

STRAIN-GAGE MEASUREMENTS IN CARLSBAD CAVERNS, NEW MEXICO

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Work done in cooperation with the U.S. National Park Service

Abstract.—Displacement transducers installed on a near-vertical joint in the lunchroom in Carlsbad Caverns measured small movements along the joint with a resolution of 3.7×10^{-6} in (9.4×10^{-6} cm). During 1973 the maximum annual displacement horizontally, vertically, and perpendicularly to the plane of the joint was 4.7×10^{-4} , 4.0×10^{-4} , and 1.1×10^{-4} in (1.2×10^{-3} , 1.0×10^{-3} , and 2.8×10^{-4} cm), respectively.

In March 1971 the U.S. Geological Survey, in cooperation with the U.S. National Park Service under NPS Research Project CACA-001a, began a project to measure small displacements in a joint in the rock

wall of the lunchroom of Carlsbad Caverns (fig. 1). The output signal from the transducers was measured daily with a digital millivoltmeter by Park Service personnel.

In this report values are given in both English and metric units of measurement. The following table lists the factors used for conversion of the English units to the metric International System (SI) units:

Inch (in)	$\times 2.54$	= centimetre (cm)
	$\times 2.54 \times 10^{-4}$	= micrometre (μm)
Foot (ft)	$\times 0.3048$	= metre (m)

CARLSBAD CAVERNS

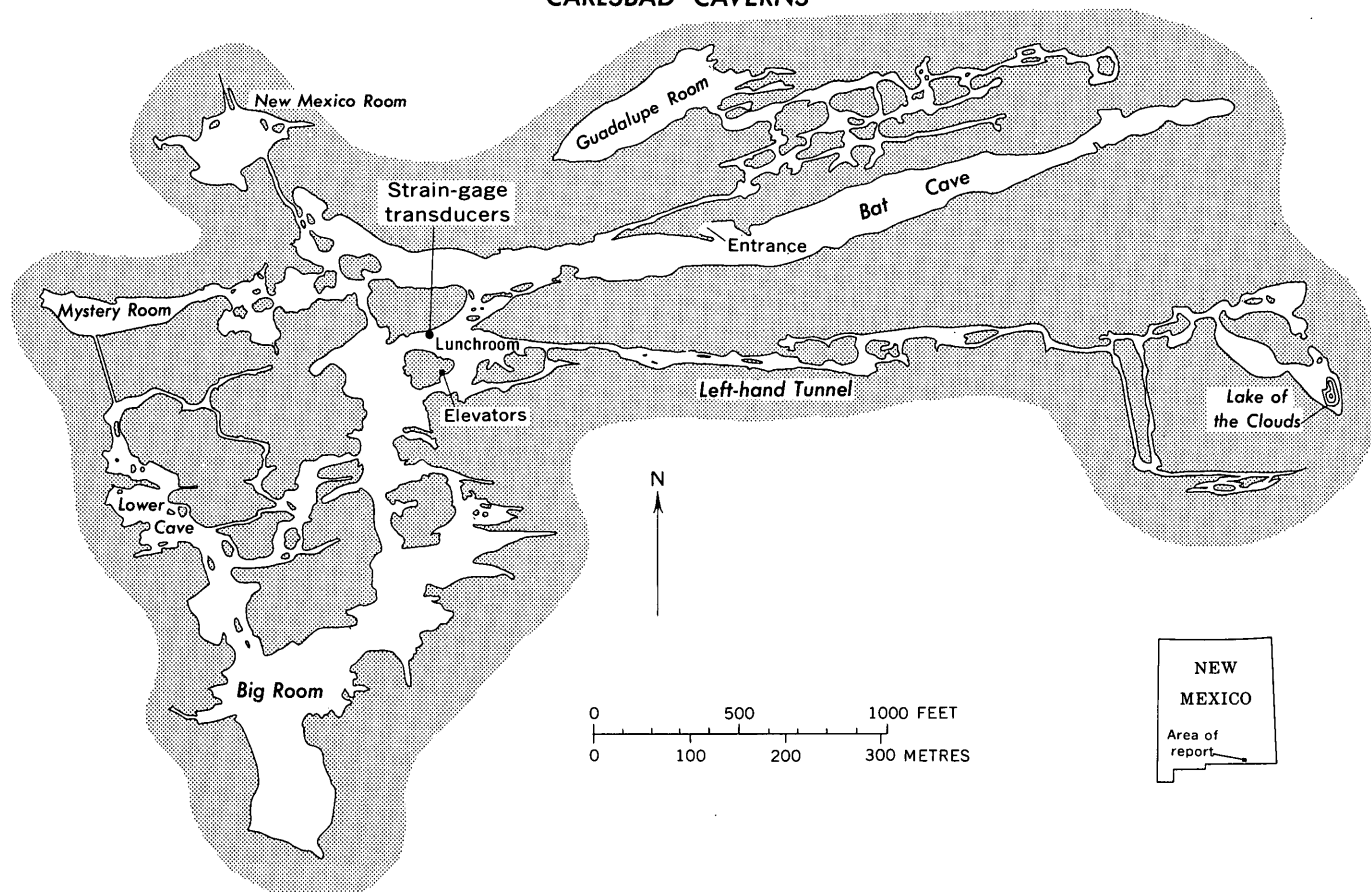


FIGURE 1.—Location of strain-gage transducers. Base modified from Moore (1960).

LOCATION OF STRAIN-GAGE TRANSDUCERS

Three transducers were installed on the conspicuous near-vertical joint in the rock wall on the north side of the lunchroom at a depth of about 750 ft (229 m) below the land surface. One transducer was installed vertically; another, horizontally in the plane of the joint; and the third, perpendicularly to the plane of the joint.

PREVIOUS INVESTIGATIONS

Strain gages have not previously been placed in Carlsbad Caverns. Davis and Moore (1965) studied the motion along a steeply dipping joint in Wool Hollow Cave in California. They recorded diurnal movements of 0.4 and 0.6 μm parallel to the dip and strike of the joint, respectively. An earthquake during the course of the study produced abrupt, steplike displacements of as much as 0.03 μm .

MEASURED DISPLACEMENTS

The strain-gage transducers were read with a digital millivoltmeter by National Park Service personnel, usually once a day. The results of these measurements are shown in figure 2. The transducers were calibrated prior to installation. Marks on the transducer mounting plate provided a rough check on the meter readings. The meter used is accurate to 0.1 mV, which is equivalent to a displacement of 3.7×10^{-6} in (9.4×10^{-6}

cm), or roughly 1 mV/ μm of displacement. The maximum displacements during 1973 are summarized below:

Transducer	Displacement	
	Inch	Centimetre
Horizontal	4.7×10^{-4}	1.2×10^{-3}
Vertical	4.0×10^{-4}	1.0×10^{-3}
Perpendicular	1.1×10^{-4}	2.8×10^{-4}

The vector sum of these movements was therefore 0.00063 in (0.0016 cm) during 1973.

CAUSES OF MOTION

Movement along the joint appears to consist of a slow, irregular creep that has a series of short-term fluctuations superimposed. The record is infrequently disturbed by abrupt "steps." The long-term creep may represent the response of the rocks in the vicinity of the cave to unloading by removal of overburden and to local erosion.

The short-term fluctuations noted are of the same order of magnitude as the earth-tide induced fluctuations noted by Davis and Moore (1965). They probably represent the effects of earth tides, small earthquakes, and local effects such as blasting. They do not appear to induce permanent displacement in the joint, although they may act to release preexisting stress.

Some of the steps in the record are due to equipment malfunction and to disturbance of the sensors by people in the cave, particularly during 1972. However, some of the large steps took place when there was no

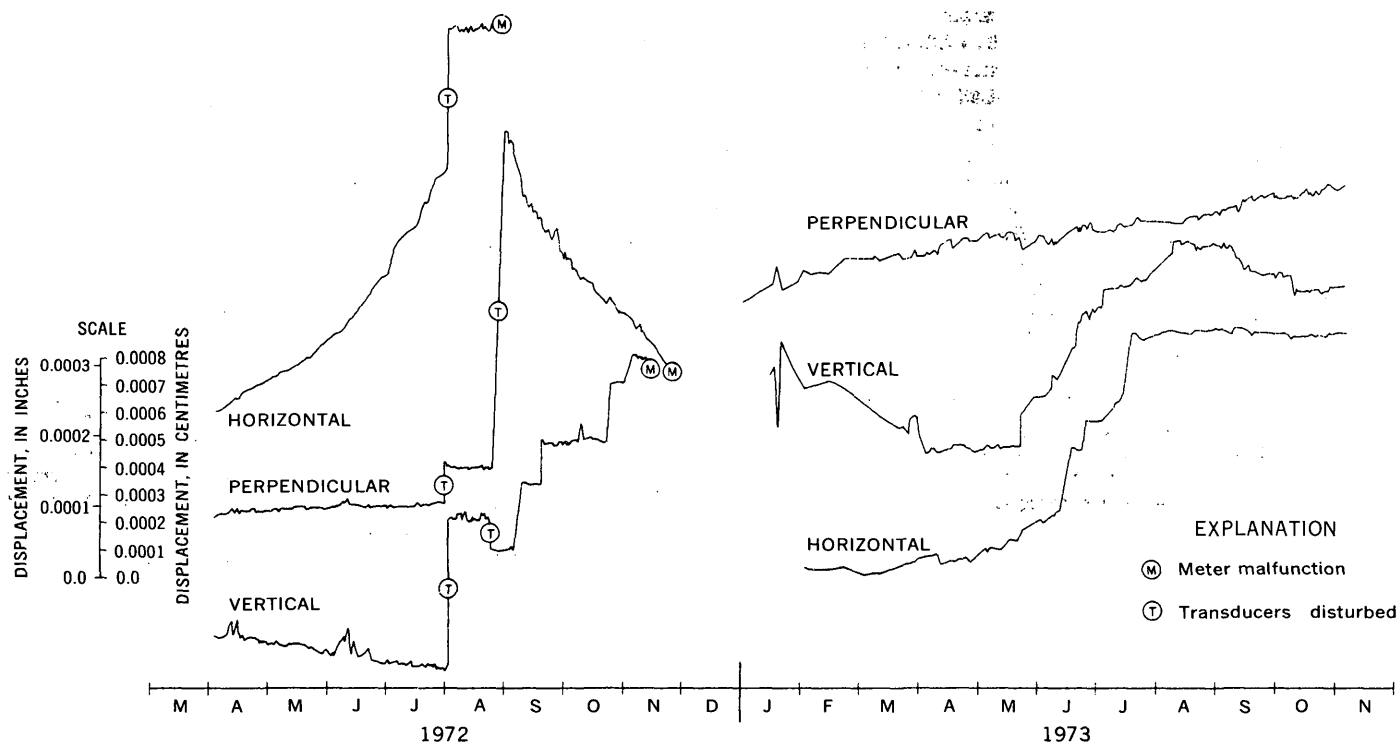


FIGURE 2.—Movement of a joint in Carlsbad Caverns.

equipment malfunction or disturbances. These seem to represent abrupt movement along the joint. Some of these steps appear to coincide with major earthquakes and may represent the triggering of the release of stress in the joint by earthquakes. The data are inadequate to allow a detailed correlation between earthquakes and abrupt displacements.

REFERENCES CITED

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JOURNAL OF RESEARCH

OF THE U.S. GEOLOGICAL SURVEY

MAY-JUNE 1975

VOLUME 3, NUMBER 3

*Scientific notes and summaries
of investigations in geology,
hydrology, and related fields*



U.S. DEPARTMENT OF THE INTERIOR