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# Southeastern Caribou County, Idaho
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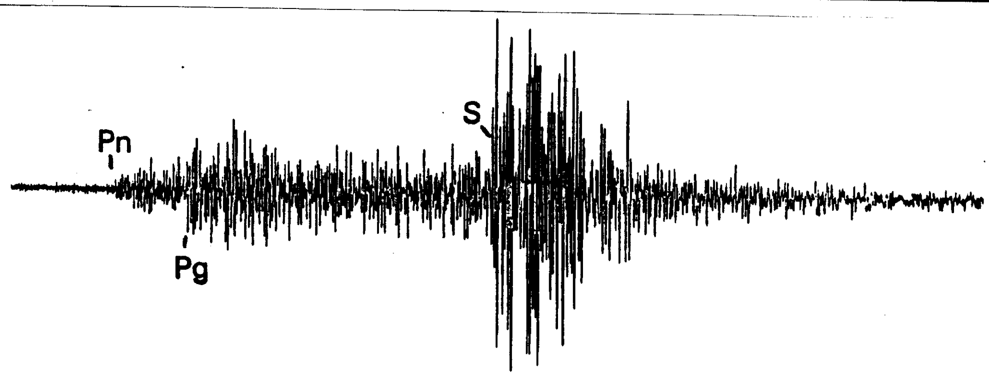


The largest foreshock in the Draney Peak sequence as recorded by a University of Idaho seismograph on Lindstrom Peak near St. Maries, Idaho, about 420 miles NNW of the epicenter. This M 4.4 foreshock preceded the Mw 5.9 main shock by 110 minutes. The majority of large earthquakes in the western cordillera are preceded by foreshocks. Pn = mantle P wave, Pg = crustal P wave, S = shear and surface waves. Duration of seismogram = 4 minutes.

Staff Report 94-2
April 1994

Idaho Geological Survey
University of Idaho
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# Contents

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K.F. Sprenke[1], M.C. Stickney[2], and R.M. Breckenridge[3]

## ABSTRACT

Beginning January 30, 1994, a sequence of earthquakes, the largest (Mw 5.9) on February 3, occurred in southeastern Caribou County, Idaho, in the Webster Range near Draney Peak. The purpose of this report is to summarize the preliminary information that the Idaho Geological Survey has received from agencies investigating this earthquake sequence and to evaluate these data in terms of the state's seismicity and seismotectonics. The main shock, centered very close to Draney Peak about 24 miles northwest of Soda Springs, Idaho, was the largest earthquake in the Idaho region since the 1983 Ms 7.3 Borah Peak event. The main shock reached a maximum intensity of VII and was felt over more than a 50,000-square-mile area as far south as Moab, Utah, and as far north as Rexberg, Idaho. The main shock was preceded by foreshocks; aftershocks, including at least three above ML 5, continued for at least several months. Seismic sequences are common in the western cordillera, and a review of the timing and magnitude of the largest foreshock and aftershock suggests nothing unusual about the Draney Peak earthquake and its early aftershocks. However, a late sequence which culminated in a ML 5.2 event two months after the main event seems anomalous. The fault-plane solution indicates normal faulting, with a suggestion of a strike-slip component. The aftershocks have occurred along a northerly trend about 8 miles wide by 20 miles long, generally parallel to the Star Valley fault, 12 miles to the east, which has proven movement 4,500 years ago. However, many other faults also exist in this overthrust area. No surface rupture has been found to date.

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# INTRODUCTION

A significant sequence of seismic activity began January 30, 1994, in southeastern Caribou County, Idaho, near the Wyoming border (Figure 1). The sequence culminated in a main shock of ML 5.8 (Mw 5.9) at 09:05:03.8 UTC on February 3, and was preceded by at least four foreshocks increasing in magnitude from ML 3.2 on January 30 to ML 4.5 about two hours before the main shock. Large aftershocks have included a ML 5.2 event 17 hours after the main event, a ML 5.3 event about a week later on February 11, and a ML 5.2 event about two months later on April 7.

Regional seismic networks in Montana, Utah, and Idaho have recorded well over 100 events above magnitude 3 from the sequence (Figure 2), and the University of Utah, which deployed a 10-station local network in the vicinity of the epicenter for two weeks after the shock, recorded over 1500 smaller aftershocks (Nava and others, 1994).

## Purpose

The purpose of this report is to summarize the preliminary information that the Idaho Geological Survey has received from agencies investigating this earthquake sequence and to evaluate these data in terms of our present knowledge of seismicity and seismotectonics of the state. Our primary sources of information on the sequence are the U.S. Geological Survey-National Earthquake Information Center, the Geological Survey of Wyoming, the Montana Bureau of Mines and Geology, the Idaho Bureau of Disaster Services, various regional seismic network operators, and the University of Utah, which deployed temporary seismic stations in the epicentral area.

# DESCRIPTION OF EVENTS

## Significance

The size of the main shock, Mw 5.9, is certainly significant in terms of historic seismicity. Only about 16 previous events in the intermountain west have exceeded this magnitude in historic time (Figure 3), the most recent being the Ms 7.3 Borah Peak, Idaho event of 1983, and, before that, the 1975 M 6.0 Malad City, Idaho, event.

The foreshock and early aftershock activity associated with the Draney Peak earthquake has been a subject of considerable interest. Foreshocks have occurred in about 60 per cent of historic western cordillera earthquake sequences compared to 35% of San Andreas sequences (Doser, 1990). The time interval between the largest aftershock of each sequence and the main shock for all the historic seismic sequences in the western cordillera has ranged widely from a few minutes to 18 days. In the western cordillera, about one-third of the largest aftershocks occurred within 1 hour of the main shock, three-fifths occurred within one week, but a full one-third occurred more than a week after the main shock. Figures 4 and 5 show where the Draney Peak sequence fits in with data from 27 other historic seismic sequences as compiled by Doser (1990). These graphs suggest nothing unusual about either the timing or the magnitude of the largest foreshock and aftershock associated with the main Draney Peak sequence compared with other western cordillera events. However, the late sequence of events from April 7 to 10, including a ML 5.2 aftershock, over two months after the main shock, seems anomalous (Figure 2).

## Epicenter Location

Because the main shock was close to the Idaho-Wyoming border, confusion abounded as to the location of the epicenter. In southeastern Idaho, the Idaho-Wyoming border is at longitude 111.052 W. The U.S. Geological Survey-National Earthquake Information Center located the event at 42.751 N, 110.983 W (in Wyoming); the University of Utah, using better data from regional networks, located the epicenter much more accurately at 42.740 N, 111.148 E (in Idaho). The University of Utah also located the three largest aftershocks in Idaho (Figure 6) as well as the bulk of the multitudinous smaller events (Nava and others, 1994).

The main shock occurred below Draney Peak, the highest summit (EL 9131 feet) in the Webster Range of the Caribou National Forest (Figure 6). The foreshocks and aftershocks mostly occurred in a seven-mile-wide zone extending 18 miles SSE from the epicenter as far south as the Gannett Hills (Nava and others, 1994).

## Regional Setting

The Draney Peak sequence occurred within the Intermountain Seismic Belt, a 1500-km-long zone of unknown tectonic significance that extends from Las Vegas, Nevada, to Flathead Lake, Montana, cutting through Salt Lake City, Utah, southeastern Idaho, Yellowstone Park, and Helena, Montana, along its arcuate route (Figure 3). The event also fits well into the parabolic or V-shaped distribution of seismicity about the presumed migratory path of the Yellowstone hot spot (Figure 7).

## Shaking Intensity

The three shocks above ML 5 were felt in southeastern Idaho as far northwest as Idaho Falls and Pocatello, in western Wyoming as far east as Dubois, in eastern Utah as far south as Moab, and in extreme northwestern Colorado. The felt area was bounded on the north and northwest by the Yellowstone region and the Snake River Plain. There were no felt reports whatsoever in Montana. The regional isoseismal map for the main shock (Figure 8) shows a definite asymmetry with far stronger wave propagation to the south than to the north, suggesting that the fault rupture was north to south, thus focusing wave propagation in that direction. Also possible is an attenuation effect of the Snake River Plain and Yellowstone areas on seismic waves propagating across these youthful volcanic provinces.

The preliminary local isoseismal map (Figure 9) shows maximum Mercalli intensities of VI-VII for the main shock. At intensity VII, damage is considerable in poorly built or badly designed structures (Table 1). Seven of the ten public school buildings in Caribou County, being at least partially constructed of unreinforced masonry, fit this description as do all four public school buildings in nearby Bear Lake County (Breckenridge and Sprenke, 1988). Fortunately, the epicentral zone of the main shock was quite remote, and only minor damage was reported. A woman in Wyoming received a head injury from a flower pot falling off a shelf. Most areas of Caribou County and Bear Lake County experienced shaking at the intensity IV and V levels, which, though generally felt, produced no more damage than broken dishes or cracked plaster (Table 1). The residents of these counties should not believe that this level of shaking is the worst a future earthquake can do in their vicinity. Had the epicenter been closer to population centers or had the event been a magnitude larger, injuries and destruction of property would have been correspondingly greater.

## Fault-Plane Solution

The geologic setting of the earthquake sequence is uncertain, although the far-field seismic data indicate a normal-faulting mechanism (Figure 10). According to the Harvard focal mechanism solution, the main shock occurred on a pure dip-slip fault striking N24°W and dipping either 69°SW or 21°NE. The U.S. Geological Survey focal mechanism solution is oblique, dominantly dip-slip but suggestive of minor strike-slip movement as well (right-lateral on the plane dipping steeply SW, or left lateral on the plane dipping moderately east). Both solutions have seismic T-axes oriented SW-NE, typical of the present extension direction in this part of the Basin and Range province (Fig 11).

## Geologic Setting

The epicenters of the Draney Peak shocks were located between the surface expression of two major active faults: the Star Valley fault to the east and the Bear Lake fault to the west (Figure 1). Both faults have proven Holocene or latest Pleistocene movement within the last 15,000 years. Historically, seismicity is common in the area. A number of events above M 5 have been instrumentally recorded within 25 miles of the epicentral area (Figure 1). A major event in 1884 (probably above M 6 near the Bear Lake fault) caused considerable damage (intensity VII) at Paris, Idaho. Events near Montpelier, Idaho, caused slight damage (intensity VI) in 1925 and 1947; events near Soda Springs did the same in 1960 and 1982. A prior intensity VI event has also occurred in 1930 near Afton, Wyoming.

Figure 12 shows the location of the four largest shocks in the Draney Peak sequence plotted on a tectonic map of the area. The epicentral zone lies within the Webster Range, which is structurally dominated by the Meade Thrust. However, the fault-plane solution precludes this thrust from being involved in the main shock (unless it steepens to the west and has been re-activated as a normal fault at depth). An unnamed normal fault of unknown age trends north-south up the south slope of Draney Peak and extends to within a mile of the epicenter of the main event. However, this fault dips west, and because the hypocenter is probably 6-9 miles deep, this fault would not seem to be a candidate for the locale of the main shock. Other normal faults exist 6 miles or more southwest of the epicenter, but these all dip west as well. Eleven miles east of the main shock epicenter at Afton, Wyoming, normal faults bordering Star Valley extend to the north and south. The Star Valley fault has proven Holocene movement about 4,500 years ago (McCalpin and others, 1990), but it may prove to be too far from the epicenter to explain the main shock and aftershock pattern, particularly because the west-dipping fault-plane solution is steep (69°-79°).

In addition to Star Valley, two other elongated north-south basins exist in the meisoseismal area: the Tygee Creek valley and the Sage Valley (Figure 6). Border faults of these basins, though not mapped to date, would be possible candidates as the causative fault. However, these faults would have to extend well beyond the present topographic basins to explain the 18-mile-long zone of seismicity associated with the seismic sequence.

Surface rupture is not common for events of similar magnitude as the Draney Peak earthquake. Therefore, it is unlikely that geological evidence of ground breakage will be found in the area. Detailed plots of aftershock hypocenters located by the University of Utah local network should reveal more information on the actual failure plane.

## DISCUSSION

The Draney Peak sequence, though inconsequential in fatalities or damage, reminds us that much of Idaho is at high seismic risk. As with previous major seismic events in Idaho, it was only the remoteness of the epicenter from urban areas and critical facilities that averted catastrophe.

This earthquake sequence also points out, once again, the need for a statewide seismic network and an earthquake studies center in Idaho. The U.S. Geological Survey national network cannot provide sufficiently accurate epicenter locations for emergency response purposes; to this date, the National Earthquake Information Center is still locating aftershocks of this sequence inaccurately across the border in Wyoming. Regional networks (Montana, Utah, Teton Dam, Idaho National Engineering Laboratory, North Idaho Seismic Network, Boise State University, Ricks College) do not have the mission or the funding to respond to events outside their immediate areas of responsibilities. No state agency in Idaho has the equipment, funding, or personnel to launch a field team to adequately investigate seismic occurrences. Had the University of Utah somehow not managed to deploy portable instruments into this region of Idaho outside their "area of responsibility for continuous surveillance" (W. Arabasz, written commun., Feb 23, 1994), we would have few clues as the to seismotectonic significance of the Draney Peak sequence.

## REFERENCES

Anders, M.H., J.W. Geissman, L.A. Piety, and J.T. Sullivan, 1989, Parabolic distribution of circumeastern Snake River Plain seismicity and latest Quaternary faulting: Migratory pattern and association with the Yellowstone hotspot: Journal of Geophysical Research, v. 94, p. 1589-1621.

Arabasz, W.J., J.C. Pechmann, S.J. Nava, and R.B. Smith, 1994, The magnitude (Mw) 5.8-5.9 earthquake in SE Idaho of February 3, 1994, and associated shocks: University of Utah Seismic Stations Preliminary Earthquake Report, 5 p.

Blackstone, D.L., 1977, Tectonic map of the overthrust belt,western Wyoming, southeastern Idaho and northeastern Utah: Guidebook, 28th Annual Field Conference, Wyoming Geological Association.

Breckenridge, R.M. and K.F. Sprenke, 1988, Completion report, Seismic safety standards for Idaho Schools: State of Idaho Bureau of Disaster Services, 42 p.

Doser, D.I., 1990, Foreshocks and aftershocks of large (M>5.5) earthquakes within the western cordillera of the United States: Bulletin of the Seismological Society of America, v. 80, p. 110-128.

Hilt, A.P., R.M. Breckenridge, and K.F. Sprenke, 1994, Preliminary Neotectonic Map of Idaho: Idaho Geological Survey Technical Report 94-1, 1:1,000,000.

Idaho Bureau of Disaster Services, 1994, Situation Summary Report, Star Valley Earthquakes, February 3, 1994, 2 p.

McCalpin, J.P., L.A. Piety, and M.H. Anders, 1990, Latest Quaternary faulting and structural evolution of Star Valley, Wyoming, *in* S. Roberts, ed., Geologic field tours of western Wyoming and parts of adjacent Idaho, Montana, and Utah: Geological Survey of Wyoming, Public Information Circular No. 29, p. 5-14.

Nava, S.J., W.J. Arabasz, and J.C. Pechmann, 1994, The M 5.9 Draney Peak, Idaho (Idaho-Wyoming Border) Earthquake of February 3, 1994—a preliminary report (Abstract and two maps): Seismological Society of America Annual Meeting, April, 1994.

Smith, R.B., 1978, Seismicity, crustal structure, and intraplate tectonics of the western cordillera, *in* R.B. Smith and G.P. Eaton, eds., Cenozoic Tectonics and Regional Geophysics of the Western Cordillera: Geological Society of America Memoir 152, p. 111-114.

U.S. Geological Survey-National Earthquake Information Center, 1994, Afton, Wyoming Earthquake Series, Listing of events January 30, 1994-February 14, 1994, 3 p.

Zoback, M.D. and M.L. Zoback, 1991, Tectonic stress field of North America and relative plate motions, *in* D. Burton Slemmons, E.R. Engdahl, M.D. Zoback, and D, Blackwell, eds., Neotectonics of North America: Geological Society of America Decade Map Volume, p. 339-366.

Table 1. Modified Mercalli Intensity Scale

| | |
|---|---|
| I. | Not felt except by a very few under especially favorable circumstances. |
| II. | Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. |
| III. | Felt quite noticeably indoors, especially on upper floors of buildings, but many people did not recognize it as an earthquake. Standing motor cars may rock slightly. Duration estimated. |
| IV. | During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed walls made cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. |
| V. | Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles and other tall objects sometimes noticed. Pendulum clocks may stop. |
| VI. | Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. |
| VII. | Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars. |
| VIII. | Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbed persons driving motor cars. |
| IX. | Damage considerable in specially designed structures; well designed frame structures thrown out of plumb great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. |
| X. | Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundation, ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks of rivers, canals, etc. |
| XI. | Few if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly. |
| XII. | Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air. |

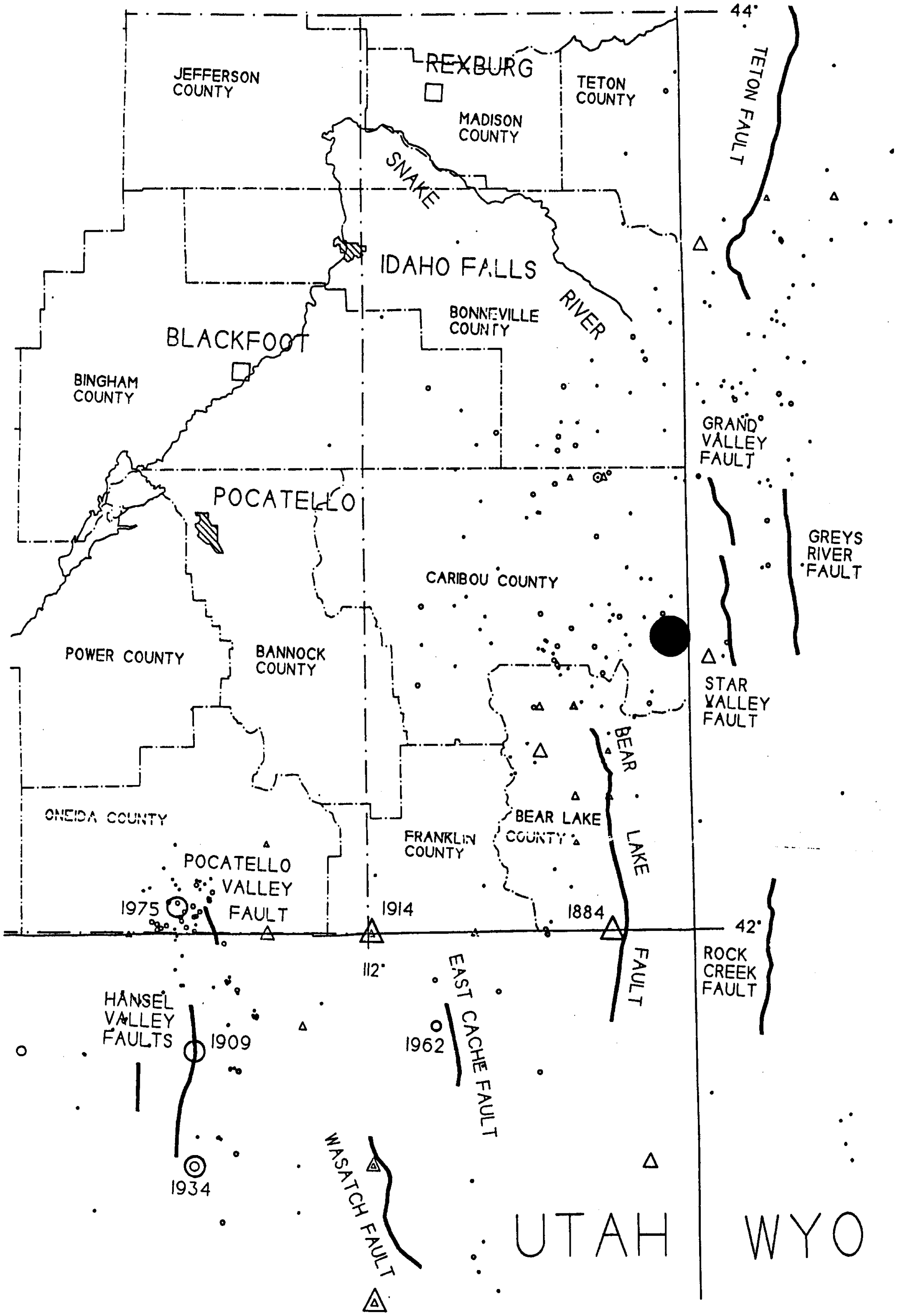



Figure 1. Location map of the Draney Peak sequence, historic seismicity, and proven active faults in southeastern Idaho. After Hilt and others, 1994.

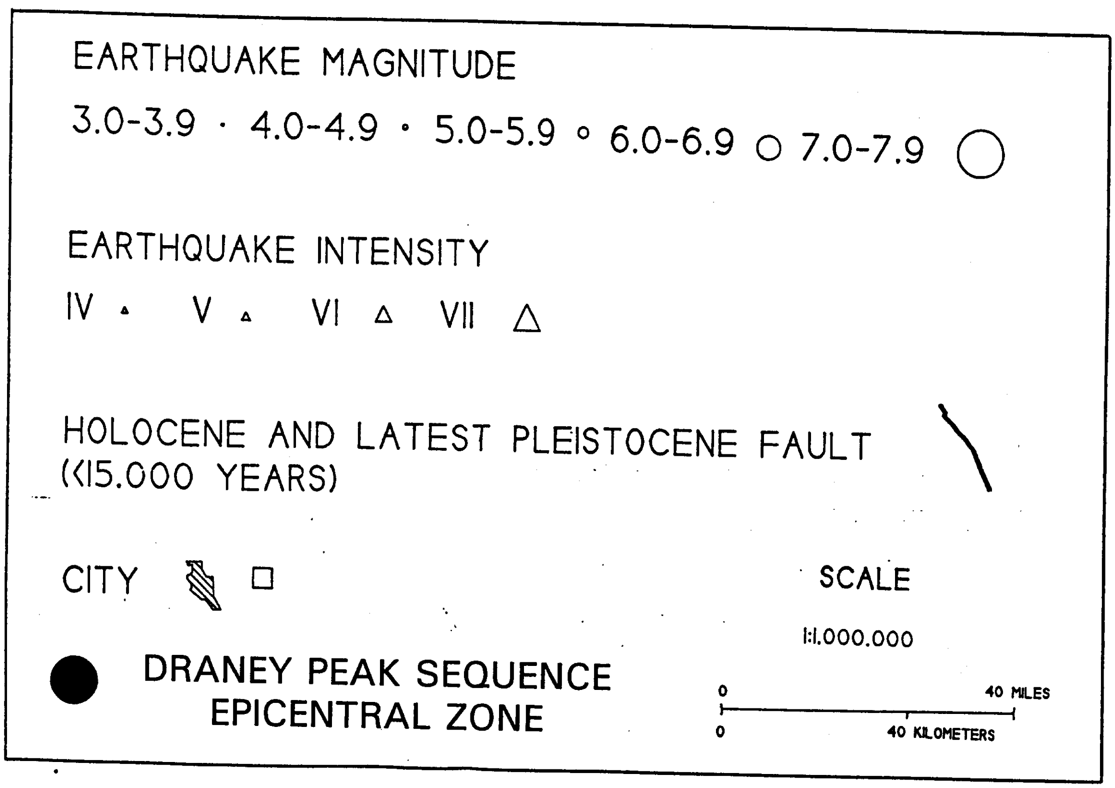



Figure 1 (continued). Legend for seismotectonic map.

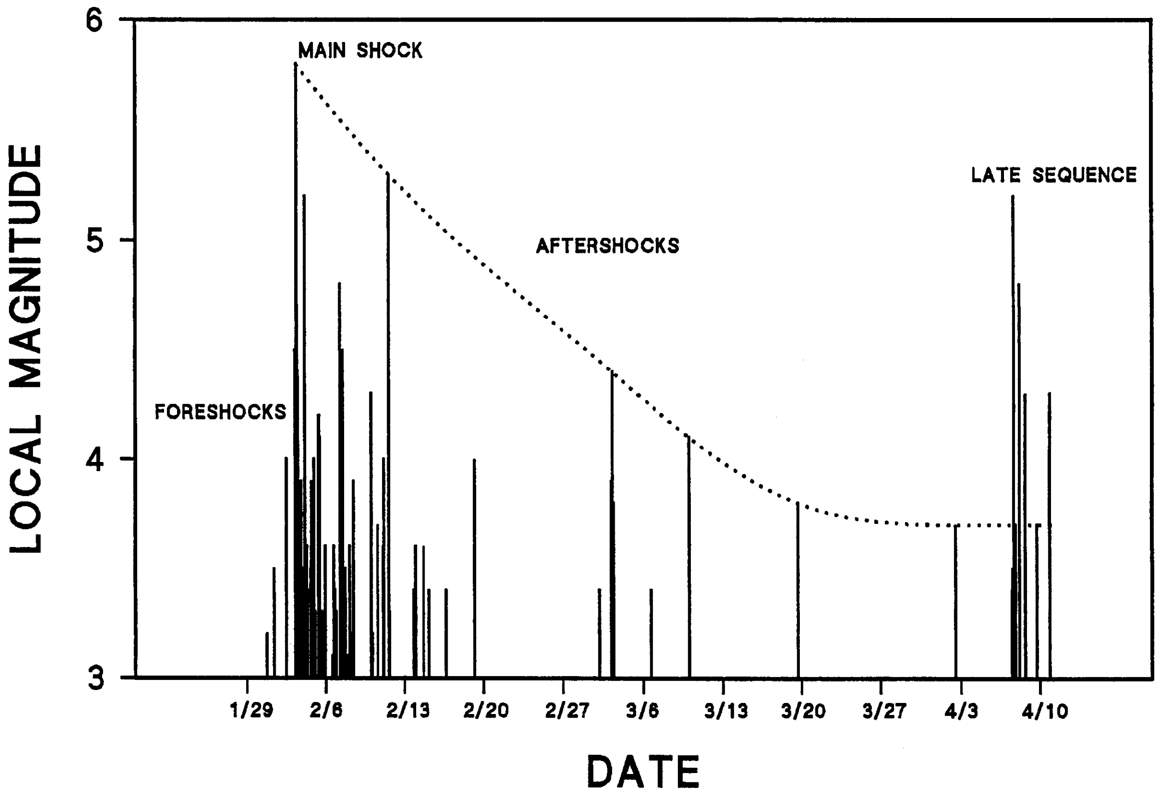



Figure 2. The Draney Peak seismic sequence. Only events above ML 3 are shown. Magnitudes and times for the main sequenec are as reported by the U.S. Geological Survey (1994), for the late sequences are as recorded by the Eerthquake Studies Office, Montana Bureau of Mines and Geology. The dotted line shows the smooth decay in magnitude of the main sequence, and the anomalous nature of the late sequence.

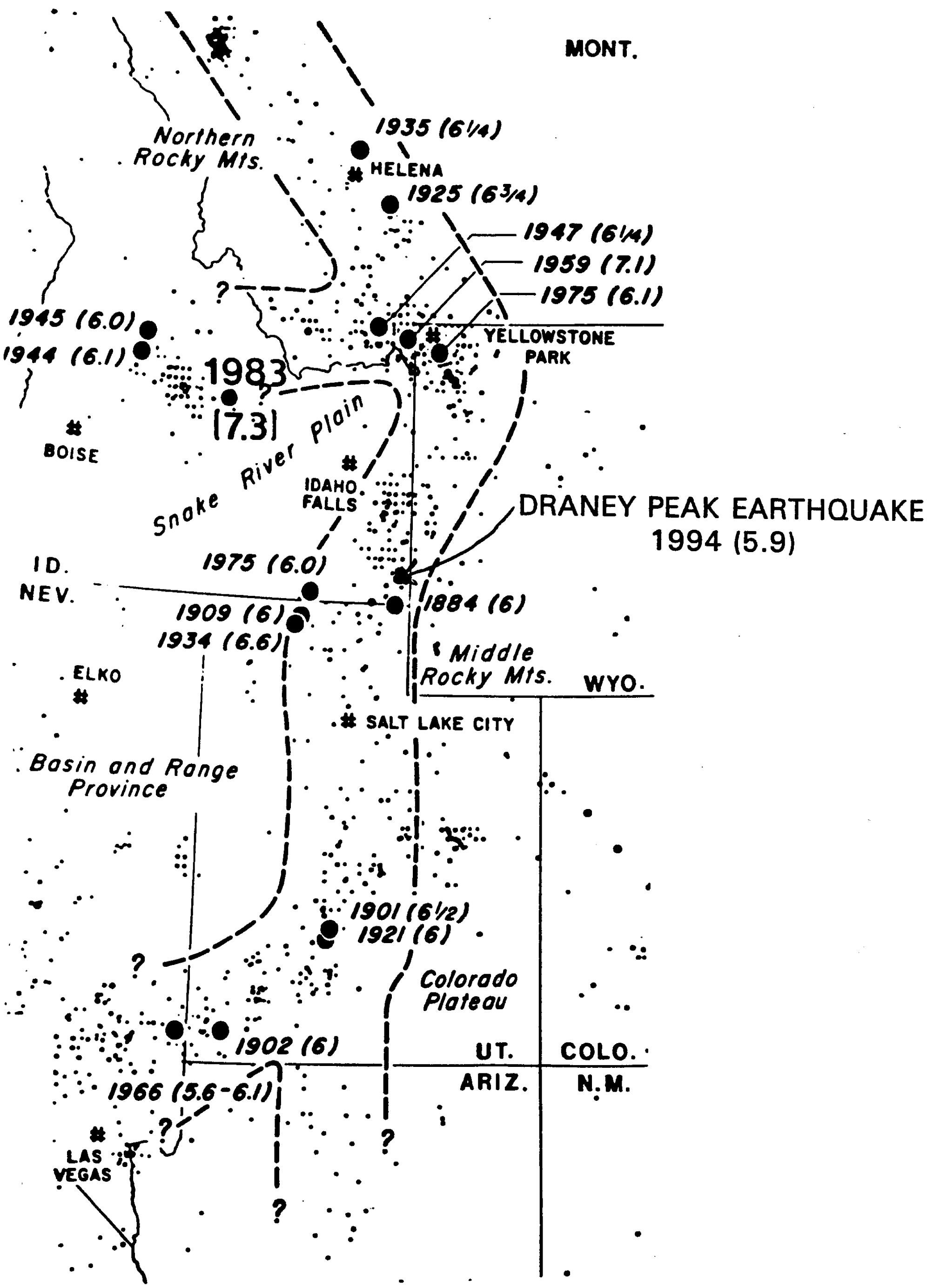
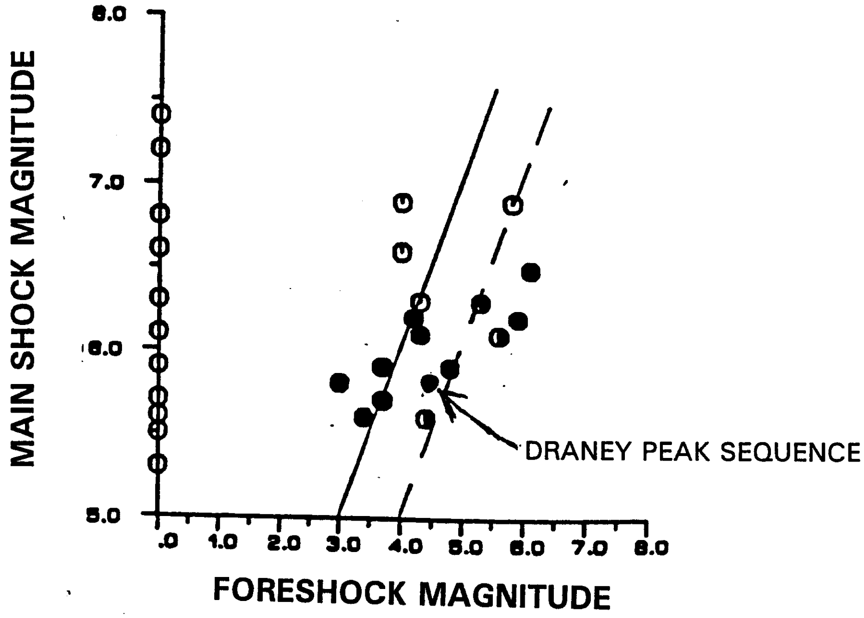



Figure 3. The location of the Draney Peak earthquake within the Intermountain Seismic Belt. Modified from Smith (1978).



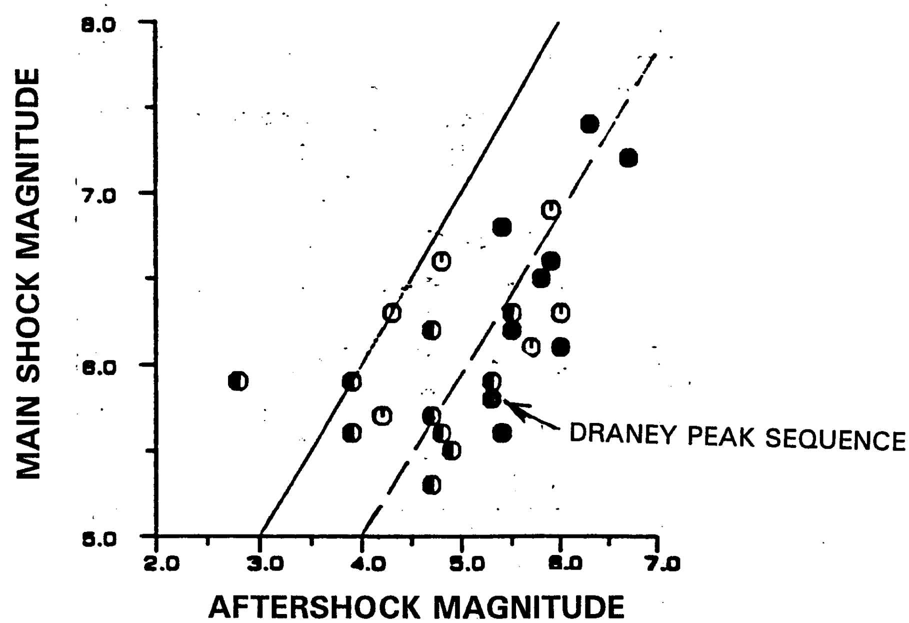




Figure 4. The magnitudes of the largest foreshock and aftershock of the Draney Peak sequence compared to other large historic seismic sequences in the western cordillera. Modified from Doser (1990).

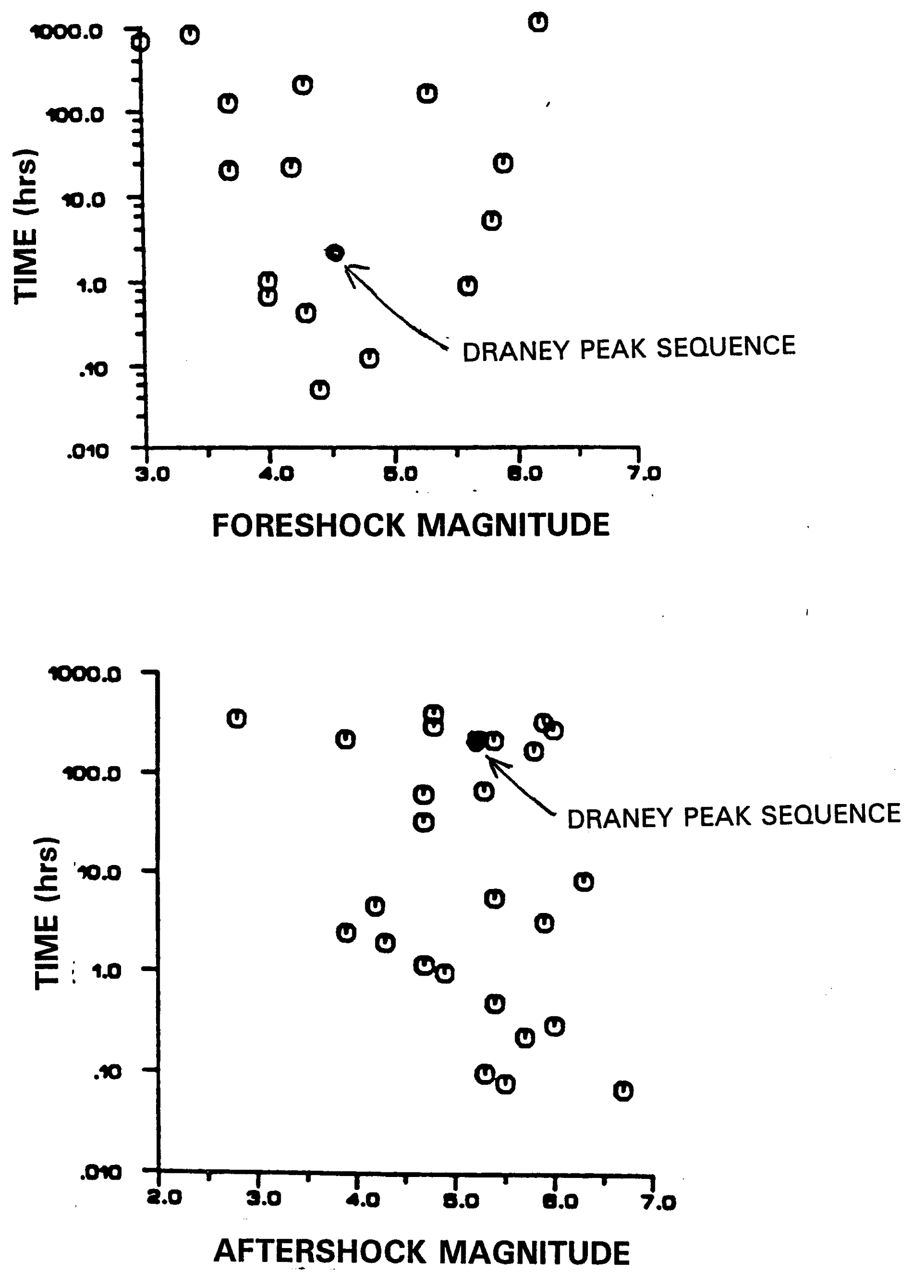



Figure 5. The timing, relative to the main shock, of the largest foreshock and largest aftershock of the Draney Peak sequence. Modified from Doser (1990).

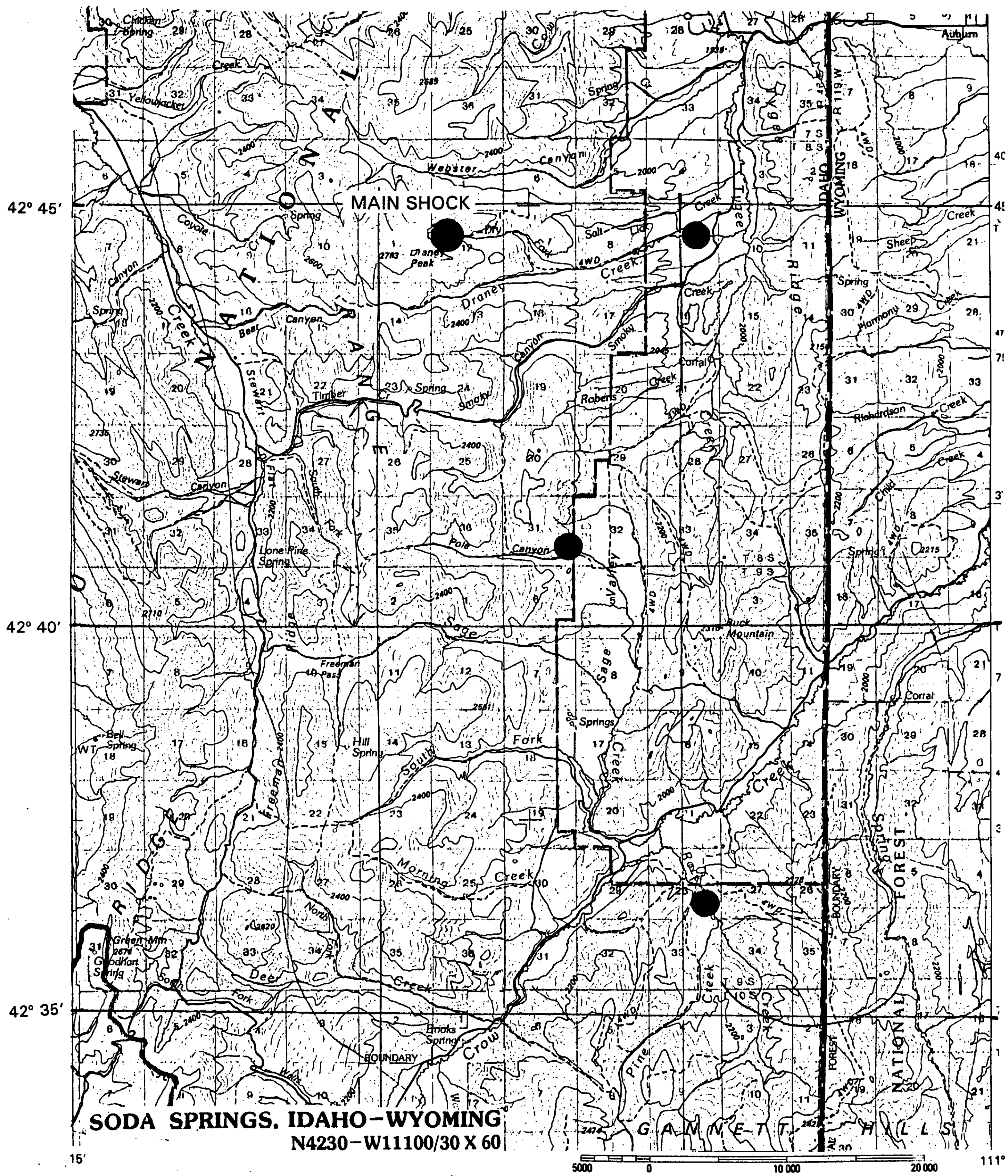



Figure 6. Epicenter locations of the main shock and three largest aftershocks of the main Draney Peak sequence. These locations are from the University of Utah, based on regional network data (Nava, 1994).

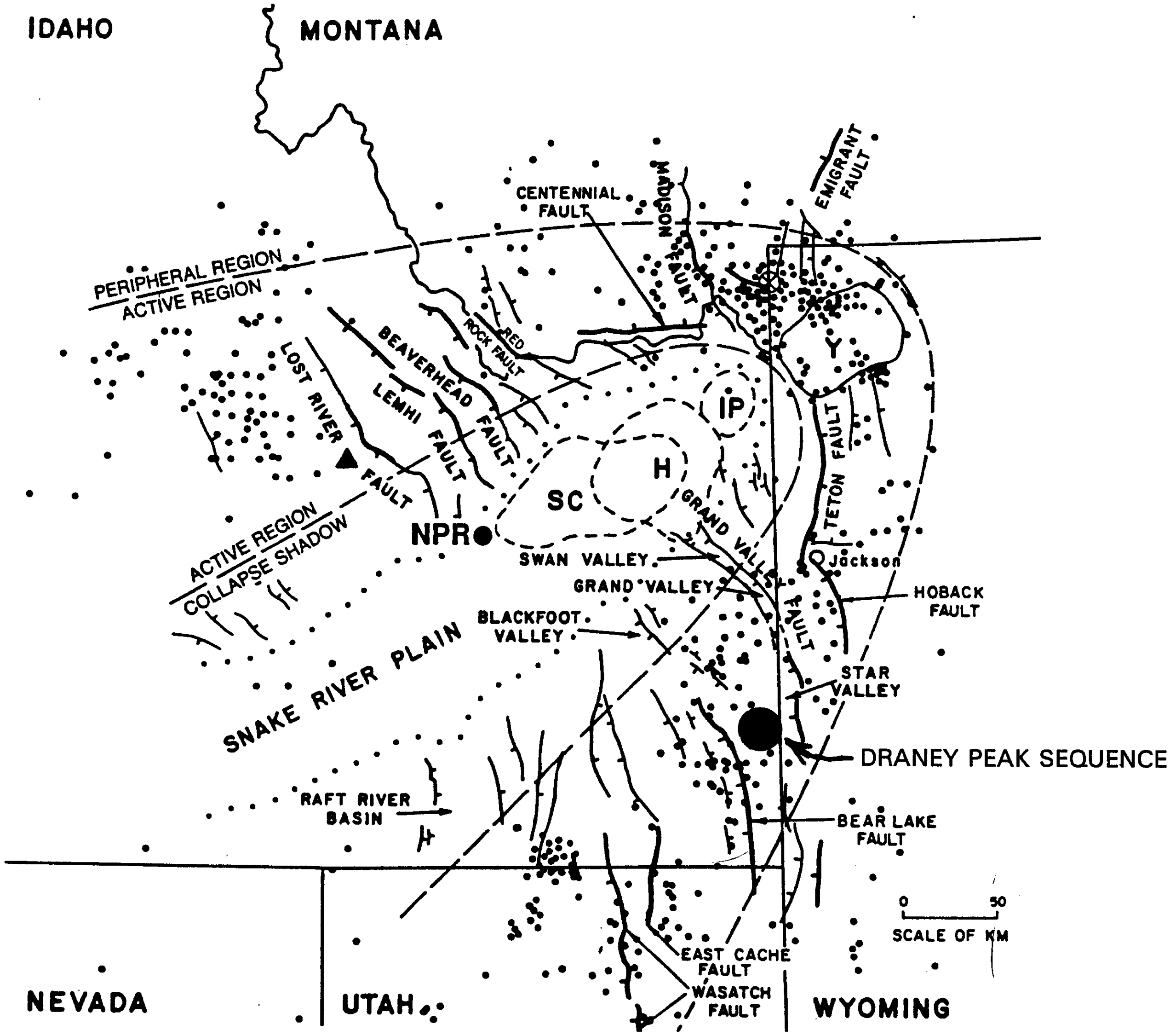



Figure 7. The location of the Draney Peak sequence within the seismic parabolas about the eastern Snake River Plain. Dots are historic earthquakes ($M > 3$); dark curves are latest Quaternary faults; light lines are Cenozoic faults; dotted curve is limit of eastern Snake River Plain; dashed line of inner parabola represents the hypothetical limit of the seismically quiescent collapse shadow of the hotspot; outer parabola is the boundary between the seismically active region and the surrounding peripheral region of less active basin and range extension.; dashed circles represent silicic calderas of decreasing ages as Yellowstone is approached. Modified from Anders (1989).

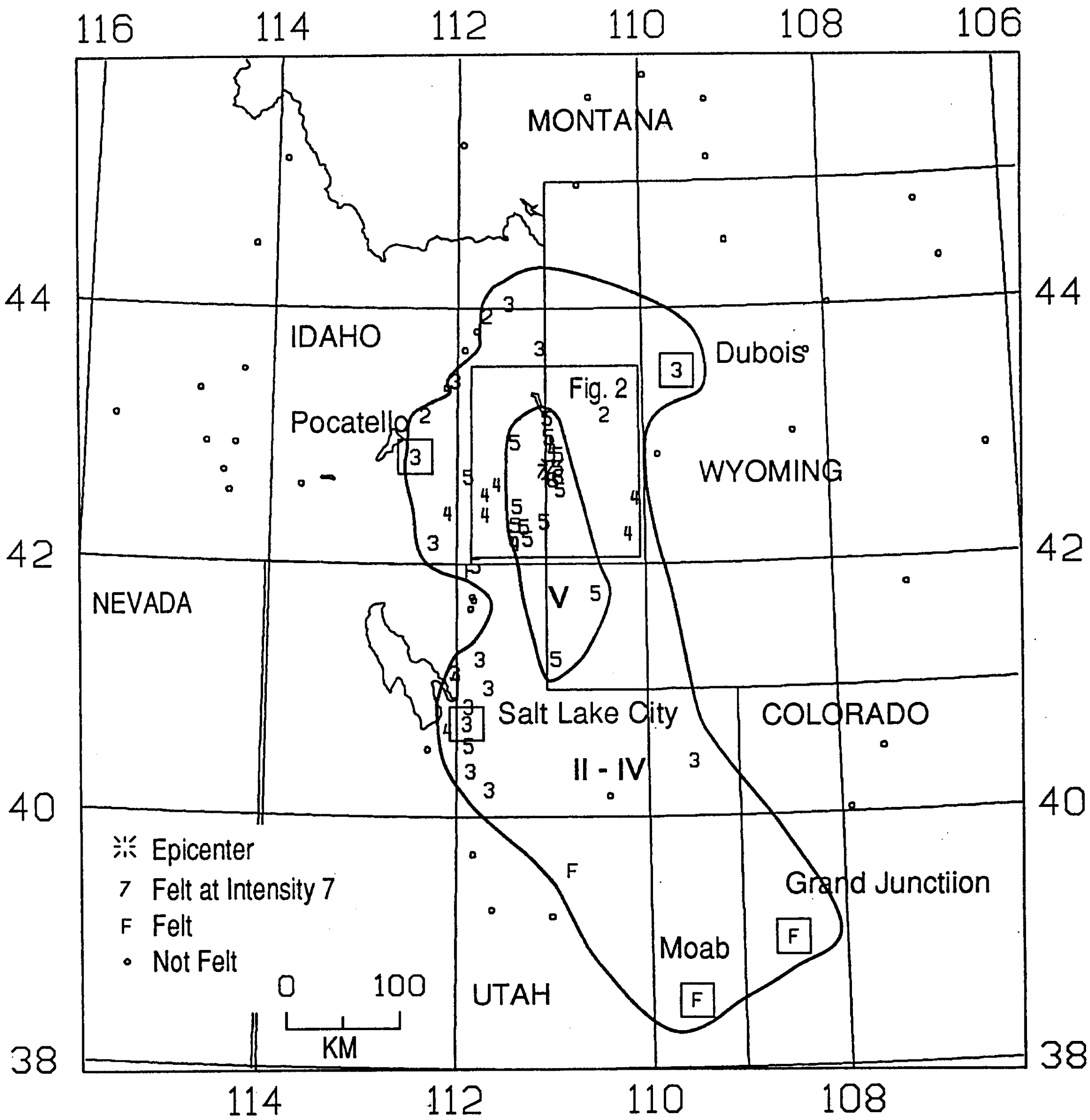



Figure 8. Preliminary U.S. Geological Survey far-field isoseismal map for the Draney Peak earthquake (J. Dewey, written commun., March 4, 1994).

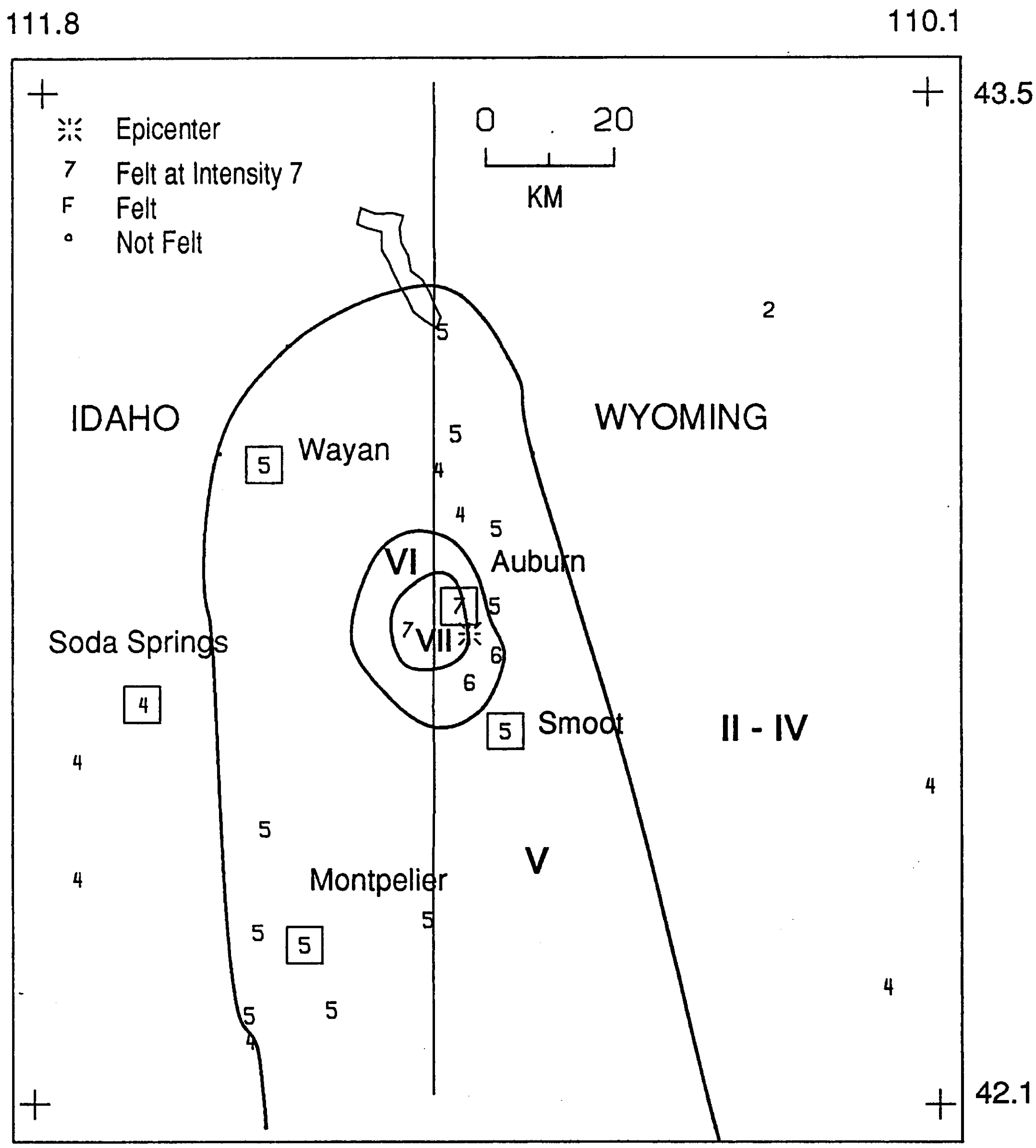



Figure 9. Preliminary U.S. Geological Survey near-field isoseismal map for the Draney Peak earthquake (J. Dewey, written commun., March 4, 1994).

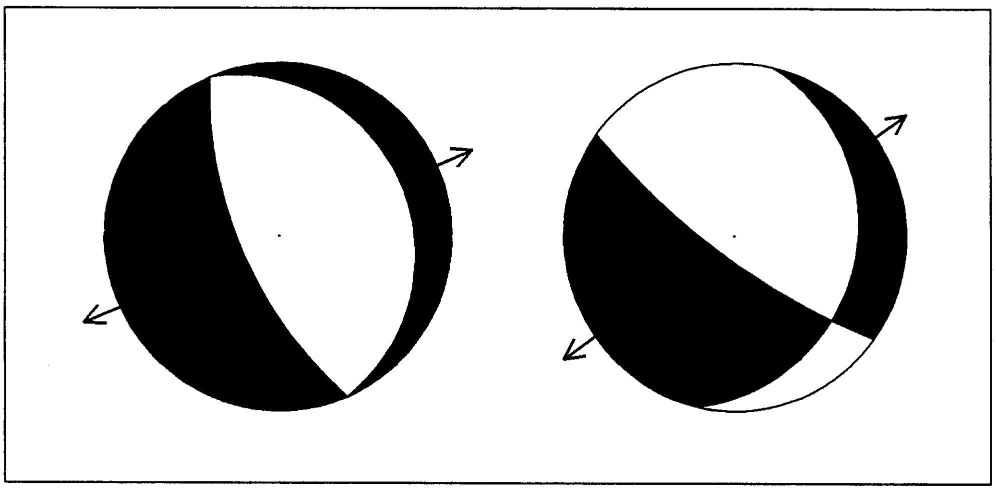


Figure 10. Fault-plane solutions for the Draney Peak earthquake, main shock: Harvard (left), U.S. Geological Survey (right). Compressional quadrants are dark. The Harvard solution is pure dip-slip; the U.S. Geological Survey solution is dominantly dip-slip but includes some right-lateral strike-slip on the SW dipping plane or left-lateral slip on the east dipping plane.

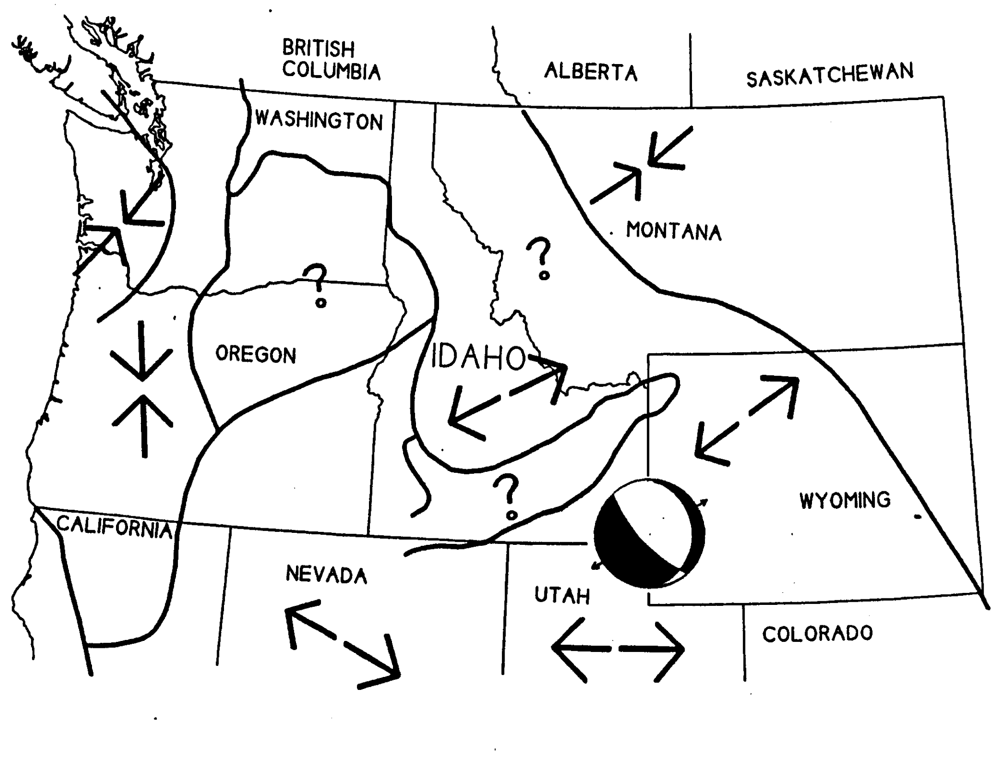



Figure 11. The mean fault-plane solution for the Draney Peak main shock plotted on a map of regional stress. Modified from Zoback and Zoback (1991).

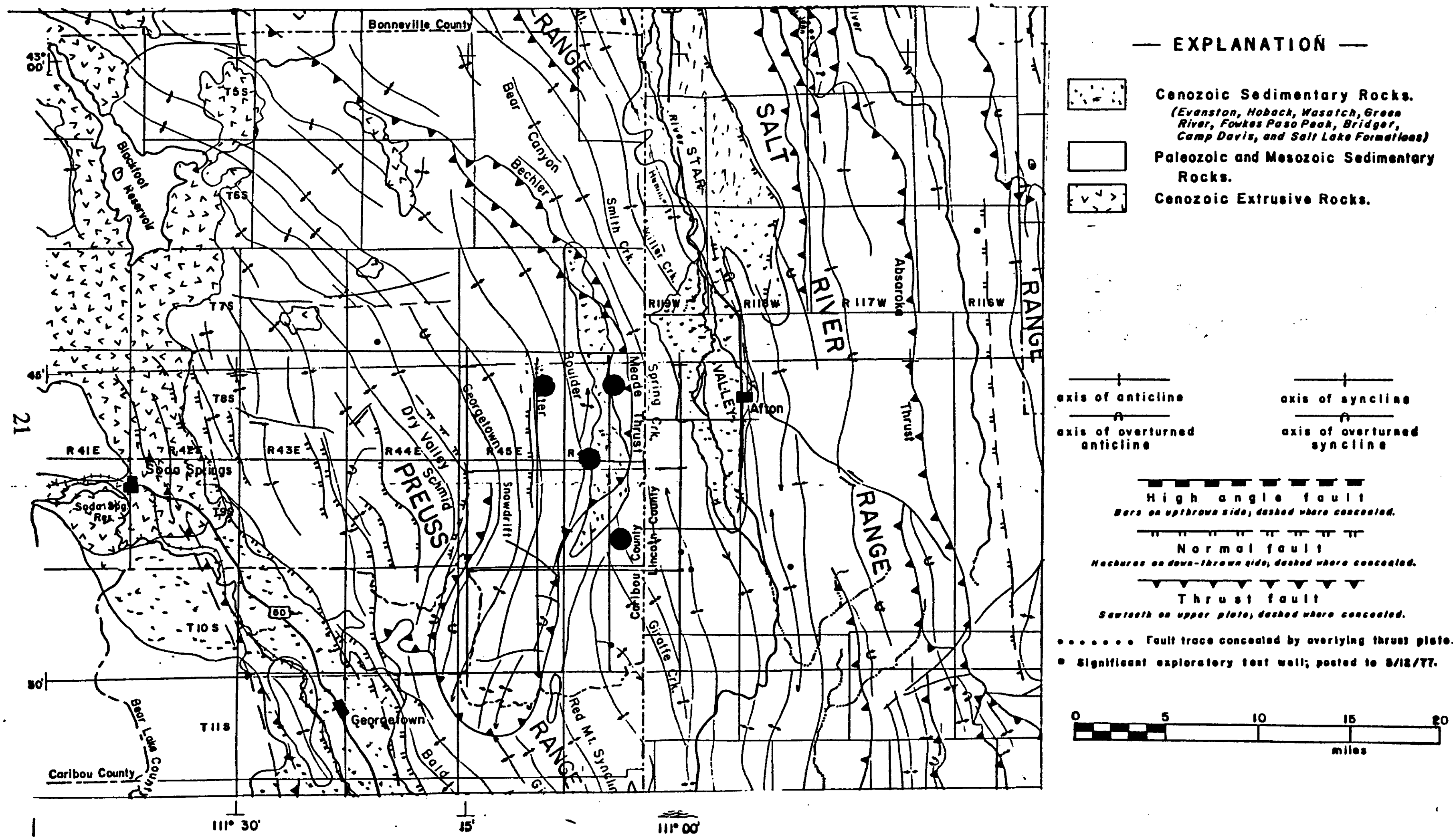



Figure 12. The Draney Peak main shock and three largest aftershocks plotted on a tectonic map of the larger epicentral area. Modified from Blackstone (1977).