

SUMMARY OF EARTHQUAKE ACTIVITY IN ARIZONA FOR 1990 AND 1991

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Earthquake activity in northern Arizona during 1990 and 1991 mainly occurred in two regions: the Grand Canyon and Mogollon Plateau (Table 1; Figure 1). Several earthquakes had also been recorded in these areas in 1989 (Brumbaugh, 1990).

Earthquake activity in the Grand Canyon area greatly increased in 1988, when a swarm of events shook the South Rim in September. This trend continued in 1989, capped in March by two tremors with a local magnitude (M_L) of 4.0. In 1990 and 1991, the earthquakes at the South Rim were of lower magnitudes: a total of 11 events of M_L 1.8 to 3.0 were recorded.

The largest earthquake in Arizona in 1990 and 1991 was an M_L 4.0 event that occurred in April 1991 at Jacob Lake, approximately 40 kilometers north of the Grand Canyon's North Rim. This earthquake was felt at Fredonia, Kanab, Big Springs, and Jacob Lake. Although Big Springs and Jacob Lake were the communities closest to the epicenter, the highest intensity (V on the Modified Mercalli scale) was felt at Fredonia. Reports of the tremor's effects in Fredonia included windows, doors, and dishes rattling; pictures swinging; and small objects (e.g., dishes) moving. The earthquake appears to be associated with the West Kaibab fault zone. Seismic events in this area have been well documented since 1980 (Kruger-Knuepfer and others, 1985; Bausch and Brumbaugh, 1992).

The Mogollon Plateau had been an area with little historical earthquake activity: only two tremors (M_L 4.0 in 1953 and M_L 4.1 in 1967) had been located in the region before 1989. This changed in April 1989, when an M_L 3.4 earthquake was recorded at Chavez Mountain and was followed that same year by 18 more events on the plateau, two of which were M_L 3.0 to 3.5. Twelve events occurred in this region in 1990 near Sunset Mountain, but no events were detected in 1991. None of the earthquakes on the Mogollon Plateau were reported as being felt.

Other earthquake activity in northern Arizona during 1990 and 1991 included scattered events from the Utah border to the southern part of the Mogollon Rim. There were two events in 1991 (in January and November) in Chino Valley, which is just south of the Mogollon Rim. The second event (M_L 3.5) shook residents in Prescott and Prescott Valley.

Local police and fire departments reported numerous calls about the tremor. Some callers thought they had felt an explosion. The ground shaking was especially noticeable to those on the second and third floors of buildings, such as the Prescott County Annex. The events in this area ended a period of quiescence that followed an M_L 5.1 earthquake in 1976.

The Northern Arizona Seismic Network, operated by the Arizona Earthquake Information Center (AEIC), continued to expand and upgrade during 1990 and 1991. The network grew to seven stations when the newest station at Blue Ridge (BRDG) on the Mogollon Plateau began operating in 1990. The station

at Flagstaff was upgraded in 1991 by conversion to broadband digital recording for its three seismometers. A new seismic alarm system being installed in Flagstaff will notify AEIC personnel whenever a significant earthquake ($M_L \geq 4.0$) occurs in Arizona.

References

- Bausch, D.B., and Brumbaugh, D.S., 1992, Catalogue of historical activity: Arizona Earthquake Information Center Report 92-1, 9 p., 2 sheets, scale 1:3,500,000.
Brumbaugh, D.S., 1990, Summary of earthquake activity in Arizona for 1989: Northern Arizona: Arizona Geology, v. 20, no. 1, p. 6-7.

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Table 1. Arizona earthquakes ($M_L > 1.0$) detected in 1990 and 1991 by the AEIC network.

Date (1990)	Latitude (°N)	Longitude (°W)	Depth (km)	Origin Time	M_L^1	Epicenter
2-25	34.95	111.13	3	17:38:19.5	1.9	Sunset Mtn.
3-1	35.10	111.08	21	2:10:38.7	2.0	Sunset Mtn.
3-1	36.02	112.22	12	20:22:29.5	1.9	Grand Canyon
4-1	35.04	111.04	5	19:58:4.0	1.8	Sunset Mtn.
4-12	34.91	110.99	15	20:15:38.8	2.2	Sunset Mtn.
4-13	35.02	111.10	4	8:54:3.4	1.9	Sunset Mtn.
4-15	36.10	110.99	18	7:25:37.1	1.8	Coal Mine Mesa
4-18	35.08	111.63	18	0:29:29.2	2.2	Coulder Mtn.
4-25	35.02	110.99	3	22:45:29.9	2.1	Sunset Mtn.
5-7	36.06	112.28	14	5:2:59.2	2.2	Grand Canyon
5-7	36.07	112.16	14	6:35:6.7	2.1	Grand Canyon
5-19	35.10	111.13	3	5:5:44.2	1.9	Sunset Mtn.
5-20	34.99	110.98	11	3:1:1.4	2.3	Sunset Mtn.
5-26	36.04	111.99	8	3:46:6.0	1.8	Grand Canyon
5-27	34.99	110.97	2	21:11:36.7	2.4	Sunset Mtn.
5-29	34.90	110.94	14	17:34:53.8	2.6	Sunset Mtn.
6-8	35.49	111.61	11	21:11:53.2	2.3	S P Crater
6-13	35.19	110.98	8	2:0:23.5	2.5	Sunset Mtn.
6-13	34.99	111.07	11	4:59:9.7	2.0	Sunset Mtn.
6-13	36.41	112.54	12	6:46:20.4	2.2	Steamboat Mtn.
6-22	36.05	112.22	2	16:24:57.4	2.2	Grand Canyon
7-18	37.06	113.46	1	1:33:6.7	2.8	west of Fredonia
10-17	36.53	111.13	3	11:48:23.5	2.9	Kaibito Plateau
(1991)						
1-25	34.76	112.17	8	17:9:42.0	1.7	Prescott/Jerome
1-30	35.35	111.72	16	4:11:37.5	1.7	Flagstaff
4-26	36.60	112.40	4	13:8:30.0	4.0	Jacob Lake
5-16	35.97	112.27	22	0:47:13.9	1.8	Grand Canyon
5-25	36.20	112.39	10	20:57:26.9	1.8	Grand Canyon
7-10	36.95	111.59	5	6:14:14.0	3.0	Glen Canyon
8-14	35.94	112.21	20	12:19:50.7	2.9	Grand Canyon
8-14	36.05	112.16	11	19:48:21.7	2.0	Grand Canyon
8-22	36.00	112.13	2	16:41:1.0	3.0	Grand Canyon
11-13	34.60	112.30	5	21:37:26.8	3.5	Prescott Valley

¹ M_L = Local magnitude.

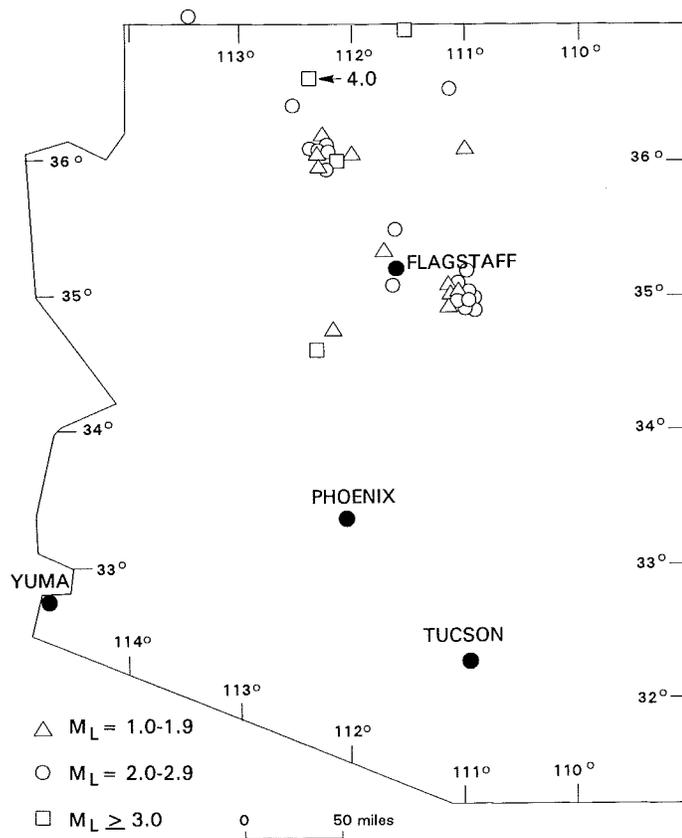


Figure 1. Epicenters of earthquakes of $M_L > 1.0$ that occurred in Arizona during 1990 and 1991. The earthquake of $M_L 4.0$ at Jacob Lake is identified. See Table 1 for more precise magnitudes of these earthquakes.

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would severely restrict all natural-resource development. In December, the bill was passed by the House of Representatives and sent to the Senate. Late in the year, a controversial proposal to ban cyanide heap-leach gold mining in New Mexico was initiated by the State Attorney General and the State Land Commissioner. These officials urged the Governor to take whatever steps possible to prevent such gold-extraction procedures until the State enacts a comprehensive, noncoal-mining law.

The New Mexico Legislature attempted to enact a noncoal-mine reclamation statute through House bill 564. Although generally supported by the minerals industry, the bill failed to pass primarily because some environmental groups opposed parts of the bill that concerned effective dates of regulation and citizen suits. Other citizen-suit bills related to environmental laws also failed to pass. House bill 348, which established a new Environment Department, was passed and signed by the Governor. The director of this agency is appointed by the Governor and serves as a member of the executive cabinet.

The Santa Fe County Board of Commissioners adopted a new mining law that regulates mineral development in the county. The regulations have been described as the most stringent in New Mexico and among the most restrictive in the Nation. The new law established a nine-member Mining Plans Review Board

that will evaluate all applications for mineral exploration and mine operation.

The BOM, in conjunction with the U.S. Geological Survey and the New Mexico Bureau of Mines and Mineral Resources, continued to investigate mineral deposits near the margin of the Great Plains in New Mexico. This investigation was designed to evaluate a variety of mineral deposits, including rare earths associated with alkaline intrusive complexes along the margin. Two other BOM studies that were nearly completed at yearend were a mineral appraisal of the 14.5-million-acre Roswell Resource Area in southeastern New Mexico and a mineral-resource evaluation of the 100,000-acre, Valle Vidal addition to the Carson National Forest in the northern part of the State.

UTAH

Nonfuel mineral production in Utah in 1991 was estimated at \$1.2 billion (Table 1). This amount reflected a decline of about 11 percent from the previous year. The State, however, maintained its ninth-place ranking nationally in the output of nonfuel minerals.

Approximately 81 percent (\$960 million) of the total value of production was attributed to the metals sector, which included copper, gold, iron, magnesium, molybdenum, and silver. Utah mines also produced significant quantities of beryllium, portland cement, magnesium compounds, salt, construction sand and gravel, and vanadium.

Utah ranked third among States in the production of copper, gold, magnesium metal, and iron ore and was the only U.S. source of mined beryllium in 1991. The production of magnesium compounds rose about 28 percent over that of 1990.

Controversy over the cause of salt loss in the Bonneville Salt Flats continued in 1991. Since 1960, the amount of salt in this area has declined by 30 percent; researchers estimate that the annual loss is 1 percent, or 1.6 million short tons. Possible causes include the hydrologic effects of the railroad and I-80 highway and the removal of saline ground water by a nearby mining operation, which recovers potash, magnesium compounds, and salt from ground water through solar evaporation. The BLM is trying to determine how much loss is due to natural causes and how much is due to human activities.

Through Senate bill 34, the Utah Legislature established a new Department of Environmental Quality. The director of the new agency will be appointed by the Governor and serve as a member of the Governor's executive cabinet. Supported by the Governor, the State legislature passed House concurrent resolution 13, which urged Congress to add no more than 1.4 million acres of BLM land in Utah to the National Wilderness Preservation System.

Congressional hearings were held during the year to consider various wilderness proposals. Although the BLM has recommended approximately 2 million acres of its land be designated for wilderness protection, the congressional delegation was not unified in its recommendation. One faction proposed 1.4 million acres be classified as wilderness; another recommended 5.5 million acres.

The BOM continued a study begun in 1988 under the auspices of the Inventory of Land Use Restraints Program (ILURP). The goal of this long-term program is to inventory Federal land-use restrictions to assess the availability of Federal lands for mineral entry. In 1991 the BOM prepared draft computer plots that show the availability status for locatable and leasable minerals.

The U.S. Environmental Protection Agency presented Geneva Steel and the citizens of Utah County with its Outstanding Achievement Award for their cooperative effort in developing one of the Nation's first State Implementation Plans designed to control fine-particulate pollution.