Mammoth Lakes Michelson Tiltmeter

USGS 14-08-0001-G6170

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A pair of Michelson tiltmeters are maintained within the Long Valley Caldera 1 km north of the Mammoth Lakes airport. The tiltmeters are designed to monitor tilts of the Earth's surface caused by changes in magma pressure in a subsurface magma chamber approximately 5 km to the NW of the instruments. Between late 1989 and late 1991 we observed a slow swelling of the Earth's surface over the magma chamber that resulted in tilts of 4 microradians. This is equivalent to an expansion of the magma chamber by approximately 2 cm. The swelling appears to have slowed down but has not subsided. One possible interpretation is that the magma pressure has been incrementally increased in the past two years.

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Investigations:

A pair of Michelson tiltmeters are maintained within the Long Valley Caldera 1 km north of the Mammoth Lakes airport. The tiltmeters are modelled after one designed by Michelson in 1914 and consist of two horizontal water pipes each with a continuous water surface, terminated by optical interferometer transducers.

Location	37°37'58"N, 118°50'01" West (center vault) See Fig. 1.
East/West tiltmeter	length 423.3 m, azimuth 280°, least count 0.57 nanoradians
North/South tiltmeter	length 449.2 m, azimuth 16°, least count 0.53 nanoradians
Pipe	20 cm diameter bell-ended PVC at a mean subsurface depth of 1.5 m.
Water level detectors	1. Equal-arm Michelson-Interferometers powered by polarized He/Ne lasers. Resolution 0.25 μm, range 1 cm.
	2. Experimental LCD sensors on East West arm.
Surface displacement sensors	10 mm diameter invar rods to 26 m maximum depth.
	LVDT sensors with accuracy ±1 μm and range 3 mm.

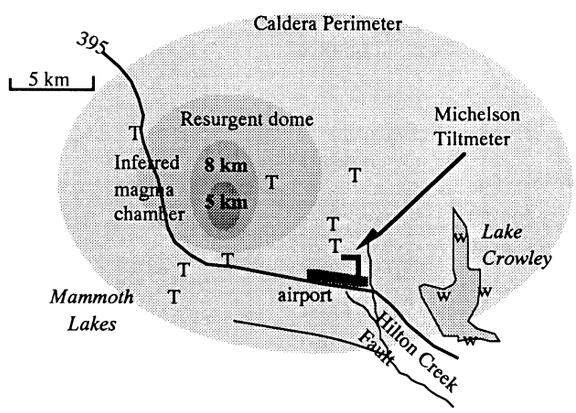

Figure 1 Sketch of location of biaxial Michelson tiltmeter. Borehole tiltmeters (T) and Lake Crowley water sensors (w) provide alternative measures of caldera tilt. A level line exists along Highway 395.

Results:

1. Tilt in the floor of the Caldera appears to have stabilised in the past year with a tilt down to the SE of approximately 1 μrad. From late 1989 to late 1990 an inflation event NW of the tiltmeter has caused a 3 μrad tilt down to the south and 4 μrad tilt to the east. Data from the instrument are shown in Figures 2 and 3.

2. Microseismic activity close to the tiltmeter has resulted in frequent loss of counts on the interferometers. In conjunction with J. Beavan (Lamont-Doherty) a prototype water surface monitoring system using Charge Coupled Detectors has been installed on the east-west sensor. The sensor is unaffected by water surface vibration and promises to provide a reliable ± 1 μm monitoring system (Pratusevitch G, J. Beavan, J. Behr and R. Bilham, CCD Sensors and Mammoth Lakes tilt data(1991) *Eos Trans. Am. Geophys. Un.* **70**, 505.

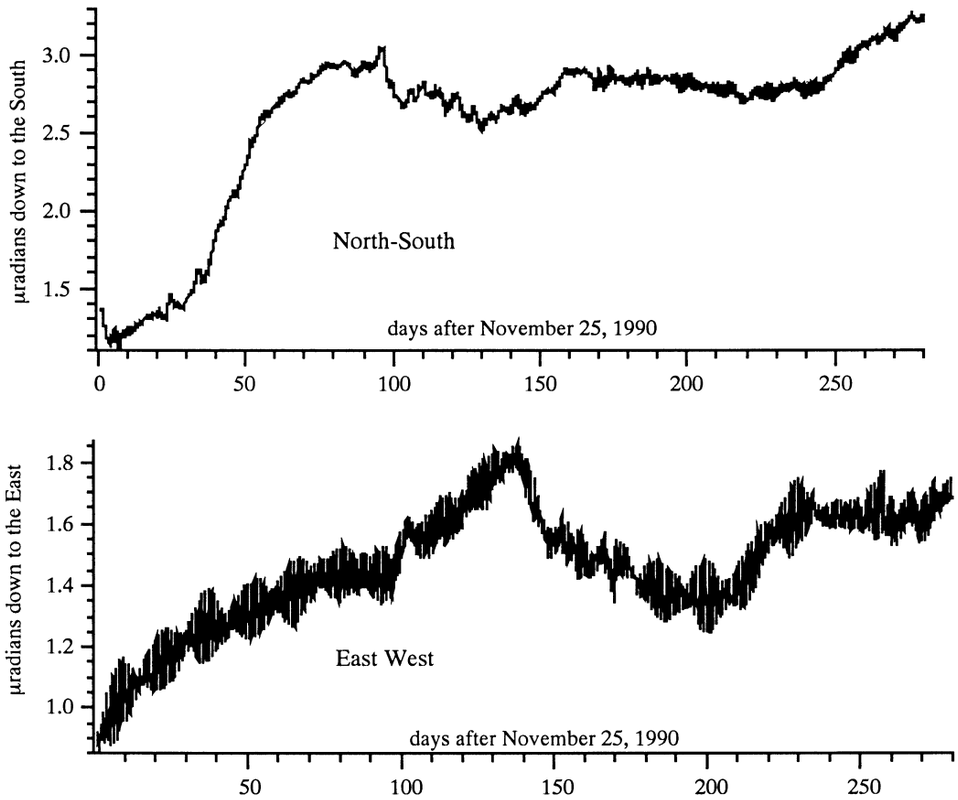

Figure 2 Tilt relative to base of boreholes for the period Nov 25 1990 to Sept 1 1991. The thickness in line is caused by the daily tide which is approximately a factor of three higher in the east west than in the north south direction.

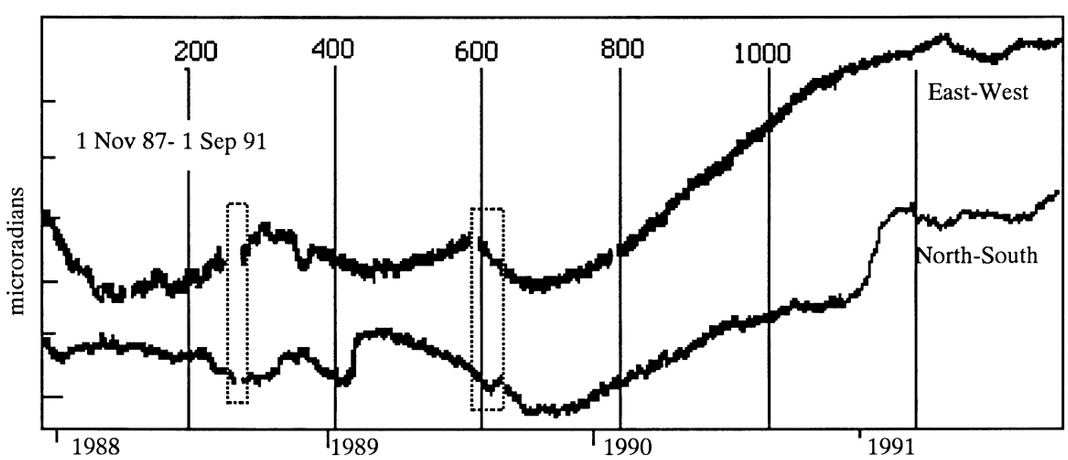

Figure 3 Cumulative tilt from the biaxial Michelson tiltmeter for the period 1987-1991. Two dotted boxes indicate times of major disturbance to the instrument. Vertical extensometers were installed in late 1989.