UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary isoseismal map and intensity distribution for the Borah Peak, Idaho, earthquake of October 28, 1983

by

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INTRODUCTION

The earthquake of October 28, 1983 in the Borah Peak, Idaho area was felt over a contiguous area of approximately 670,000 km of the United States. It was felt in all or parts of seven western states: Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. A single felt report from North Dakota was also received. According to press reports, the quake was also felt in many western Canada communities. The hypocenter was located by the U.S. Geological Survey at 44.058° N., 113.857° W., fixed depth of 10 km, origin time 14h06m06.3s UTC. The magnitude was computed at 6.2mb and 7.3MS. It caused the death of two children in Challis and injured one woman in Mackay. The Idaho Bureau of Disaster Services estimated the damage attributed to this earthquake at $12.5 million as of March 1, 1984.

The Borah Peak earthquake, maximum intensity VII, is the largest magnitude event in recorded history to occur within the state of Idaho. The largest magnitude previous to 1983 was the 1944 Seafoam earthquake, magnitude 6.1, located at 44.5° N., 115.5° W. Since many of the earlier earthquakes had no computed magnitudes, relative sizes can be based on the maximum intensities which have been published for most large events. Five earthquakes in Idaho have been documented with a maximum intensity VII and one with an intensity of VIII. The earliest of these was an intensity VII in 1884; the latest was the intensity VIII in 1975. These two earthquakes, in 1884 and 1975, and one in 1962 occurred in southeastern Idaho near the Utah border. The other three intensity VII events occurred in 1905, 1916, and 1944 and were located near Shoshone, Boise, and Seafoam respectively. None of these six quakes are located near the epicenter of the Borah Peak earthquake. The two closest ones are the 1905 Shoshone and 1944 Seafoam events which have published epicenters that are located at distances of 136 and 138 km. The Borah Peak earthquake is located about 40 to 50 km east of the central Idaho seismic zone in an area that has almost no record of seismic activity.

The Borah Peak earthquake can be compared with the 1959 Hebgen Lake, Montana earthquake. The Hebgen Lake event was rated at a maximum intensity of X based on surface faulting; however, the maximum intensity based on vibrational motion was VII or VIII (Steinbrugge and Cloud, 1962). The Borah Peak earthquake was rated a maximum intensity of VII for vibrational effects (fig. 1). Surface faulting was not used as a basis of rating intensity even though faulting occurred over a distance of 43 km (Crone and Machette, in press). If faulting had been a criteria for rating intensities the maximum intensity would probably be rated about the same as the Hebgen Lake earthquake. The magnitudes can be compared by averaging the magnitudes for the Hebgen Lake earthquake that were reported in the Bureau Central International de Seismologie, Bulletin Mensuel (BCIS), Strasbourg, France, at distances greater than 30 degrees and assuming they are surface wave (MS) magnitudes. The average for 8 magnitudes at distances of 67° to 125° was 7.5. Thus the Hebgen Lake event had a slightly larger surface wave magnitude of 7.5 compared to 7.3 for Borah Peak.

ISOSEISMAL MAP

Figure 1 shows the areal distribution of intensities in the United States for the Borah Peak earthquake. The press reported the quake as also being extensively felt in Canada as far north as Dawson Creek, British Columbia and in multi-story buildings in such widely separated cities as Vancouver, British Columbia; Edmonton, Alberta; and Regina and Saskatoon, Saskatchewan. A final version of the isoseismal map, including the felt data from Canada, will be published in 1985 in the U.S. Geological Survey Special Publication "United States Earthquakes, 1983".

The isoseismal map was compiled from data obtained in a questionnaire canvass of postmasters and police departments (within 200 km of the epicenter), supplemented by a damage survey (Reagor and Baldwin, 1984) and by information from numerous press reports. Intensities were rated using the Modified Mercalli Intensity Scale of 1931 (Wood and Neumann, 1931).

The isoseismal defining the limit of perceptibility in figure 1 is drawn to enclose all contiguous localities that felt the earthquake. Two anamolous areas south of Portland, Oregon and Seattle, Washington outline a small region of numerous felt reports. A few isolated felt reports from communities in Nevada, Oregon, and Washington were rated at intensity III but they are not enclosed within an isoseismal and are not shown on the map.

The comparison of the isoseismal maps (figs. 1 and 2) for the Borah Peak and Hebgen Lake earthquakes shows a distinct difference in shape and orientation. This difference may be explained by the extent and direction of the associated faulting. The fault scarps and surface ruptures resulting from the Borah Peak earthquakes trended in a northwesterly direction from the epicenter for a distance of 34 km (Crone and Machette, in press), while the Hebgen Lake earthquake caused multiple surface ruptures that extended both to the southeast and northwest from the epicenter for a total distance of about 27 km (measured from fig. 1 by Witkind and others, 1962). The focal mechanisms for these shocks show a strike of N 28° W with a dip of 60° SW for Borah Peak (Crone and Machette, in press), and a strike of N 80° W with a dip of 54° SW for Hebgen Lake (Ryall, 1962; Dewey and others, 1973). The focal mechanism for the Hebgen Lake earthquake is not consistent with the fault scarps which strike in a northwesterly direction, but it is believed to be associated with a deeper east-west structure in alignment with the 80-kilometer-long aftershock zone (Dewey and others, 1973). The shape of the isoseismal maps seems to correlate with the faulting and the direction of rupture since the major axis of both isoseismal maps are compatible with the strike of their respective focal mechanisms. This correlation would also explain the difference in the size of the felt area within the United States, about 870,000 km^2 for Hebgen Lake versus 670,000 km^2 for Borah Peak, for earthquakes of nearly equal magnitude, 7.5 and 7.3, as the nearly east-west faulting in the Hebgen Lake earthquake would cause shaking over a larger region of the United States.

DAMAGE AND GEOLOGIC EFFECTS

The most severe damage occurred at Mackay and Challis, Idaho where the Governor's office has listed 11 businesses and 39 homes with major damage and 200 homes with minor to moderate damage. Both Mackay and Challis were rated at intensity VII. Most of the businesses located on Main Street of Mackey were damaged to some degree, eight of them were condemned as irreparable by building inspectors. Damaged buildings were of a masonry type of construction of brick, concrete block, or stone. The type of damage was mostly severe cracking or partial collapse of exterior walls, some cracking of interior walls, and some separation of walls at corners. One person was injured on Main Street by debris from a collapsing wall. About 90 percent of the chimneys in the residential area of Mackay were damaged to some extent; either they collapsed, were twisted, or were so severely cracked they had to be torn down. Large amounts of merchandise were thrown off store shelves and most glass containers were broken. Mackay High School suffered much the same type of damage as the masonry buildings along Main Street.

Challis had less damage to buildings than Mackay; however, two childern were killed when an upper part of the front wall of an old rock-exterior building, built in 1879, collapsed onto them. The Challis High School was the only other building to suffer major damage. Stone facing fell from the top of a wall, a chimney and exterior brick walls were cracked, the stone entrance was separated from the building, and interior walls were cracked. Some chimneys in both the residential and business districts were damaged but not as extensively as in Mackey. Reagor and Baldwin (1984) have published detailed descriptions from other communities in the epicentral area.

The most common damage and effects reported from the communities located within the intensity VI isoseismal (fig. 1) were: Cracked exterior brick or cinderblock walls, cracked foundations, cracked chimneys or bricks fallen from chimneys, many small objects overturned or fell, trees and bushes shaken moderately to strongly, and standing automobile or trucks rocked moderately. No damage was reported at any of the 30 dams located within 250 miles of the epicenter operated by the U.S. Bureau of Reclamation.

The Borah Peak earthquake had a large impact on the physiography of the region because of the amount of surface faulting, numerous landslides and rockfalls, water fountains, and changes in the flow of water from springs. The 34-kilometer-long discontinuous surface faulting had a throw that ranged from 50 cm to 2.7m and ground breakage over a width of as much as 100m (Crone and Machette, in press). Landslides and rockfalls were common on the steep slopes of the Lost River Mountains. Highways in many areas had to be cleared of boulders that had rolled down the slopes. Some homes in Challis located at the base of large bluffs were damaged by falling boulders (Reagor and Baldwin, 1984).

The quake caused water fountains in at least two locations: Near Chilly Buttes and at the upper end of Mackay Reservoir (Reagor and Baldwin, 1984). The fountains lasted only a short time leaving many holes of various sizes and depths. The flow of water from springs was also affected. A spring near Mackay Reservoir increased its flow by more than 25 percent, another at Ingram Ranch near Challis became temporarily dry but flow returned in 13 days, and

two others near Ketchum, Geyser Hot Springs and Easley Hot Springs, began flowing at a higher than normal rate. The flooding of the Clayton Silver Mine with more than 100 feet of water was attributed to this earthquake.

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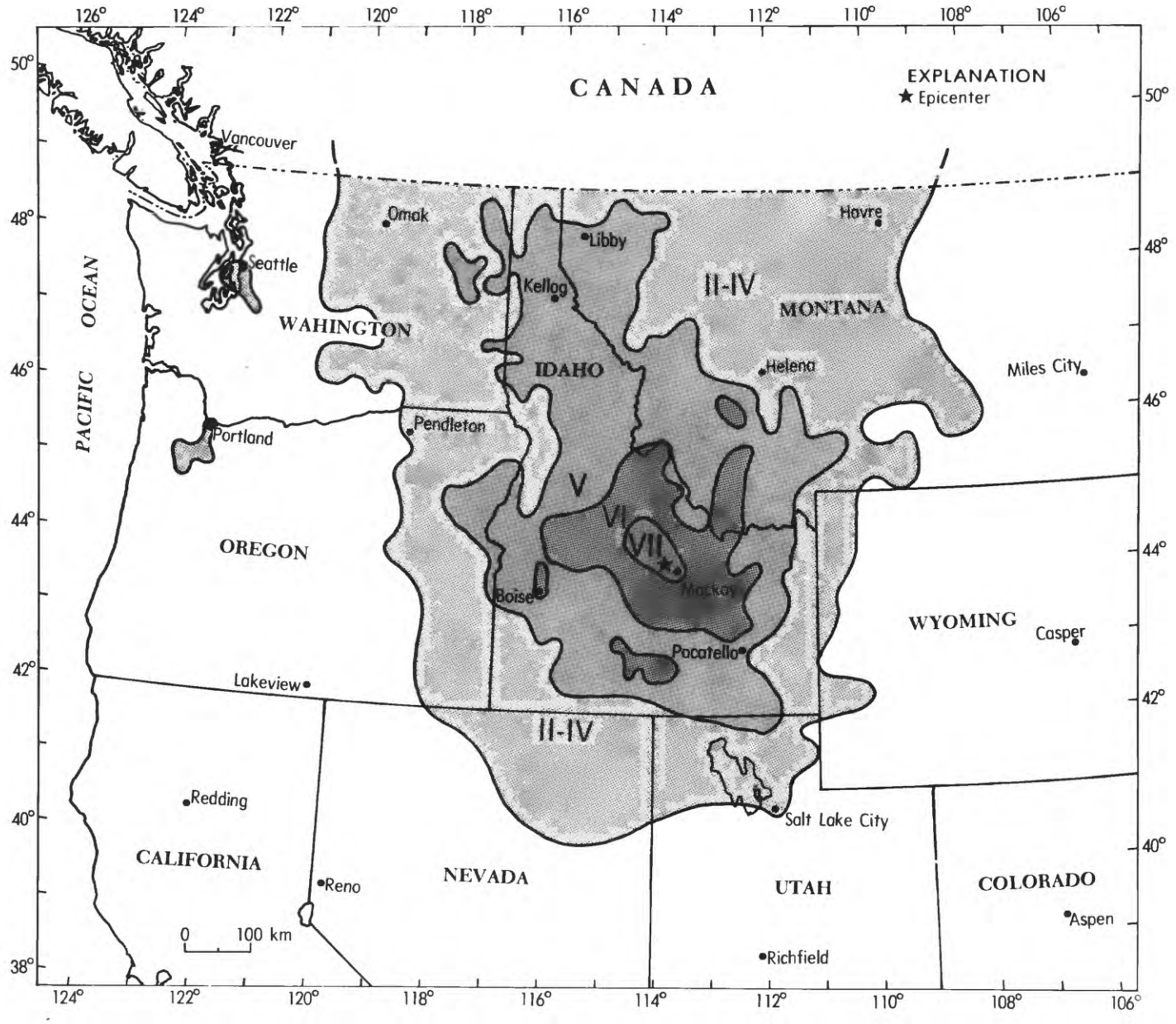

FIGURE 1.--Isoseismal map for the Borah Peak, Idaho, earthquake of 28 October 1983 UTC.

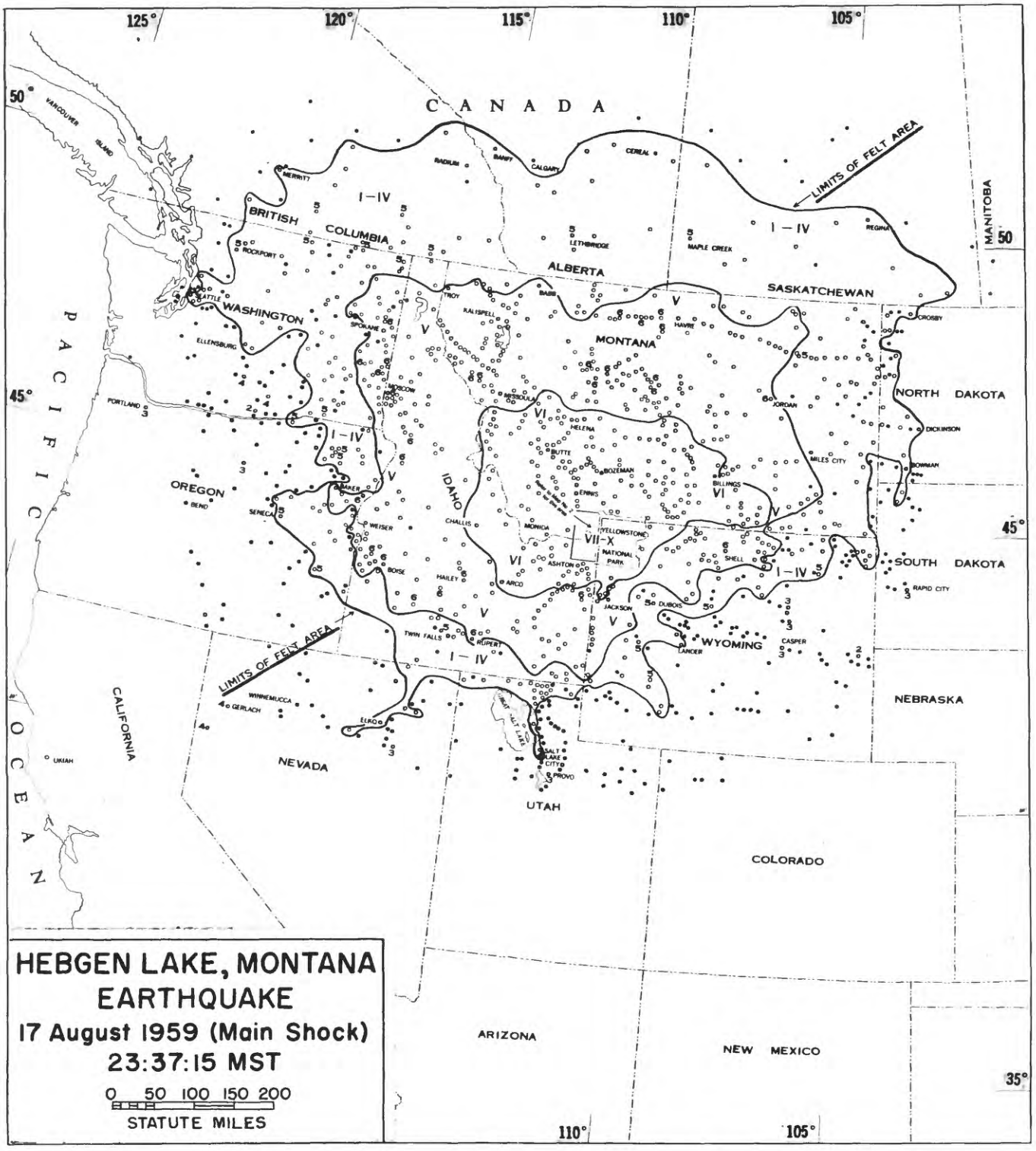

FIGURE 2.--Isoseismal map for the Hebgen Lake, Montana, earthquake of 18 August 1959 UTC (Eppley and Cloud, 1959).