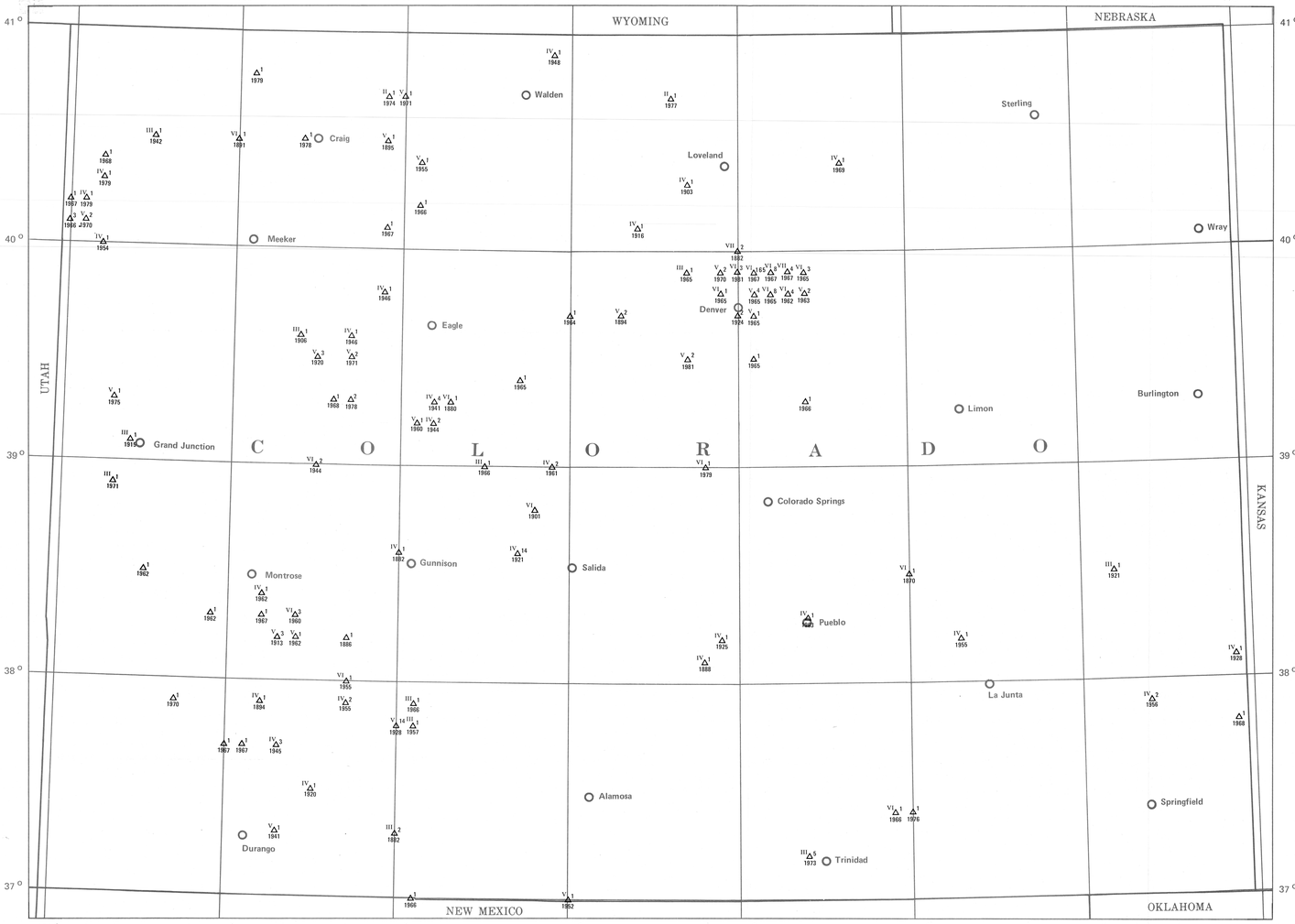

Data compiled in 1983

INTRODUCTION

The data shown on this map and listed in table 1 are for earthquakes that were originally included in a study of seismic risk in the United States (Algermissen, 1969). This data file has been recompiled and updated through 1981. Some revisions of epicenters and intensities in the original file have been made, and intensities have been assigned to earthquakes that previously had none assigned. Only earthquakes that had epicenters within the boundary of the State are listed in table 1, even though earthquakes that had epicenters in bordering states or countries may have been felt or may have caused damage in the State. Intensity values were estimated from data sources that were not available at the time of original compilation. Some epicenters were relocated on the basis of new information. The data shown in table 1 represent best estimates of the epicenter, magnitude, and intensity of each earthquake on the basis of historical and current information. Some of the aftershocks from large earthquakes are listed, but not all, especially for the earthquakes that occurred before seismic instruments were universally used.

Accurate descriptions of the effects of the November 8, 1882, earthquake are very sparse, thus making it difficult to fix the true location. In table 1 we have listed the location near Denver, the location most publications list; however, other possible and equally valid locations should be considered. These include a location somewhere north and west of Denver, possibly the Piceance Basin (40.5°N., 108.0°W.) as suggested in data source no. 283, as well as, the occurrence of two earthquakes, one in the Denver area and another about the same time in the known seismic areas of northern or northeastern Utah. In a general way, each of these locations could fit the distribution of reported effects. If the epicenter was in the Piceance Basin the maximum intensity would be VIII.

The data in table 1 were used to compile the seismicity map. The latitude and longitude coordinates of each epicenter were rounded to the nearest tenth of a degree, and the number of events that had identical locations were counted. The triangles on the map represent epicenters plotted to the nearest tenth of a degree. The number of earthquakes at each location is shown on the map by the number to the right of the triangle. A known numerical error in the magnitude of earthquakes in the Charleston, South Carolina seismic zone (Wood and Neumann, 1931) of all earthquakes at that geographic location. The absence of an intensity value indicates that no intensities have been assigned to earthquakes at that location. The four-digit number shown below each triangle is the latest year for which the maximum intensity was recorded.

EXPLANATION OF THE TABLES

The data are listed chronologically in table 1 in the following categories: date, origin time in Coordinated Universal Time (UTC), N. latitude, W. longitude, depth, hypocenter quality and referenced data sources, magnitude, and intensity (Modified Mercalli) and intensity source referenced to table 2. If no magnitude was recorded in the magnitude column if an earthquake was felt but not enough information was available to assign an intensity. Table 1 has some basic limitations in terms of the size (magnitude or intensity) of the earthquakes listed. All felt earthquakes or those with magnitudes greater than the 2.5-3.0 range are listed. If no magnitude was recorded and the earthquake was felt or an epicenter published it was included in the earthquake list. The low-magnitude events located in recent years with data from dense seismograph networks have not been included.

Listed below is an explanation of the symbols and codes used in table 1:

1. Leaders (..) indicate information not available.
2. Latitude and longitude are listed to a hundredth of a degree if they have been published with that degree of accuracy, or greater; however, most historical events have assigned locations based on felt or damage information and are listed in table 1 only to the nearest degree or tenth of a degree. An asterisk (*) to the right of the longitude indicates that the latitude and longitude were not given in the source reference, but were assigned by the compilers of the data file. An x to the right of the longitude indicates that the event is an explosion, a suspected explosion, a rockburst, or a nontectonic event; these have not been plotted on the map.
3. The letter code in the HYPOCENTER, QUAL column is defined below:
   a. Determinations of instrumental hypocenters are estimated to be accurate within the ranges of latitude and longitude listed below; each range is letter coded as indicated:

      A 0.0°-0.1°
      B 0.1°-0.2°
      C 0.2°-0.5°
      D 0.5°-1.0°
      E 1.0° or larger

   b. Determinations of noninstrumental epicenters from felt data are estimated to be accurate within the ranges of latitude and longitude listed below; each range is letter coded as indicated:

      F 0.0°-0.5°
      G 0.5°-1.0°
      H 1.0°-2.0°
      I 2.0° or larger

4. The reference identification numbers in the HYPOCENTER, REF and INTENSITY, REF columns indicate the sources of the hypocenter and intensity data. They are listed in numerical order in table 2.
5. The magnitudes listed under USGS are mb values (Gutenberg and Richter, 1956) published in the Preliminary Determination of Epicenters (PDE) by the National Earthquake Information Service, U. S. Geological Survey and predecessor organizations. Associated with the magnitude value listed under OTHER are the source code and type. Type is defined by i = MI (Richter, 1958), 2 = mblg (Nuttli, 1973), 3 = MS (Rabb, 1966 or Gutenberg, 1945), 4 = mb (Gutenberg and Richter, 1956), 5 = mblg modified, 6 = duration or coda length, 7 = mNUT (Lawson and others, 1979), 8 = magnitude based on felt areas or attenuation, and 9 = unknown. Magnitudes computed solely from epicentral intensity have not been included. The source codes are listed below:

   BRK - Seismograph Station, University of California, Berkeley, Calif.
   GOL - Geophysical Observatory, Colorado School of Mines, Golden, Colo.
   GS - National Earthquake Information Service (and predecessor organizations), U. S. Geological Survey, Golden, Colo.
   HER - Hermann, R. B., Pets, M. and Wang, C.-Y., 1981, Seismological Society of America Bulletin, v. 71, no. 3, p. 731-745.
   NUT - Nuttli, O. W., Bollinger, G. A., and Griffiths, D. W. 1979, Seismological Society of America Bulletin, v. 69, no. 3, p. 893-909.
   UU - University of Utah, Salt Lake City, Utah.

6. An asterisk (*) in the INTENSITY, MM column indicates that the intensity was assigned by the compiler on the basis of the available data at the time the catalog was compiled.

REFERENCES

Algermissen, S. T., 1969, Seismic risk studies in the United States: Fourth World Conference on Earthquake Engineering, Santiago, Chile, January 13-18, 1969, Proceedings, v. 1, p. 14-27.

Rabb, Marcus, 1966, Earthquake energy and magnitude, in Physics and chemistry of the Earth, v. 7: Oxford and New York, Pergamon Press, p. 115-165.

Gutenberg, Beno, 1945, Amplitudes of surface waves and magnitudes of shallow earthquakes: Seismological Society of America Bulletin, v. 35, no. 1, p. 3-12.

Gutenberg, Beno, and Richter, C. F., 1956, Magnitude and energy of earthquakes: Annali di Geofisica, v. 9, no. 1, p. 1-15.

Lawson, J. E., Jr., Luza, K. V., Dubois, R. L., and Foster, P. R., 1979, Inventory, detection, and catalog of Oklahoma earthquakes: Norman, Oklahoma Geological Survey, text accompanying Map OK-19, 15 p.

Nuttli, O. W., 1973, Seismic wave attenuation and magnitude relations for eastern North America: Journal of Geophysical Research, v. 78, no. 5, p. 876-885.

Richter, C. F., 1958, Elementary seismology: San Francisco, W. H. Freeman and Co., Inc., 768 p.

Wood, H. O., and Neumann, Frank, 1931, Modified Mercalli Intensity Scale of 1931: Seismological Society of America Bulletin, v. 21, no. 4, p. 277-283.

MODIFIED MERCALLI INTENSITY SCALE OF 1931

Adapted from Sieberg's Mercalli-Cancani scale, modified and condensed (Wood and Neumann, 1931)

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, 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 lights 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 clatter. Creaking of walls, frame, especially in the upper range of this grade. Hanging objects swung, in numerous instances. Standing liquids in open vessels slightly. Rocked standing motor cars noticeably.

V. Felt indoors by practically all, outdoors by many or most—direction estimated. Awakened many, or most. Frightened few—slight excitement, a few run 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 pictures swung, often quite 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.

VI. Felt by all, indoors and outdoors. Frightened many, excitement general, some alarm, many run 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.

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

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; three 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 chimneys, columns, monuments, also factory stacks, towers. Moved conspicuously, overturned, very heavy furniture.

IX. Panic general. Cracked ground conspicuously. Damage considerable in (masonry) structures built especially to withstand earthquakes. Three on of plumb some wood-frame houses built especially to withstand earthquakes; great in substantial (masonry) buildings, some collapse in large part; or wholly shifted frame buildings off foundations, racked frames; serious to chimneys, factory stacks, towers, monuments.

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. Water ran banks of canals, lakes, rivers, etc. Damage serious to dams, dikes, embankments. Severe to well-built wooden structures and bridges, some to considerable extent. Developed cracks in excellent brick walls. Destroyed most masonry and frame structures, also their foundations, best 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 amounts centered with sand and mud. Water disturbed to great waves) of significant magnitude. Damage severe to well-built structures, especially near shock centered. 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. Best 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 changed 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.

Table 1.—Chronological listing of earthquakes for the State of Colorado

DATE YEAR	MONTH	DAY	ORIGIN TIME(UTC) H	M	S	LAT. N	LONG. W	DEPTH (KM)	HYPOCENTER QUAL	REF	MAGNITUDE USGS	OTHER	INTENSITY MM	REF
1870	DEC	04	12	00	..	38.5	N. 104.0	W. ..	H	273	..	.. ..	VI	273
1871	NOV	09	17	13	..	39.7	N. 105.7	W. ..	G	273	..	.. ..	IV	273
1880	SEP	17	07	00	..	39.3	N. 106.7	W. ..	G	273	..	.. ..	VI	273
1882	FEB	12	08	30	..	37.3	N. 107.0	W. *	G	271	..	.. ..	V	271
1882	MAY	12	03	..	..	37.3	N. 107.0	W. *	G	271	..	.. ..	III*	271
1882	NOV	08	01	30	..	40.0	N. 105.0	W. ..	I	38	..	.. ..	VII	273
1882	NOV	08	11	45	..	40.0	N. 105.0	W. ..	I	283	..	.. ..	F	283
1882	NOV	10	..	..	..	38.6	N. 107.0	W. ..	H	273	..	.. ..	IV	273
1882	NOV	23	..	..	..	37.7	N. 107.7	W. ..	H	273	..	.. ..	IV	273
1886	JUL	..	..	..	..	38.2	N. 107.3	W. ..	H	273	..	.. ..	F	273
1888	OCT	23	18	40	..	38.1	N. 105.2	W. ..	H	273	..	.. ..	IV	273
1889	JAN	15	..	..	..	39.5	N. 107.3	W. ..	H	273	..	.. ..	V	273
1891	DEC	..	21	..	..	40.5	N. 108.0	W. ..	H	273	..	.. ..	VI	273
1894	JAN	01	10	00	..	37.9	N. 107.8	W. ..	H	296	..	.. ..	IV	296
1894	AUG	05	12	00	..	39.7	N. 105.7	W. ..	H	273	..	.. ..	V	273
1895	MAR	22	..	..	..	40.5	N. 107.1	W. ..	G	273	..	.. ..	V	38
1901	NOV	15	10	00	..	38.8	N. 106.2	W. ..	G	273	..	.. ..	VI	273
1903	SEP	09	..	..	..	40.3	N. 105.2	W. *	G	84	..	.. ..	IV	84
1906	DEC	21	16	10	..	39.6	N. 107.6	W. *	G	58	..	.. ..	III	84
1913	NOV	11	21	55	..	38.2	N. 107.7	W. ..	G	38	..	.. ..	V	38
1913	NOV	11	22	18	..	38.2	N. 107.7	W. ..	G	38	..	.. ..	F	58
1913	NOV	11	23	45	..	38.2	N. 107.7	W. ..	G	38	..	.. ..	F	58
1915	FEB	28	07	51	..	39.1	N. 108.6	W. ..	G	84	..	.. ..	III*	272
1916	OCT	12	03	41	..	40.1	N. 103.6	W. *	G	272	..	.. ..	IV	272
1920	DEC	29	02	50	..	39.4	N. 107.5	W. ..	G	272	..	.. ..	V	272
1920	DEC	29	03	00	..	37.5	N. 107.5	W. *	G	272	..	.. ..	IV	272
1920	DEC	30	09	50	..	39.5	N. 107.5	W. ..	G	272	..	.. ..	V	272
1920	DEC	30	17	50	..	39.5	N. 107.5	W. ..	G	272	..	.. ..	V	272
1921	FEB	06	06	15	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	IV*	272
1921	FEB	06	06	25	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	V*	272
1921	FEB	06	06	30	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	IV*	272
1921	FEB	17	01	45	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	III	272
1921	FEB	17	03	05	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	III	272
1921	FEB	26	15	55	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	III	272
1921	FEB	27	21	00	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	III	272
1921	MAR	04	06	00	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	III	272
1921	MAR	08	19	15	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	IV	272
1921	MAR	09	03	30	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	III	272
1921	MAR	12	07	00	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	III	272
1921	MAR	22	21	45	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	III	272
1921	JUL	27	21	30	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	III*	272
1921	JUL	29	12	30	..	38.6	N. 106.3	W. ..	G	272	..	.. ..	III*	272
1921	OCT	13	02	55	..	38.5	N. 102.8	W. ..	G	272	..	.. ..	III	105
1921	JAN	27	04	00	..	39.7	N. 105.0	W. ..	H	265	..	.. ..	F	265
1924	JAN	04	21	56	30	39.7	N. 105.0	W. ..	H	265	..	.. ..	F	265
1925	FEB	18	20	..	..	38.2	N. 103.1	W. *	G	218	..	.. ..	IV*	218
1928	APR	20	09	40	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	APR	24	10	..	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	APR	29	11	..	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	APR	29	10	20	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	APR	29	10	45	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	APR	29	11	..	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	APR	29	11	30	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	APR	30	15	50	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	V*	1
1928	MAY	01	08	22	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	MAY	01	09	25	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	MAY	01	09	35	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	MAY	01	12	20	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	MAY	03	19	40	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	MAY	04	10	00	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	MAY	10	10	10	..	37.8	N. 107.0	W. ..	G	1	..	.. ..	IV*	1
1928	SEP	29	07	17	..	38.1	N. 102.1	W. ..	G	1	..	.. ..	IV*	1
1940	APR	08	17	00	..	39.3	N. 106.8	W. *	G	13	..	.. ..	III*	13
1941	FEB	13	11	32	30	39.3	N. 106.8	W. ..	G	273	..	.. ..	IV	273
1941	FEB	21	21	22	..	39.3	N. 106.8	W. ..	G	273	..	.. ..	IV*	14
1941	FEB	28	06	19	..	39.3	N. 106.8	W. ..	G	273	..	.. ..	III*	14
1941	AUG	29	11	34	..	37.3	N. 107.7	W. ..	G	273	..	.. ..	V	273
1942	AUG	..	..	..	..	40.5	N. 108.5	W. *	G	331	..	.. ..	III*	331
1944	SEP	09	14	22	20	39.0	N. 107.5	W. ..	G	266	..	.. ..	VI	38
1944	OCT	05	14	05	..	39.2	N. 106.8	W. *	G	17	..	.. ..	IV	259
1945	APR	29	17	08	..	37.7	N. 107.7	W. ..	G	18	..	.. ..	IV	259
1945	APR	29	17	32	..	37.7	N. 107.7	W. *	G	18	..	.. ..	III*	259
1946	JAN	31	22	45	..	39.6	N. 107.3	W. *	G	19	..	.. ..	IV	259
1946	APR	03	02	05	..	39.8	N. 107.1	W. *	G	19	..	.. ..	IV	259
1948	OCT	03	06	30	..	40.9	N. 106.1	W. *	G	21	..	.. ..	IV	259
1952	OCT	07	07	00	..	37.0	N. 106.0	W. ..	G	36	..	.. ..	V	25
1956	FEB	21	20	20	51	40.0	N. 108.75	W. ..	D	27	..	.. ..	IV	27
1955	FEB	10	17	30	..	40.4	N. 106.9	W. ..	G	273	..	.. ..	V	38
1955	AUG	03	06	35	..	37.9	N. 107.3	W. *	F	28	..	.. ..	IV*	28
1955	AUG	03	06	37	..	37.9	N. 107.3	W. *	F	28	..	.. ..	F	28
1955	AUG	03	09	39	42	38.0	N. 107.3	W. ..	F	273	..	.. ..	VI	28
1955	NOV	28	03	25	13	38.2	N. 103.7	W. ..	G	273	..	.. ..	IV	28
1956	JAN	14	18	40	..	37.9	N. 102.6	W. *	F	29	..	.. ..	III*	29
1956	JAN	14	20	30	..	37.9	N. 102.6	W. *	G	273	..	.. ..	III*	29
1957	MAY	03	08	30	..	37.8	N. 106.9	W. *	F	30	..	.. ..	III*	29
1960	OCT	11	08	05	30.5	38.3	N. 107.6	W. .049	C	33	..	5.58RK	4 VI	33
1960	OCT	12	00	30	..	38.3	N. 107.6	W. *	F	33	..	.. ..	IV*	33
1960	OCT	17	16	00	..	39.2	N. 106.9	W. ..	F	34	..	.. ..	V	38
1961	NOV	27	00	55	45.7	39.0	N. 106.1	W. .033	C	266	..	.. ..	IV	34
1961	NOV	27	01	05	..	39.0	N. 106.1	W. *	F	34	..	.. ..	III*	34
1962	JAN	13	13	33	..	38.4	N. 107.8	W. ..	F	273	..	4.4GOL	1 IV	35
1962	JAN	18	01	28	..	39.9	N. 104.9	W. ..	F	105	..	.. ..	IV	105
1962	JAN	18	01	36	..	39.9	N. 104.9	W. ..	F	105	..	.. ..	IV	105
1962	FEB	03	14	45	51.1	38.2	N. 107.6	W. .025	C	266	..	4.7GOL	1 V	35
1962	MAR	05	04	23	06.7	39.2	N. 106.8	W. .025	C	35	..	.. ..