA EPICENTERS

Date Year-Mo-Day	Time (P.S.T.) Hr-Min-Sec	Lat. N	Long. W	Mag.	REMARKS
1852		39.5	119.5		Paiute Indians report earthquake near Pyramid Lake. Great cracks opened from which water spouted 100 feet in air. Large landslide occurred on Slide Mountain in Carson Range.
1860-03-15	10:45:			7.	Widely felt from California (Sacramento-Yreka) to Utah. Very violent in Carson City. First known event in Virginia City. Felt area over 250,000 sq. mi.
1868-05-29	21:11:	39.5	120.	6.	Maximum intensity of VII in Virginia City area. Several aftershocks. Felt area of at least 40,000 sq. mi. Double shock.
1869-12-26	17:30:	39.5	120.		Maximum intensity of IX. Three shocks at Gold Hill. N-S motion felt underground in Virginia City mines. Brick buildings damaged. Felt in Camptonville, Sacramento, Stockton, Chico, and Truckee, Calif. Buildings damaged in Downieville, Calif. 26 aftershocks felt at Virginia City.
1869-12-26	21:50:	39.5	120.		Maximum intensity of VII. Three aftershocks of 12-26 event. E-W motion at Gold Hill. Felt at Nevada City, Calif. Not as strong as main shock. Epicenter may be in California.
1869-12-27	01:40:	39.5	120.		Maximum intensity of VIII. Aftershock of 12-26 event. E-W motion at Gold Hill, Nevada. Strong at Marysville, Calif. Epicenter may be to NW of 12-26 event.
1872-03-23	13:41:	40.0	117.5	5.5	Maximum intensity of VII at Austin. Felt in Unionville & Winnemucca. Violent shock at Austin, E to W motion. Shook brick walls; some plaster in courthouse fell. Felt area over 12,000 sq. mi.
1872-11-12				6.	Light at Stockton, Calif. and sharp at Austin, Nev. Felt area over 50,000 sq. mi.
1873-11-05	09:00:	40.0	118.	5.5	Heavy at Unionville; four shocks at Virginia City. Eight shocks in 2 days at Carson Sink. Waters agitated. Felt area over 10,000 sq. mi.
1875-04-01	18:00:	39.5	115.8		Maximum intensity of VII at Eureka. Shock of 3-6 sec. duration. Frightened many. Buildings seriously damaged. E-W motion at Eureka.
1887-06-03	02:48:	39.2	119.8		Maximum intensity of VII in Carson City, very severe for 6 or 7 sec. Rotary motion, noise like thunder prior to shock. Stone and brick walls cracked.
1894-11-18	02:49:	39.2	119.5		VII at Virginia City, with cracked plaster, some damaged walls, and many broken windows. N-S motion. III at Carson City. E-W motion. This is probably the main shock. Over 100 shocks were felt in Virginia City within a week.
1896-01-27	13:01:	39.1	119.8		VI at Carson City. Mainly vertical, with SW to NE component. Large crack in side of government building, and plaster fell in county building, Carson City.
1897-05-15	11:04:	39.3	119.7		Intensity V, severe 3-sec. shock in Carson City. NE to SW motion. Plaster broken in many buildings.
1901-07-26	14:20:	40.8	115.7	5.0	Intensity VII in Elko. Series of heavy shocks, N to S vibrations, dishes broken, new brick school and other buildings damaged. At Deeth, goods shaken from shelves (V). Felt in Carlin. Felt area 3,500 sq. mi.
1903?		39.5	118.1		Wonder, Nevada. Historic faulting over a distance of at least 3 miles along the Gold King fault. Year of earthquake is uncertain.
1910-11-21	15:23:	38.	118.		Intensity VIII. Duration of 2 min. at Tonopah Junction. Broke windows. Threw watchman's car from track.
1914-02-18	10:17:	39.5	119.8	6.	Intensity VII in Truckee Meadows area. Two distinct shocks lasting from 6 to 30 sec. Cracked buildings. Felt area 50,000 sq. mi. Palisades, Nev. to Downieville, Calif., and as far south as Tonopah.
1914-04-24	00:34:	39.5	119.8	6.4	Intensity VIII in Reno. Heaviest shock in Reno since 1868, and in U.S. this year. Lasted 10 sec., toppled chimneys. Felt area about 100,000 sq. mi. Intensities at Winnemucca and at Stockton and Susanville, Calif. were IV.
1915-10-02	17:49:	40.5	117.5		Intensity VIII in a strong Pleasant Valley foreshock. Felt 200 mi. away in Camptonville, Calif. Felt 45-50 sec. in Reno — no damage.
1915-10-02	22:53:	40.5	117.5	7.8	Maximum intensity X in great Pleasant Valley shock. Felt from Wash. to Mexican border, and from Pacific Ocean to Mont., Colo., and Ariz. — over 500,000 sq. mi. Surface fault up to 15 feet high extending for 20 miles along and near foot of Tobin Range. Destructive in sparsely settled country.
1916-02-02	21:03:04	41.	117.8	5.9	Maximum intensity over VI. Origin probably somewhat N of Pleasant Valley quake. Felt in Gerlach (VI), Rebel Creek (IV to V), Fallon (III), Amos and Winnemucca (IV). Felt area about 30,000 sq. mi.
1916-08-03	05:50:	41.5	116.5	5.6	Intensity over IV. Felt in Elko and Winnemucca; lasted 12 seconds.
1916-08-03	06:21:	41.5	116.5	5.8	Intensity over III. Northern Nevada. Reported from Winnemucca, McDermitt, and Rebel Creek.
1916-11-10	01:11:	35.5	116.0	6.1	Intensity over V. Southern Nevada. May have originated east of Death Valley.
1932-12-20	22:10:04	38.80	117.98	7.2	Maximum intensity X in western Nevada, in Basin between Gabbs Valley Range and Pilot Mountains on west and Paradise Range and Cedar Mountain on east. Major event. Recorded 2,000 aftershocks, accompanied by formation of a group of tension faults or rifts in the epicentral area 38 miles long by 4-9 miles wide. Felt in Reno.
1933-01-04	22:51:	38.77	117.74	5.9	Intensity IV. Felt in Mina, Potts, and Wabuska. Aftershock of 12-20 event.
1933-02-13	14:09:	38.	118.	5.5	Intensity IV at Benton, III at Reno, Mina, and Austin.
1933-06-25	12:45:	39.1	119.3	6.0	Intensity VII near Wabuska and Yerington. Felt area 40,000 sq. mi., including Sacramento, Stockton, Tahoe City, Reno, Fallon.
1934-01-30	11:24:	38.3	118.4	5.6	Intensity VII at Mina. Strong foreshock of later one same day; did slight damage — cracked plaster and courthouse wall. Slighter foreshock 6 min. later felt at Fallon, Hawthorne, Ione. One shock 16 min. later.
1934-01-30	12:16:35	38.28	118.37	6.3	Maximum intensity VIII. Severe quake, felt widely over Nevada, and parts of Utah and Calif. Damaged several buildings in Mina. Many small aftershocks were felt. Fault developed on Excelsior Mtn. up to 3 inches wide, and with vertical displacement of up to 5 inches on main scarp. Some left-lateral displacement.
1934-01-30	12:30:	38.3	118.4	5.7	In Hawthorne. Aftershock of medium intensity. Lasted 15 sec. Not felt at Bishop.
1934-02-09	01:21:	38.3	118.4	5.5	Intensity IV. Epicenter in western Nevada.
1939-05-11	10:40:	38.6	117.8	5.5	Maximum intensity of VI in west-central Nevada, from Beatty to Lovelock, and Jeno to Eureka. Felt area 38,000 sq. mi. Two foreshocks 33 min. earlier were felt in Reno.
1942-12-03	01:44:42	39.7	119.3	5.9	Intensity VI at Fernley, Fallon, and Reno, where small objects fell. Duration 1½ min. at Fernley. Felt by and awakened many at Minden. Windows rattled. Felt over 24,000 sq. mi.
1943-08-08	21:30:04	38.2	118.2	5.5	Maximum intensity VI. Felt over an area of 34,000 sq. mi. in east-central Calif. and western Nevada. Four large aftershocks.
1948-12-29	04:53:27	39.5	120.1	6.0	Maximum intensity VII at Verdi. Strong quake affected a 40,000 sq. mi. area, with epicenter apparently in Verdi Fault; many were awakened and frightened; the first and strongest shock lasted 5 to 20 sec. Damage was minor, except in Verdi, where walls, windows, and dishes were cracked and broken. Town's 75 houses all damaged. Over 200 aftershocks with average magnitude of about 3 were recorded at Reno in the next few weeks.
1950-12-14	05:24:19	40.08	120.07	5.6	Intensity VII at Herlong, Calif. Main shock, felt over an area of 20,000 sq. mi. in northeast Calif. and western Nevada. Considerable damage was done at Herlong and Doyle, Calif., and plaster was cracked at Flanigan, Nev.
1953-09-25	19:34:29	39.53	119.98	5.5	Maximum intensity VI. 8 miles west of Reno. Shock felt over approximately 12,000 sq. mi. of western Nevada and northeast California. Minor damage at Reno. Maximum intensity VI at Olinghouse Canyon, Reno, and Vista. In Reno at least two chimneys toppled, dishes rattled, chandeliers swung. Near Vista the temblor caused an earthslide partly blocking U.S. Highway 40.
1954-07-06	03:13:20	39.42	118.53	6.8	Maximum intensity IX E. of Fallon. Epicenter was assigned to the main fault zone on the east edge of Rainbow Mt. in the Stillwater Range, 15 miles SE of Fallon. Felt over about 130,000 sq. mi. Principal damage was to the canal and drainage system of the Newlands Project — estimated at $200,000. Highway 50 east of Fallon was cracked and buckled.
1954-07-06	03:49:00	39.42	118.53	5.7	Felt at Fallon.
1954-07-06	14:07:41	39.3	118.5	6.0	Fallon aftershock. Frame store creaked at Baxter, Calif. Aftershock at 15:57:07 felt at Wabuska.
1954-08-23	21:51:32	39.42	118.53	6.8	VIII. Fallon. Second major Fallon earthquake. Felt over 150,000 sq. mi. Additional vertical surface movement, west side uplifted, occurred in the same rupture zone as July 6 event, with the extension of breakage 11 miles to the North. Rogers Dam was considerably damaged. Instances of more severe damage than with main shock.
1954-08-31	14:20:32	39.6	118.2	5.8	Intensity VII at Dixie Valley. Felt very strongly in the Stillwater Mtns. Epicenter vicinity of Job Peak.
1954-12-16	03:07:11	39.28	118.12	7.3	Maximum intensity X at Frenchman Station. Felt over area of 200,000 sq. mi. Maximum intensity X assigned to surface faulting. 50-foot section of Highway 50 E of Frenchmans dropped 5.5 feet; $3,000 in store goods lost. Other damage in Fallon, Carson City, Elko, and in Sacramento, Calif. About 50 miles of normal faulting occurred on Fairview Peak, and along the Clan Alpine Range to E. Displacements were mainly vertical; maximum exceeded 20 feet, with the mountain rising relative to the valley.
1954-12-16	03:11:34	39.8	118.1	6.9	Maximum intensity X in Dixie Valley.
1954-12-16	06:16:57	39.5	118.0	5.8	Aftershock, with surface faulting on W side of Dixie Valley at E side of Stillwater Range.
1959-03-22	23:10:20	39.60	118.07	6.3	Intensity VI in Dixie Valley. Slight plaster cracks reported at Frenchman Station and Carson City. Reports from Dixie Valley indicate shock had rolling motion and was not too strong. Felt over an area of about 50,000 sq. mi.
1959-04-01	10:18:28	39.7	120.2	5.8	Intensity VII at Doyle, Calif. Felt from Reno to San Francisco. Damage amounted to $5,000 at Loyalton, Calif., where chimneys toppled, merchandise was knocked from shelves, windows cracked. An old stone building near Vinton collapsed; a crack appeared in Sacramento city hall.
1959-06-23	06:35:02	39.08	118.82	6.3	Intensity VI at Schurz. Main shock of series. One foreshock and 2 aftershocks. Felt over about 35,000 sq. mi. area, including Reno, Fallon, Lovelock, Carson City, and Hawthorne, Nev., and Turlock, Calif. Principal effects in Schurz, where a road embankment cracked.

EARTHQUAKE EPICENTER MAP OF NEVADA

COMPILATION: D. B. SLEMMONS, J. I. GIMLETT, A. E. JONES, R. GREENSFELDER, J. KOENIG

Supported by grant no. AF-AFOSR-62-285 of the Air Force Office of Scientific Research

Scale 1:1,000,000

0 10 20 30 40 50 100 Miles

0 10 20 30 40 50 100 Kilometers

Contour Interval 1000 Feet

MAGNITUDE SCALE

1854-1931	1932-1960
	7.0+
	6.0-6.9
	5.0-5.9
	4.0-4.9
Low Magnitude, felt	

Zones of historic surface faulting; faults indicated by solid lines.

NOTE: Figures adjacent to circles indicate the number of events that occurred at those locations.

DECEMBER 1964

Price 75 cents

Nevada Bureau of Mines
University of Nevada
Reno, Nevada

Base from NBM Map 17

PROVISIONAL MAP OF ACTIVE FAULTS OF THE BASIN-AND-RANGE PROVINCE

Edition of May 1964

COMPILATION: David B. Slemmons, James I. Gimlett, Hatti Bishop, Larry Gedney, Roger Greensfelder, Larry Herber, James Koenig, Tony Mindling and John Sales.

NOTES: The current compilation for Nevada and parts of California is based on photogrammetric interpretation, parts of California are from the Geologic Map of California by the California Division of Mines & Geology, and the Utah faults are compiled from the Geologic Map of Utah by L.F. Hintze.

—— Faults in late Quaternary alluvium, playa, Bonneville or Lahantan type lake sediments or glacial deposits.

-------- Frontal faults that do not offset Qal, or are compiled from the literature.