THE MAGNITUDES OF THE MONTANA (HEBGEN LAKE) 1959 AND THE IDAHO (MOUNT BORAH) 1983 EARTHQUAKES

by

Bruce A. Bolt
Seismographic Station
University of California
Berkeley, California 94720

The Preliminary Reconnaissance Report on the Mount Borah earthquake of October 28, 1983, by the EERI Reconnaissance Team (Newsletter, 17, No. 6, 1983) was of considerable interest. This earthquake is, as the authors pointed out, the largest to occur in Idaho during the time that seismographs have been operating in North America, which begins with the installation of seismographs at Lick Observatory and Berkeley by the University of California in 1887.

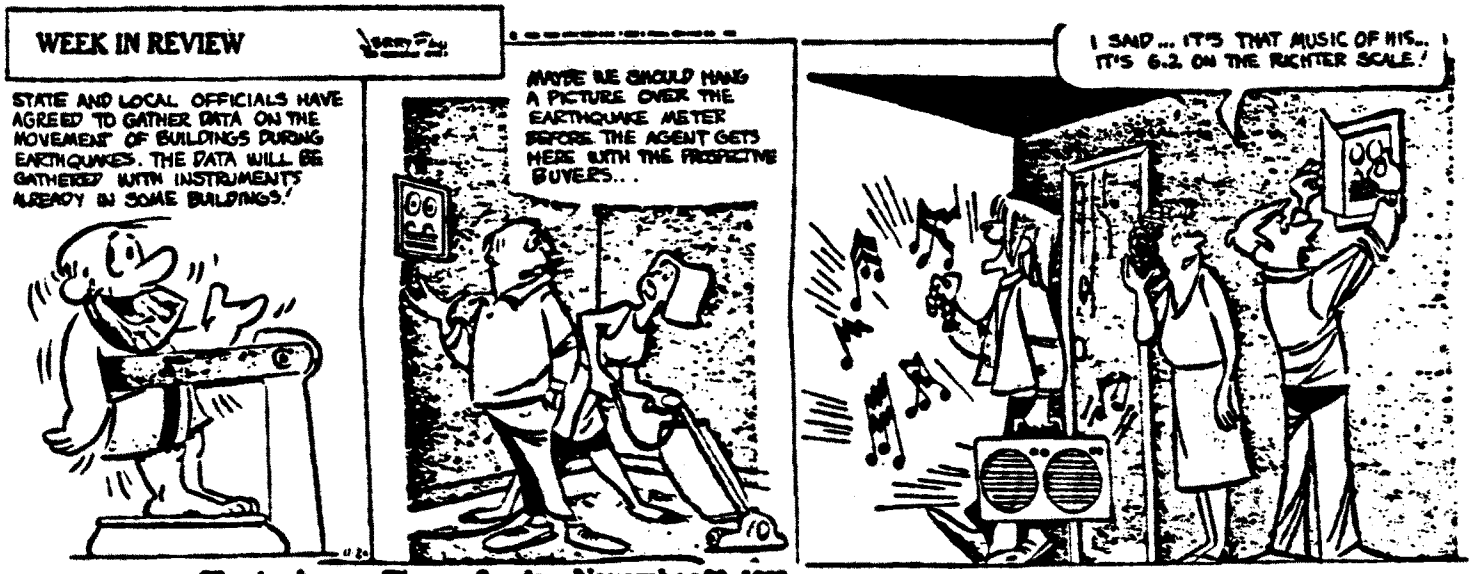
In the Report, the Mount Borah earthquake is stated to have had a preliminary Richter magnitude of 6.9 and it is compared with the Hebgen Lake earthquake of August 18, 1959, which is assessed at a Richter magnitude of 7.1. In the process of working out the Berkeley estimate of the magnitude of the Mount Borah earthquake, I have found a major discrepancy in the often quoted magnitude given above for the important Hebgen Lake earthquake. In order to clarify the record, it is worth giving a brief account for interested members of EERI of the results of analysis of the appropriate Wood-Anderson seismograms. A more detailed analysis will be published later in the Bulletin of the Seismological Society of America.

The epicenters of the Idaho mainshock of October 28, 1983, and the Hebgen Lake mainshock of August 18, 1959, are 250 km apart. Both earthquakes were recorded on Wood-Anderson seismographs used for calculating the Richter magnitude at both UC Berkeley stations in Northern California and at the California Institute of Technology stations in Southern California. The average distance of the 1959 earthquake from the Berkeley stations is 1,200 km and from Pasadena stations 1,300 km. The corresponding distances for the 1983 Idaho earthquake are 1,000 km and 1,200 km. Wood-Anderson seismograms from both these networks have been compared, with the following results. For the 1959 earthquake, readings of amplitudes from Wood-Anderson seismograms at six Berkeley stations give an average Richter magnitude of 7.7 (± 0.2 standard error). Three Pasadena stations yield an average Richter magnitude of 7.8, giving close agreement between the two networks. It should be noted that this value for the magnitude agrees with the surface wave magnitude M_S calculated at many distant observatories around the world; on the overall information available to me from these various sources, there is almost no doubt that the large Hebgen Lake earthquake of 1959 should be allocated a Richter magnitude of approximately 7.7. By comparison, the Berkeley seismograms show that the Idaho earthquake is definitely a smaller earthquake than the Hebgen Lake earthquake. Four Wood-Anderson amplitude readings from the Berkeley network give an average value of 7.2, which again agrees with a Richter magnitude calculated from Wood-Anderson records kindly made available by Pasadena.

The value quoted by the EERI Team of 7.1 M_L for the 1959 earthquake occurs in many catalogs. The question arises as to the source of this value.

As far as I can determine, it can be attributed to a value cited in the paper by Dr. Don Tocher in the Bulletin of the Seismological Society of America in 1962. This paper was the first of a series on the great 1959 earthquake which involved surface faulting of at least 25 km and maximum offsets along the fault of about 6 m. The 7.1 M_L value has been used in data sets which give correlations between magnitude and fault rupture, and others which correlate peak acceleration with local magnitudes. In his 1962 paper, Tocher attributed the value 7.1 to Pasadena, but gave no details of the calculation involved. In any event, as mentioned above, the readings from the three Pasadena Wood-Anderson instruments available to me contradict this value and it is possible that it is simply a typographical error, because Tocher was particularly careful in computing earthquake parameters. Because of the much greater size of the 1959 earthquake compared with the 1983 Idaho earthquake, it is now necessary for catalogs to make an upwards correction to the magnitude of the former earthquake.

In conclusion, strong motion accelerograms were obtained in the 1959 earthquake at Bozeman, Helena, and Butte, with peak horizontal accelerations of 0.07g, 0.03g, and 0.02g, respectively. These records give an independent check from closer distances of the magnitude of the 1959 earthquake and this check, while not complete, indicates that a 7.7 M_L is more appropriate. A similar check can be carried out with strong-motion records obtained in the 1983 Idaho earthquake, and this will be done in the more detailed treatment to be published later.

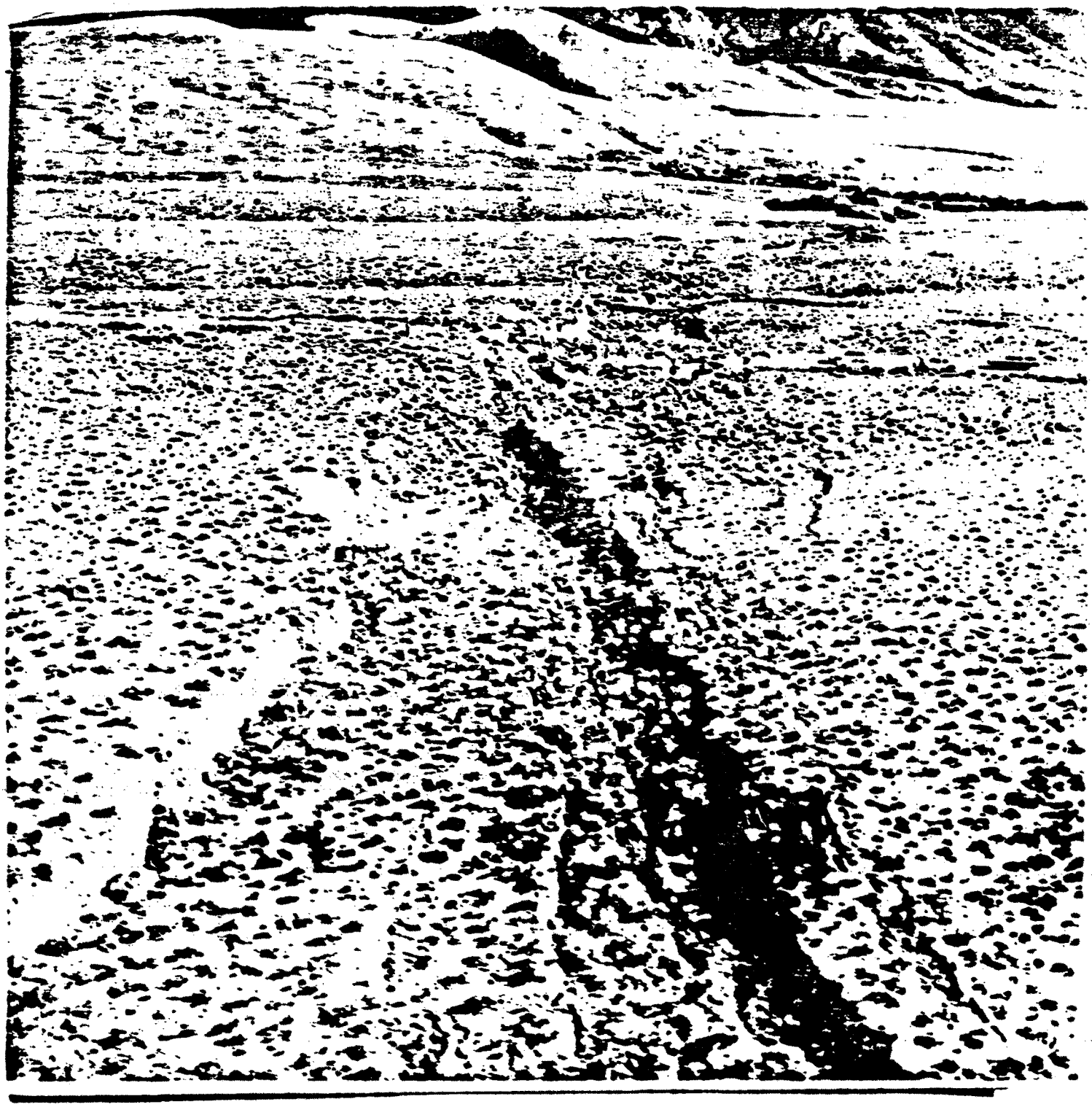


The Anchorage Times, Sunday, November 20, 1983

Lost River Range Earthquake, October 28, 1983

USGS geologist Mike Rymer surveys fault scarp produced during earthquake. The 1983 scarp is the vertical small cliff 6 feet (2 m) high and bare of vegetation. Immediately above the 1983 scarp, and below Rymer's feet, is a steep slope about a meter (3 ft.) high that represents an old eroded scarp produced by previous fault displacement. About fifteen meters (50 ft.) to the right of Rymer is a patch of ground that has slumped from the steep 1983 scarp. This is material that was backfilled into an exploratory trench dug several years prior to 1983 by Tim Hait of the USGS to evaluate previous displacements. Hait found evidence here and elsewhere of at least three previous displacements on the fault in the last 10,000 years. Vertical displacement here is about 1.2 m (3.9 ft) and left-lateral slip is about 0.5 m (1.64 ft.)

Photographer: Robert E. Wallace [EERI 1969], USGS Photo 5-3



Lost River Range Earthquake, October 28, 1983

Photo 8-11 Surface faulting twenty three miles long developed during the earthquake. Here can be seen a slumped area, or graben, about 30 m (100 ft) wide where the fault crosses the Doublespring Pass Road at Willow Creek, four and a half miles northwest of Borah Peak, Idaho's highest peak. Vertical displacement here is about 1.2 m (3.9 ft) and left-lateral slip is about 0.5 m (1.64 ft).

Photographer: Robert E. Wallace [EERI 1969]. USGS