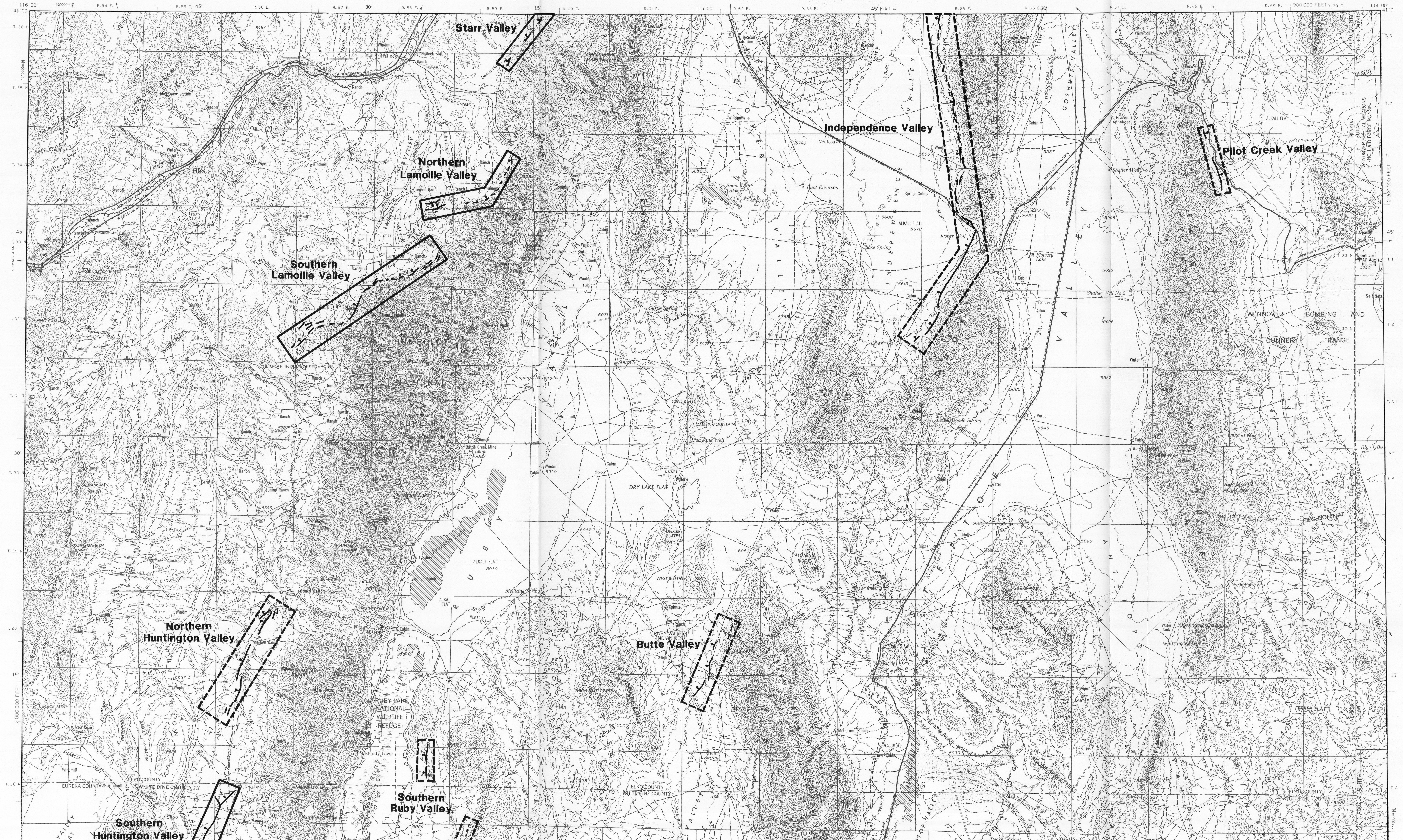
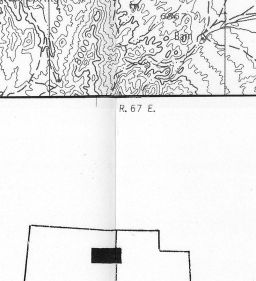


Base from U.S. Geological Survey, 1962

Data collected by T. P. Barnhard, assisted by P. C. Thenhaus, 1980-1981

SCALE 1:250 000

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
NATIONAL GEODETIC VERTICAL DATUM OF 1929



MAP OF FAULT SCARPS FORMED IN UNCONSOLIDATED SEDIMENTS, ELKO 1°X2° QUADRANGLE, NEVADA AND UTAH

By
Theodore P. Barnhard

1985

EXPLANATION

FAULT SCARP—Showing inferred age of surface faulting. Bar and ball on downthrown side

Holocene or latest Pleistocene

Late Pleistocene

INTRODUCTION

The accompanying map shows nine areas where fault scarps formed in unconsolidated sediments in the Elko 1°X2° quadrangle, northeastern Nevada and westernmost Utah. The faulted sediments include pebbly to bouldery colluvium, alluvium, and pediment gravels. They are inferred to have been deposited in Quaternary time during the last phase of basin-filling sedimentation.

Because the map shows only scarps in unconsolidated sediments, it does not show all Quaternary faults that could produce earthquakes. A comprehensive map of all Quaternary faults would also include those in bedrock and at the bedrock-alluvium contacts, as well as Quaternary faults that appear only as lineaments in surficial deposits. I have chosen not to connect discontinuous segments of on-strike fault scarps unless there is compelling evidence of such continuous surface rupture.

Initial mapping involved photointerpretation of 1:60,000-scale black-and-white aerial photographs for the entire map area. A map of suspected fault scarps compiled at a scale of 1:250,000 served as a guide for subsequent field studies. With the good to excellent 1:60,000-scale aerial photography available, offsets as small as 1 m can be detected if the faults cut planar surfaces of considerable extent.

Field studies consisted of (1) confirming fault scarps and deleting from the preliminary map those features that are not fault related or that have no surface offset (lineaments), (2) searching for stratigraphic indicators of amount and age of offset, and (3) measuring surface profiles according to procedures described in Bucknam and Anderson (1979a). Selected fault scarps were profiled where they are sufficiently continuous and unmodified by deposition or erosion such that they accurately show the surface offset.

During periods of low-sun-angle illumination (early morning or late afternoon), additional field searches were made for ground ruptures that had not been identified during the photointerpretation phase of the study. No new scarps were found.

This study ranks fault scarps or groups of scarps according to their relative age and demonstrates the amount of surface rupture associated with these Quaternary fault scarps. This map is one of a series of similar maps of western Utah (Anderson and Bucknam, 1979; Bucknam and Anderson, 1979b) and central Nevada (Wallace, 1979) that assign relative ages to fault scarps. Relative dating of fault scarps can be used as a guide to the frequency and location of relatively large earthquakes, averaged over thousands of years. For large regions, geologically determined rates of seismic activity in the Basin and Range are generally in good agreement with rates determined from historic seismicity (Bucknam and Algermissen, 1984). Fault-scarp studies such as this have been used as a guide in locating boundaries of seismic source zones used in probabilistic earthquake hazard estimates of the Basin and Range physiographic province (Thenhaus and Wentworth, 1982; Bucknam and Thenhaus, 1983). The author would appreciate comments, corrections, and additional data pertinent to this study.

GEOGRAPHIC AND GEOLOGIC SETTING

The Elko 1°X2° quadrangle lies within the north-central Great Basin (as defined by Fenneman, 1946), in the Basin and Range province of the Western United States. The primary topographic elements in the map area are structurally controlled. They consist of relatively narrow, north-trending ranges and broader intervening basins. Alluviated basins lie at elevations of 6,000 ft or less and make up about 60 percent of the map area. The remaining area consists of mountain ranges, most above 10,000 ft (fig. 1).

Bedrock exposed in the mountain ranges varies in age from Precambrian to Tertiary (Stewart and Carlson, 1978). With the exception of the northern half of the Ruby Mountains and the East Humboldt Range, the mountain ranges are composed of Paleozoic marine sedimentary rocks and lesser amounts of Tertiary volcanic rocks. The northern half of the Ruby Mountains and the East Humboldt Range are composed mainly of pegmatitic granite and other granitic rocks complexly intermixed with metasedimentary rocks. The northwest corner of the map area consists mainly of Tertiary tuffaceous sedimentary rocks, with the exception of stream-channel deposits. This area has a notable absence of Quaternary deposits (fig. 1).

About 65 percent of the map area is covered by Quaternary (60 percent) and Tertiary (5 percent) sediments; thus, about two-thirds of the map area was studied. The Quaternary sediments consist of alluvium, colluvium, pediment gravels, playa deposits, and lacustrine sediments deposited in Lake Bonneville or in other late Pleistocene lakes that occupied closed basins. Quaternary volcanic rocks are absent throughout the map area (Hope and Coats, 1976). With the exception of sparse late Pleistocene glacial deposits and Holocene stream-channel deposits, Quaternary deposits are generally limited to, and accumulated in, structurally controlled basins.

Pleistocene Lake Bonneville occupied about 5 percent of the map area at its highest stand (5,150 ft), which occurred 14,000-15,000 years ago (Scott and others, 1982). The western shores of Lake Bonneville extended only into the part of the map area east of the Goshute Mountains and the Toana Range. Basins west of, and at higher elevations than, Lake Bonneville were occupied by less extensive Pleistocene lakes (Snyder and others, 1964) in Clover, Independence, Goshute, Ruby, and Steptoe Valleys.

No fault scarps were identified on Pleistocene lake deposits or Holocene playa deposits in this study. The geographic distribution of fault scarps, particularly older scarps, may be influenced by two non-paleoseismic factors. The sparse distribution of Quaternary alluvial deposits in the northwestern part of the map area limits the potential for scarp recognition. Secondly, there is less potential for preservation of old surfaces west of the Ruby Mountains on which scarps could be recognized. In this area, most erosion is associated with the externally draining Humboldt River (fig. 1). Though these factors may preclude recognition of some pre-late Pleistocene scarps, it is unlikely that any Holocene, and possibly late Pleistocene, scarps have gone undetected.

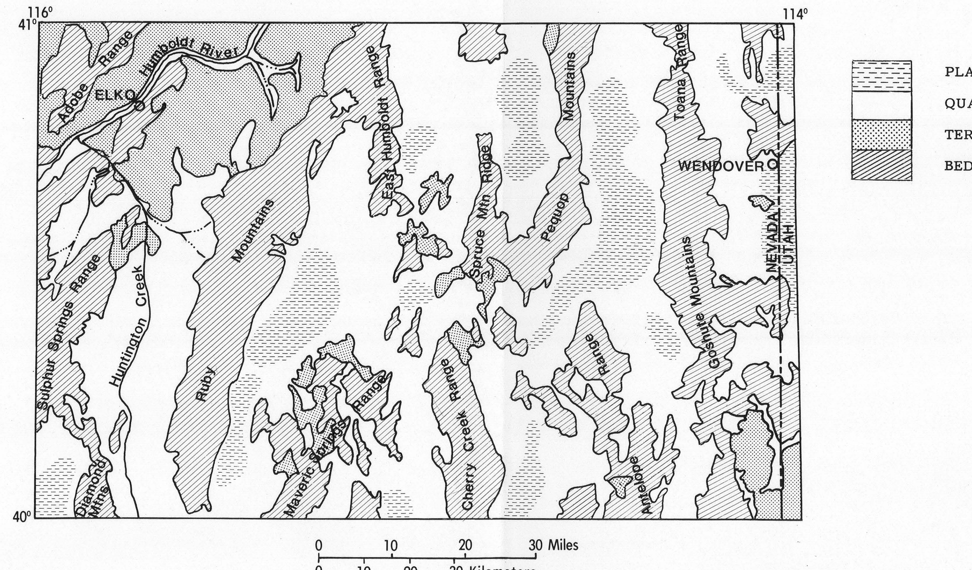


FIGURE 1.—Generalized geologic map of the Elko 1°X2° quadrangle.

METHOD FOR DETERMINING AGES OF FAULTING

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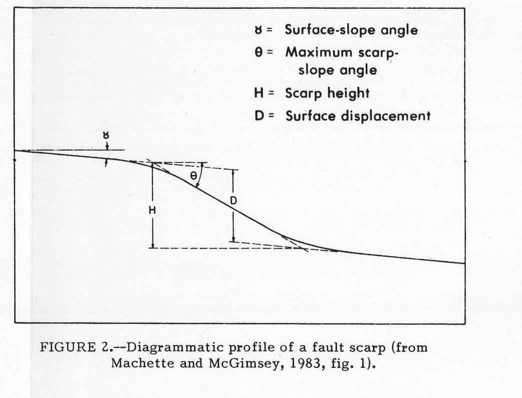


FIGURE 2.—Diagrammatic profile of a fault scarp (from Machette and McGimsey, 1983, fig. 1).

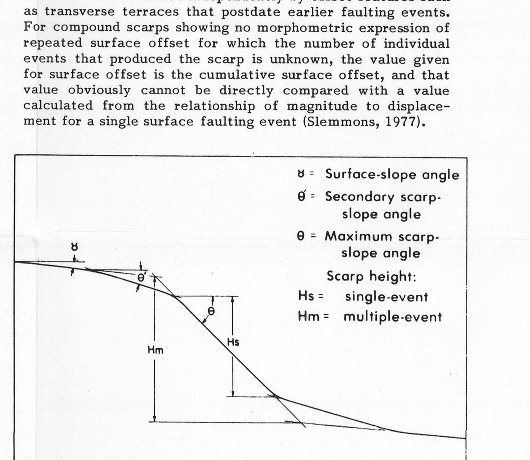
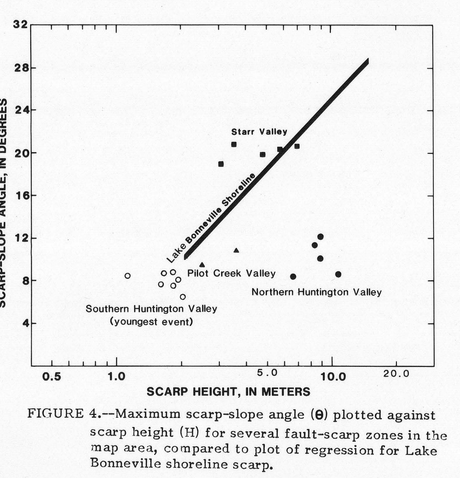
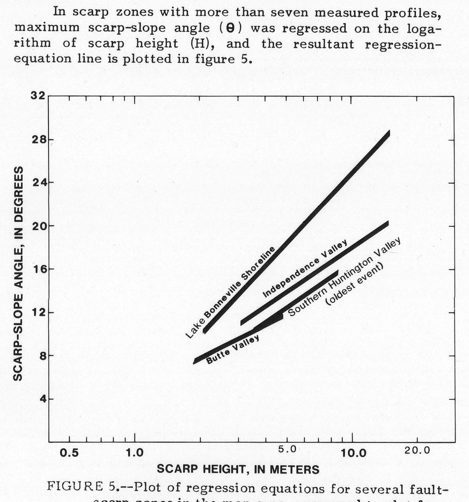


FIGURE 3.—Diagrammatic profile of a compound fault scarp (from Machette and McGimsey, 1983, fig. 3).





Butte Valley

In Butte Valley, west of the Cherry Creek Mountains, a zone of scarps 10 km long trending north-northeast to south-southwest displaces Quaternary deposits down to the west. Scarps in the Butte Valley zone (BVZ) are formed in Quaternary alluvial and colluvial deposits and are preserved only on stable alluvial-fan surfaces. There is no geomorphic evidence of Holocene movement. A lack of inflections in profiled scarps and the presence of unfaulted deposits in major and minor stream channels that cross the zone are indicators of antiquity. Along some segments of the BVZ, the only geomorphic evidence of faulting is a vegetation lineation that has no measurable surface offset.

Nine profiles measured along the BVZ indicate scarp heights ranging from 1.7 to 4.8 m (table 1). The BVZ is the oldest of the zones for which a regression equation was determined by regression analysis (fig. 5). Compared to plots of regression equations for the Independence Valley and southern Huntington Valley zones, the BVZ has a lower scarp height with increasing slope angle. An absence of offset Holocene stream deposits, lack of evidence of recurrent movement, and the position of the scarp data (fig. 5) indicate that the BVZ is probably late Pleistocene in age.

Pilot Creek Valley

An 8-km-long zone of fault scarps lies topographically above the highest stand of Lake Bonneville along the east flank of the Toana Range in Pilot Creek Valley. Offset Quaternary deposits are fine-grained pebbly gravels that are displaced down to the east.

Fault-scarp profiles and profiles of the Lake Bonneville shoreline scarp in the Pilot Creek Valley zone (PVZ), provided by R. C. Bucknam, indicate that the surface-faulting event that produced the fault scarp was earlier than the Lake Bonneville shoreline scarp (fig. 4), and a late Pleistocene age has been assigned to the PVZ.

CONCLUSIONS

Morphologic and geologic data collected on Quaternary faults that offset basin-fill deposits in the map area indicate that most (six out of nine) were formed during the late Pleistocene (10,000-150,000 years B.P.).

Surface rupturing of Holocene or latest Pleistocene (less than 15,000 years) age in the map area is restricted to faults in Starr Valley, northern and southern Lamoille Valley, and southern Huntington Valley, all of which are on the west flank of the Ruby Mountains. Surface ruptures of late Pleistocene age (10,000-150,000 years B.P.) were identified in northern Huntington Valley, Ruby Valley, Butte Valley, Independence Valley, and Pilot Creek Valley.

Recurrent fault movement is indicated in three zones. Southern Huntington Valley has a steeper scarp segment superposed on the older scarp and offset stream bottoms that incised the older scarp. Recurrent movement in northern Huntington Valley and Independence Valley is indicated by scarps that exceed 10 m in height.

The age of faulting becomes younger, and the geographic concentration of fault scarps increases to the west across the map area. Interestingly, the geographic distribution of historic seismicity follows a similar trend. A plot of historic seismicity (Askew and Algermissen, 1983) shows that seismicity, although sparse, increases in both number of events and magnitude to the west across the map area. The western part of the map area just overlaps the eastern part of a broad region of western and northern Nevada characterized by widely scattered, narrow belts of Holocene faulting (Wallace, 1978) (fig. 6). Farther west of the map area, and central to the region of scattered Holocene faulting, historic surface faulting has been associated with large-magnitude (M≥7) earthquakes along a north-trending, nearly continuous narrow zone (10-30 km), referred to as the Ventura-Winnemucca seismic zone (Ryall and others, 1966), that extends from northern Nevada south to California.

East of the map area, in Utah, is a north-trending region of Holocene faulting that extends westward from the Wasatch-Hurricane fault system to just east of the Nevada-Utah state line (fig. 6). Between the two broad regions of Holocene faulting is a north-trending region characterized by the absence of Holocene surface faulting.

The map area lies mostly in the region characterized by the absence of Holocene faulting, but the western part of the map area extends east into the region of Holocene surface faulting in the Basin and Range province.

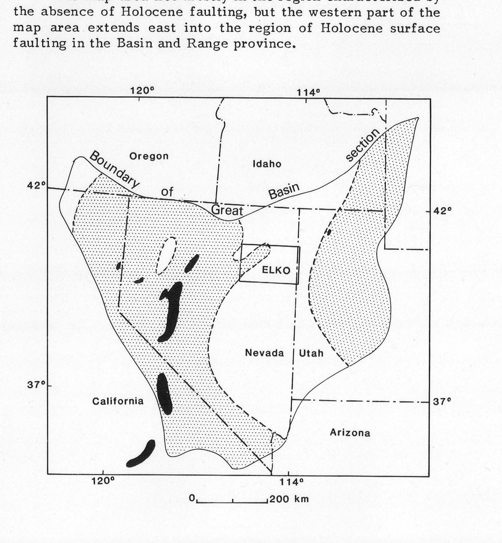


FIGURE 6.—Map showing age and distribution of surface faulting in the Great Basin section (from Wallace, 1979).

Table 1.--Fault-scarp parameters showing chronological implications, Elko 1°X2° quadrangle, Nevada and Utah

[R^2, coefficient of determination; S.D., estimate of standard deviation of θ; N, number of profiles measured; leaders (---) indicate regression equation, R^2, and SD not computed because inadequate number of profiles measured; ND, no data; NA, not applicable]

Fault-scarp zone or shoreline scarp	Regression equation	R^2	S.D.	N	Range of scarp heights (m)	Length of zone (km)
Ranking based on profile data						
Lake Bonneville Shoreline[1].....	$\theta = 3.66 + 21.4 \log H$	91	1.6	61	2.0 - 15.1	NA
Independence Valley............	$\theta = 4.64 + 13.7 \log H$	76	1.7	11	3.0 - 14.9	40
Southern Huntington Valley[2]....	$\theta = 2.69 + 14.1 \log H$	70	1.2	13	3.4 - 8.3	15
Butte Valley (oldest)..........	$\theta = 4.38 + 10.8 \log H$	72	1.2	9	1.7 - 4.8	10
Ranking based on qualitative evaluation of scarp morphology						
Starr Valley (youngest)........	---	---	---	5	3.2 - 6.2	7
Lamoille Valley................	---	---	---	N.D.	N.D.	14 (northern) 22 (southern)
Lake Bonneville shoreline[3]						
Southern Huntington Valley[4]....	---	---	---	7	1.1 - 2.0	15
Pilot Creek Valley.............	---	---	---	2	2.7 - 3.8	8
Northern Huntington Valley.....	---	---	---	5	6.6 - 10.8	14
Southern Ruby Valley...........	---	---	---	N.D.	N.D.	5 (northern) 8 (southern)

[1] R. C. Bucknam, written commun., 1982.
[2] Parameters for oldest event along southern Huntington Valley zone.
[3] Inferred relative position of time of highest stand of Lake Bonneville: 14,000-15,000 years ago.
[4] Parameters for youngest event along southern Huntington Valley zone.

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