

# Summary of Earthquake Activity in Arizona for 1989

## NORTHERN ARIZONA

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The year 1989 was marked by a sharp increase in earthquake activity. This capped a trend during the last half of the decade towards larger and more frequent events (Figure 1). The number of earthquakes of local magnitude equal to or exceeding 2.0 ( $M_L \geq 2.0$ ) increased nearly 200 percent over that in 1988. Nearly all of the events were concentrated in three areas in the northern part of the State: the Grand Canyon, the Mogollon Plateau, and the Arizona Strip (Figure 2).

The most active of these three areas was the Grand Canyon. A swarm of events was noted in the canyon area in early September 1988; three of these registered  $M_L \geq 3.0$  (Bausch, 1989). Activity subsided until March 5, 1989, when the South Rim was rocked by two  $M_L$  4.0 earthquakes, the largest to occur in Arizona since the  $M_L$  5.0 Chino Valley earthquake of 1976. These two shocks caused only minor damage at Grand Canyon Village, but triggered several rock falls in the canyon and associated earthquake lights (methane gas, or fireballs, expelled near faults, usually during large strike-slip events that fracture the rocks). The maximum intensity of ground shaking reported was VI. During the next week, more than 100 aftershocks were recorded, 15 of which were  $M_L$

$\geq 2.0$ . The rest of 1989 at the South Rim was quiet, except for three earthquakes of  $M_L$  2.9, 2.8, and 2.2 in September, one of  $M_L$  3.0 in November, and one of  $M_L$  2.9 in December (Table 1).

Activity on the Mogollon Plateau southeast of Flagstaff was initiated by an  $M_L$  3.4 earthquake at Chavez Mountain on April 18. Events continued through September 1989, at times in swarms. Two other earthquakes of  $M_L \geq 3.0$  occurred on July 17 and September 6. The latter shock was part of a cluster of five events that day near Sunset Mountain.

Other than the  $M_L$  4.0 events at the canyon, the largest earthquakes in northern Arizona in 1989 occurred in the Arizona Strip northwest of the Grand Canyon. These included one event at Colorado City on February 4 ( $M_L$  3.2), two near Fredonia on September 19 ( $M_L$  3.7) and 21 ( $M_L$  3.3), and one on the Paria Plateau on December 31 ( $M_L$  3.6).

Earthquake activity in Arizona during 1989 occurred in two areas that had previously been noted for their seismicity: the Grand Canyon and Arizona Strip. The extensive seismicity on the Mogollon Plateau, however, was surprising. Historically, this area has been almost completely aseismic; it will certainly bear watching in 1990. To aid observation, the Arizona Earthquake Information Center is installing a permanent seismograph station at Blue Ridge, near the center of the Mogollon Plateau.

## SOUTHERN ARIZONA

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The University of Arizona operates a World Wide Standardized Seismic Network (WWSSN) station, TUC, in the Catalina Mountains. The station's instrumentation consists of six seismographs: three short-period components and three long-period components. The former are run at high magnification (100,000 X) and are extremely effective for monitoring seismic activity within 500 kilometers of Tucson. In cooperation with the Arizona Sonora Desert Museum, the University of Arizona attempts to identify and locate all earthquakes that affect southern Arizona (at latitudes lower than 34° N). TUC can locate earthquakes of  $M_L \geq 2.5$  in Cochise, Graham, Greenlee, Pima, Pinal, and Santa Cruz Counties and events of  $M_L > 3.5$  elsewhere in the State.

The background seismicity level for southern Arizona is quite low, especially compared to California. The two most seismically active regions in southern Arizona are the southeastern corner of the State, extending north from Douglas along the New Mexico border to the Clifton-Morenci area, and the southwestern corner south of Yuma along the Mexico-Arizona border. During a typical year in southeastern Arizona, a single earthquake with  $M_L > 3.0$  will

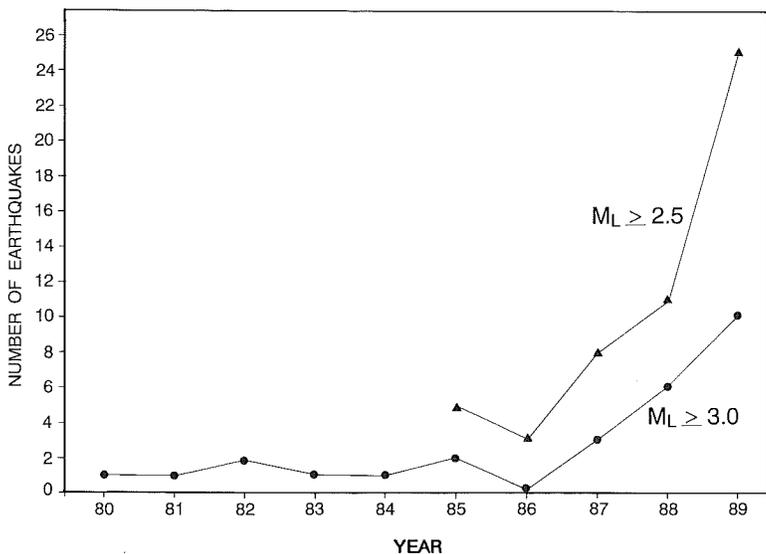
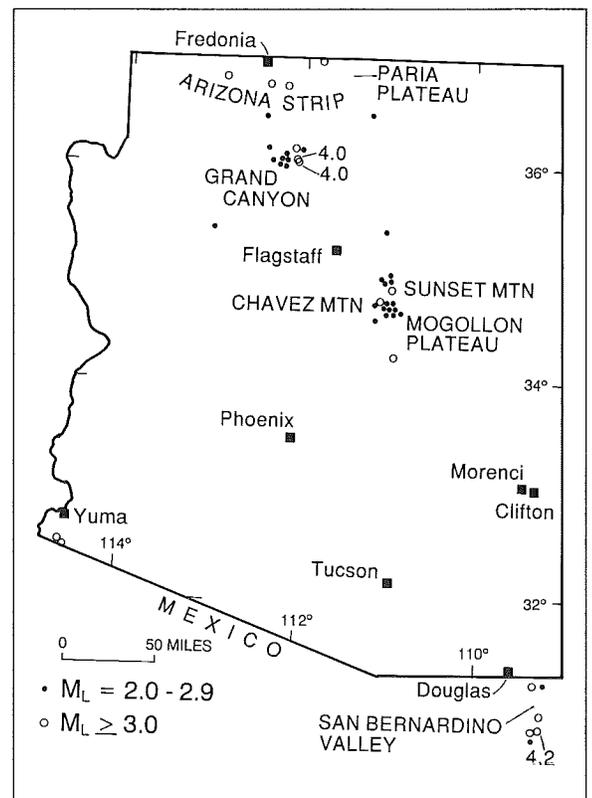


Figure 1 (above). Trend of seismic activity in northern Arizona for 1980-89.  $M_L$  = local magnitude.

Figure 2 (right). Epicenters of earthquakes of  $M_L \geq 2.0$  that occurred in Arizona during 1989. The three earthquakes of  $M_L \geq 4.0$  are identified. See Table 1 for more precise magnitudes of other earthquakes.



occur. In contrast, during one year the Yuma area will be shaken by at least one event with  $M_L > 4.5$ . Most of the seismicity that affects the Yuma region is actually located in California or Mexico and is associated with the southern terminus of the San Andreas system. The seismicity in southeastern Arizona appears to be related to the range fronts of the north- to north-west-trending mountains. The most active regions have been southeast of Douglas in the San Bernardino Valley of Sonora and near Clifton-Morenci.

The earthquake activity in southern Arizona during 1989 was concentrated in the San Bernardino Valley (Figure 2; Table 1). The largest earthquake in this area in 25 years occurred on May 25 ( $M_L$  4.2; the National Earthquake Information Center reported that  $m_b$ , or body-wave magnitude, was 4.6). This earthquake and its aftershocks on May 26 occurred near a major bend in the Pitaycachi fault (see Wallace and Pearthree, 1989). On June 9 and again on December 27, earthquakes occurred at the northern end of the valley near the Arizona-Sonora border. The seismic-energy release for this area during 1989 was extraordinarily high and represents a continuation of activity that began in March 1987 near the fault. This spring, the University of Arizona will install several temporary seismic stations in the southeastern corner of the State to monitor the valley in detail.

Although the Yuma area was shaken by several earthquakes in California and Mexico during 1989, only two were located within the boundaries of Arizona. These events occurred in February in the southwesternmost tip of the State. Both events registered an  $M_L$  of 3.1, but no one reportedly felt the tremors.

#### References

- Bausch, Doug, 1989, Grand Canyon earthquake swarm, September 1988: *Arizona Geology*, v. 19, no. 1, p. 9-10.  
 Wallace, T.C., and Pearthree, P.A., 1989, Recent earthquakes in northern Sonora: *Arizona Geology*, v. 19, no. 3, p. 6-7.

#### Newsletter Links Teachers With Scientists

Earth science teachers in grades K-12 have a new link with scientists who research the topics they teach. The National Center for Earth Science Education of the American Geological Institute (AGI) publishes a quarterly newsletter that describes projects, conferences, seminars, and publications devoted to enhancing the quality of earth science education. Subscriptions to *Earth Science Education Connection* are free from AGI, 4220 King St., Alexandria, VA 22302-1507; tel: (703) 379-2480.

Table 1. Arizona earthquakes ( $M_L \geq 2.0$ ) detected in 1989 by the AEIC network and TUC station.

Date	Latitude <sup>1</sup> (°N)	Longitude <sup>1</sup> (°W)	Depth <sup>2</sup> (km)	Origin Time (UTC) <sup>3</sup>	$M_L$ <sup>4</sup>	Epicenter
2-4	36.80	112.92	5	12:26:58	3.2	Colorado City
2-5	32.490	114.630	2	21:51:12.6	3.2	southwest of Yuma
2-5	32.400	114.610	6	22:05:15.9	3.2	southwest of Yuma
2-16	35.41	113.02	8.9	19:37:00	2.4	Aubrey Valley
3-5	36.02	112.10	10	00:40:32	4.0	Grand Canyon
3-5	95 km from FLAG		--	00:45:??	2.2	Grand Canyon
3-5	36.03	112.07	10	09:17:57	4.0	Grand Canyon
3-5	36.09	112.13	5F	09:35:59	2.1	Grand Cyn. aftershock
3-5	36.04	112.16	5F	14:40:42	2.5	Grand Cyn. aftershock
3-5	36.09	112.23	3F	17:22:10	2.0	Grand Cyn. aftershock
3-5	36.07	112.24	5F	20:51:10	2.2	Grand Cyn. aftershock
3-6	36.04	112.21	13.7	13:09:22	2.1	Grand Cyn. aftershock
3-7	36.03	112.21	13.3	01:59:08	2.2	Grand Cyn. aftershock
3-7	36.03	112.26	14.3	04:08:39	2.3	Grand Cyn. aftershock
3-7	36.04	112.16	7.4	08:24:40	2.5	Grand Cyn. aftershock
3-7	35.98	112.23	13.8	14:14:20	2.4	Grand Cyn. aftershock
3-8	36.15	112.42	16.0	02:51:52	2.3	Grand Cyn. aftershock
3-9	36.00	112.28	11.9	06:44:50	2.1	Grand Cyn. aftershock
3-9	36.05	112.22	12.5	12:16:27	2.7	Grand Cyn. aftershock
3-10	36.06	112.23	14	11:00:44	2.9	Grand Cyn. aftershock
3-10	36.01	112.23	11	15:31:33	2.5	Grand Cyn. aftershock
4-18	34.76	111.10	15.6	10:45:52	3.4	Chavez Mountain
4-26	34.58	111.18	22	23:28:50	2.5	Mogollon Plateau
4-30	34.75	111.05	14.6	16:37:21	2.6	Mogollon Plateau
5-4	34.72	110.95	10	22:46:41	2.4	Mogollon Plateau
5-4	34.70	110.92	20	22:58:07	2.7	Mogollon Plateau
5-8	34.64	111.04	2	03:12:08	2.7	Mogollon Plateau
5-9	34.68	111.08	10	07:55:54	2.0	Mogollon Plateau
5-13	36.50	111.24	9	01:06:47	2.6	Kaibito Plateau
5-14	65 km from FLAG		--	06:10:47	2.0	Chavez Mountain?
5-15	35.37	111.04	10	06:03:37	2.2	Mogollon Plateau
5-18	34.70	111.03	10F	02:35:39	2.5	Mogollon Plateau
5-20	34.68	111.00	9	00:46:42	2.0	Mogollon Plateau
5-20	34.68	110.95	5	01:31:52	2.2	Mogollon Plateau
5-22	34.78	111.02	5.7	14:25:53	2.0	Mogollon Plateau
5-25	30.841	109.332	9	07:43:18.5	4.2	near Colonia Morelos
5-26	30.820	109.382	5	09:08:10.7	3.7	near Colonia Morelos
5-26	30.742	109.401	--	11:52:11.2	2.5	near Colonia Morelos
6-9	31.252	109.271	--	17:03:20.7	2.8	Arizona-Sonora border
6-29	36.44	112.48	10.0	03:09:18	2.4	Steamboat Mountain
7-10	34.94	111.09	18	00:31:53	2.4	Mogollon Plateau
7-17	34.25	110.92	10	20:10:24	3.0	Mogollon Plateau
9-6	34.91	111.17	29	12:30:13	2.0	Sunset Mtn. foreshock
9-6	34.99	111.00	3	12:33:29	2.3	Sunset Mtn. foreshock
9-6	34.87	110.99	20	12:36:55	3.2	Sunset Mtn. main shock
9-6	34.94	111.00	38	14:18:39	2.1	Sunset Mtn. aftershock
9-6	34.98	111.01	2	17:23:21	2.6	Sunset Mtn. aftershock
9-6	36.03	112.37	10F	18:26:52	2.9	Grand Canyon
9-12	36.02	112.29	2	06:46:10	2.2	Grand Canyon
9-15	36.02	112.21	4.5	12:30:57	2.8	Grand Canyon
9-19	36.74	112.23	10F	09:46:01	3.7	Fredonia
9-21	36.77	112.44	5.5	15:38:46	3.3	Fredonia
11-28	36.10	112.20	10F	18:37:32	3.0	Grand Canyon
12-7	36.13	112.03	15F	23:14:04	2.9	Grand Canyon
12-27	31.216	109.381	--	13:18:45.4	3.1	Arizona-Sonora border
12-27	30.967	109.291	7	14:00:16.9	3.1	San Bernardino Valley
12-31	36.98	111.83	10F	09:20:49	3.6	Paria Plateau

- 1 FLAG = Seismic research station at Northern Arizona University, Flagstaff  
 2 F = Fixed  
 3 UTC = Universal Time Coordinated  
 4  $M_L$  = Local magnitude

#### 1989 Earthquake Tally

Although the magnitude 7.1 Loma Prieta earthquake that struck the Santa Cruz area of California on October 17 made Americans especially earthquake sensitive, the world actually had fewer significant earthquakes during 1989 than the average for the past two decades. The 55 significant earthquakes during 1989 were 6 fewer than the total for 1988. The U.S. Geological Survey defines a

significant earthquake as one that registers a magnitude of at least 6.5 or one of lesser magnitude that causes casualties or considerable damage.

In addition, the number (526) of persons who died in 1989 as a result of earthquakes was significantly lower than the number (28,000) who died in 1988 and well below the average of 10,000 deaths per year.