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MEMORANDUM

January 3, 1995

TO: Dennis Strong
FROM: Ben Everitt
SUBJECT: Activity classification of the Saleratus Creek Fault (?)

Introduction

During preparation of the inventory of seismically active structures in Utah (Hecker, 1993), the Utah Geological Survey (UGS) identified a structure which it called the "Saleratus Creek Fault" (Hecker No. 11-6). The postulated Saleratus Creek Fault (?) extends south-southwest along the eastern margin of Saleratus Creek Valley, south of the town of Woodruff in Rich County (Figure 1). If considered active, it could provide a significant earthquake source for Woodruff and Birch Creek Dams.

Lamerson (1982, Fig. 3) first mapped the linear contact between the Tertiary Wasatch Formation and Quaternary alluvium along the eastern margin of Saleratus Creek Valley as a normal fault, but did not suggest that it was active. It does not appear in either Gibbons and Dickey's (1983) compilation of Quaternary faults or McCalpin's (1993) review. Hecker's notes (memo of August 13, 1987 to UGS) first suggested the possibility of active faulting along Saleratus Creek. She classified it as green (middle to late Pleistocene: 10,000 to 750,000 years), which is not very well constrained in age.

To resolve some of the uncertainty, Dan Aubrey and I have reviewed it to assign it an activity classification relative to the State Engineer's criterion of 35,000 years.

Regional geology

History. Rich County lies in the Utah-Wyoming thrust belt, characterized by imbricate sheets of rock displaced eastward by low angle thrust-faulting during Cretaceous and Paleogene time (Figure 2). The major thrust faults are younger eastward, with the Crawford thrust dated as mid-Cretaceous (pre-Wasatch) in age (Lamerson, 1982). Eastward-thinning sheets of conglomerate are associated with each thrust fault, and represent the piedmont alluvial deposits derived from the wearing down of successive up-thrust mountain ranges.

During Neogene time, and continuing to the present, crustal stresses have been reversed, and the area has been subjected to normal faulting, mostly with down-to-the-west displacement. The known normal faults as mapped by Hecker (1993) appear in Figure 1.

Stratigraphy and structure. The structure of the Crawford Mountains is well known because of oil exploration (Ott and others, 1985). Except for the Crawford Mountains, the area near Woodruff is underlain by the Wasatch Formation of Eocene age, with a veneer of upper Tertiary and Quaternary sediment. The Crawford Mountains are slices of Paleozoic (older) rock thrust above and over the adjacent younger rock (Fig. 3), and bounded by faults. The fault on the east is a thrust fault, called the Crawford Thrust, along which the Crawford Mountain block was uplifted in mid Cretaceous time (Lamerson, 1982). The fault to the west, which Ott (1980) called the Leefe Fault (Hecker's Crawford Mountains west side fault, #11-4), is a normal fault, which probably represents where later backsliding on the Crawford Thrust at depth broke to the surface, as shown in Figure 3, sections A, B, and C. Deposition of the Wasatch Formation is bracketed by the activity of these two faults, being younger than the Crawford thrust and older than the Leefe normal fault.

Gravity surveys suggest that the Crawford Mountain structure ends at the south end of the Crawford Mountains, perhaps cut off by a buried east-west strike slip fault (Hurst, 1982). Most workers, beginning with Royse and others (1975, Figure 1, reproduced by Lamerson, 1982, Figure 1, and herein as Figure 2) have continued the Crawford Thrust southward along Saleratus Creek as a dashed or queried line. Lamerson (1982) was the first to show it as a normal fault, apparently believing that if it offsets the Wasatch Formation of Eocene age, it must therefore postdate the activity of the Crawford thrust as deduced from relationships elsewhere. Some evidence, however, suggests that thrust-uplift of the Crawford Mountains continued into post-Wasatch time (Baer, 1985).

Gravity anomaly. The regional gravity map (Cook and others, 1989) shows a westward gravity gradient along the Leefe fault, with a gravity depression beneath the adjacent Bear River valley. The gravity depression suggests a Neogene basin filled with less dense sediment on the downthrown side of the fault, as shown in Figure 3, sections A and B. This gravity depression continues weakly southward, but does not underlie Saleratus Creek. The Saleratus Creek Valley is underlain by a gentle eastward gravity gradient, suggesting a subsurface structure different from the western margin of the Crawford Mountains. Borehole data likewise provides no evidence for significant down-to-the-west offset (Fig. 3, Section D).

Geomorphology of Saleratus Creek Valley

Description. Saleratus Creek flows northward and joins the Bear River near Woodruff. It flows in a strike valley eroded in the Wasatch Formation, which consists of interbedded siltstones, sandstones and conglomerates. The valley is asymmetrical, with a steep linear escarpment on the east (downdip) side, and an embayed margin with large alluvial fans on the west (updip) side. The linearity of the valley suggests control by geologic structure.

Asymmetry. The asymmetry of the valley is due to the eastward dip of the bedding, parallel to the regional slope, and the tendency for the Wasatch Formation to generate low angle bedding plane slides when conditions are favorable. Long tributaries heading at high elevation on Monte Cristo flow downdip and enter the valley from the west. Their large alluvial fans have crowded Saleratus Creek against the eastern valley margin. Tributaries entering the valley from the east are short and steep, and their alluvial fans are small.

Aggradation. The valley of Saleratus Creek, especially its lower part, shows evidence of long term aggradation, as does the Bear River Valley to which it is tributary. Evidence of aggradation includes a low gradient meandering stream with ponds and sloughs. Most of these ponds lie against the eastern margin because most of the tributary sediment arrives from the west. The general aggradation of the Bear River system is due to damming of the Bear River by lava flows at Soda Springs, Idaho, in mid-Pleistocene time (more than 35,000 years ago). Therefore aggradation, driven by distant downstream rise in base level, has been continuing in Saleratus Creek Valley throughout the time of interest to this discussion. The lakes and marshes such as Blue Grass Pond can be explained by the combination of mainstem aggradation and tributary sedimentation without resort to tectonic deformation.

Quaternary scarps. A bedrock scarp forms the eastern margin of Saleratus Creek Valley. Many springs emerge at the contact between alluvium and bedrock which are responsible for vegetation lineations visible on aerial photographs. Near the mouth of Negro Dan Hollow, in Sections 6, 7, and 18 of T7N, R7E, the springs produce cold water, and are most likely derived from water within permeable strata in the Wasatch Formation. We found no offset strata in quaternary deposits exposed in gully walls, or scarps on quaternary surfaces.

Linear west-facing escarpments on Quaternary surfaces appear near the junction of Dry Creek with Saleratus Creek Valley in Sections 23 and 26, T9N, R7E. These are within three miles of the Bear River, and lie south of, and aligned with, scarps on terrace remnants north of the river described by Hecker (memo of 8/13/87) and assigned to the Leefe Fault. If fault generated, these scarps are most likely a southern extension of the Leefe fault, and not a separate fault system.

Conclusions

There is no convincing evidence of Quaternary normal faulting along Saleratus Creek except at its very lower (north) end. Neither gravity (Hurst, 1982) nor borehole evidence (Baer, 1985) suggests a normal fault. The subsurface structure given expression by the steep eastern escarpment of Saleratus Creek Valley is most likely the southern continuation of the Crawford thrust, as mapped by Royse and others (1975) and Lamerson (1982), along which some minor backsliding may have taken place in Neogene time. Since the Wasatch Formation appears on both sides of the Saleratus Creek structure, its net post-Wasatch displacement cannot have been more than a few hundred feet. Scarps in quaternary alluvium near the junction of Dry Creek and Saleratus Creek probably represent the southern end of the Leefe normal fault, poking out from under the Holocene flood plain deposits of the Bear River.

Strain rate and recurrence interval

The minor stratigraphic offset across Saleratus Creek suggests a very low rate of activity, if indeed a normal fault exists. Conservatively assuming a total offset of 1,000 feet averaged over Neogene time (40 million years), yields an average strain rate of .0008 cm/yr, which puts it in the extremely low to inactive category of Slemmons (1977), with an expected recurrence interval of half a million years for a magnitude 6.5 earthquake (Figure 4).

Recommendations

I recommend that Hecker's Saleratus Creek Fault (?) not be considered a seismic source for evaluating seismic environment under the Utah Dam Safety rules. If future trenching studies are conducted of the Leefe Fault, they should be extended south of the Bear River to evaluate the scarps near the mouth of Dry Creek.

References

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Figure 1

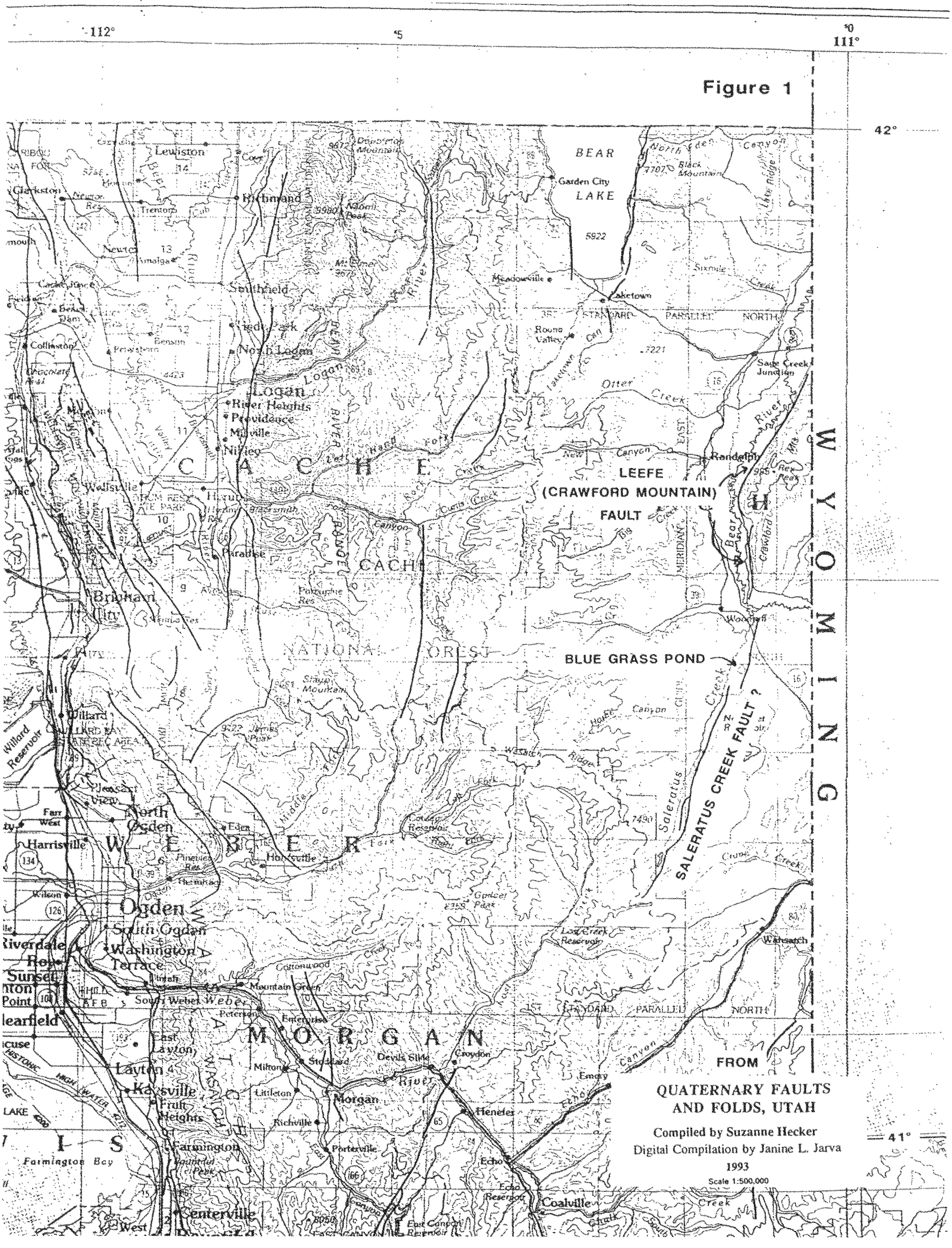

112°
111°
42°
41°
BEAR LAKE
LEEFE
(CRAWFORD MOUNTAIN)
FAULT
BLUE GRASS POND
SALERATUS CREEK FAULT ?
WYOMING
CACHE
WEBER
MORGAN
FROM
Logan
Ogden
Randolph
Woodruff
Laketown
Garden City
Morgan
Coalville
QUATERNARY FAULTS
AND FOLDS, UTAH
Compiled by Suzanne Hecker
Digital Compilation by Janine L. Jarva
1993
Scale 1:500,000

Figure 2

from Lamerson, 1982, Figure 1

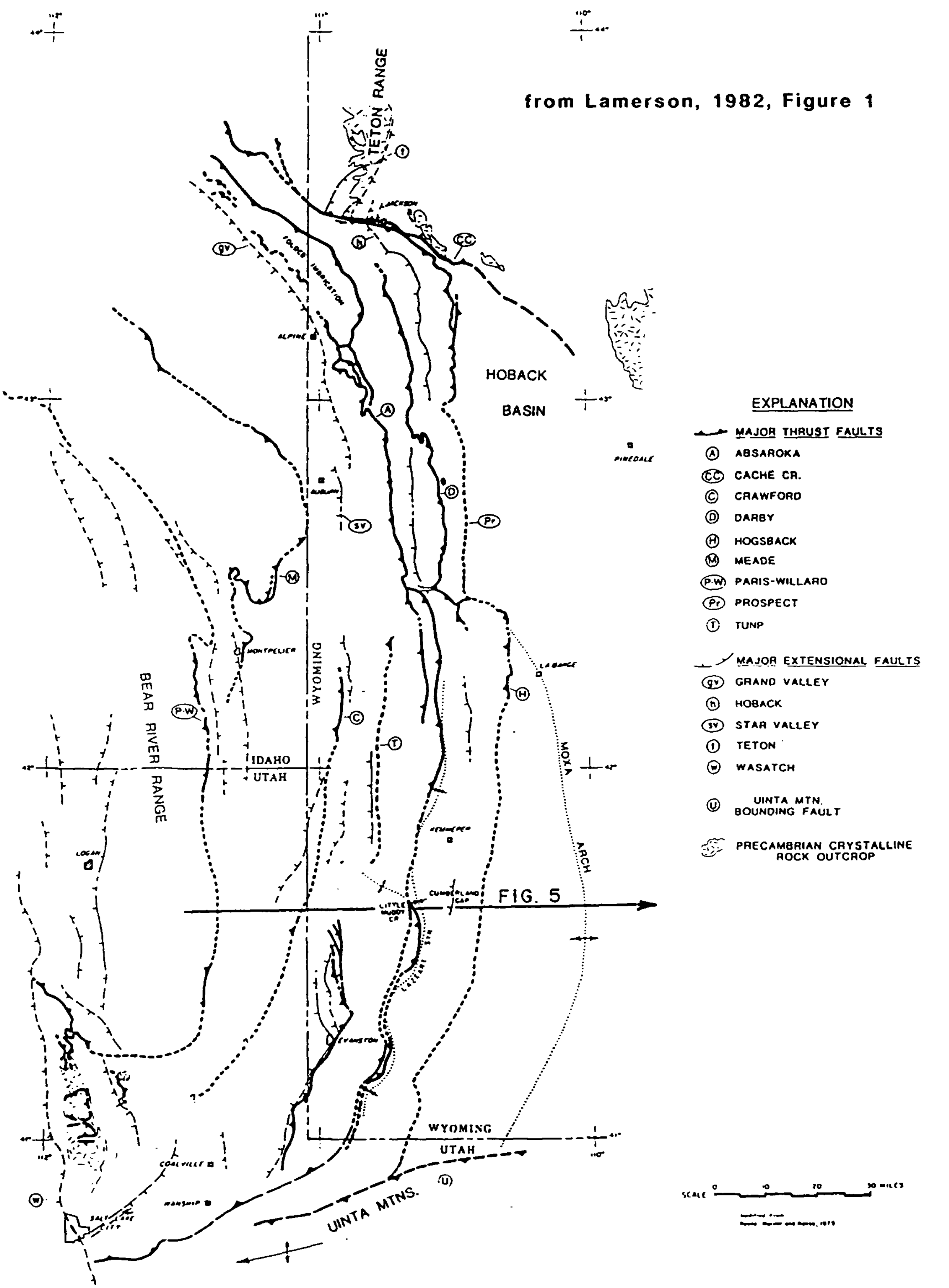
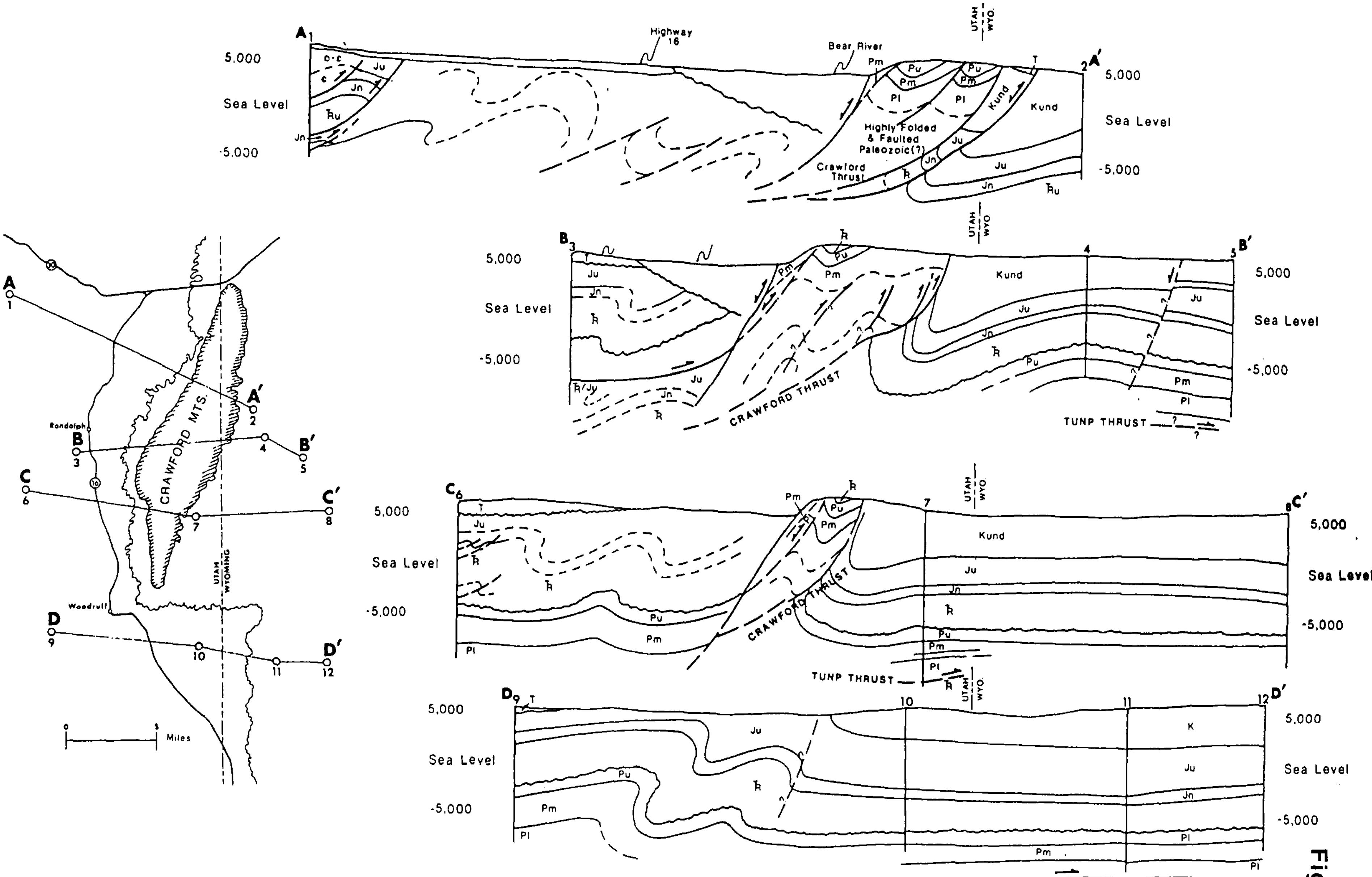


Figure 1. Index map showing principal tectonic features in the Idaho-Wyoming-Utah salient of the Cordilleran thrust belt. Modified from Royse, Warner and Reese (1975).

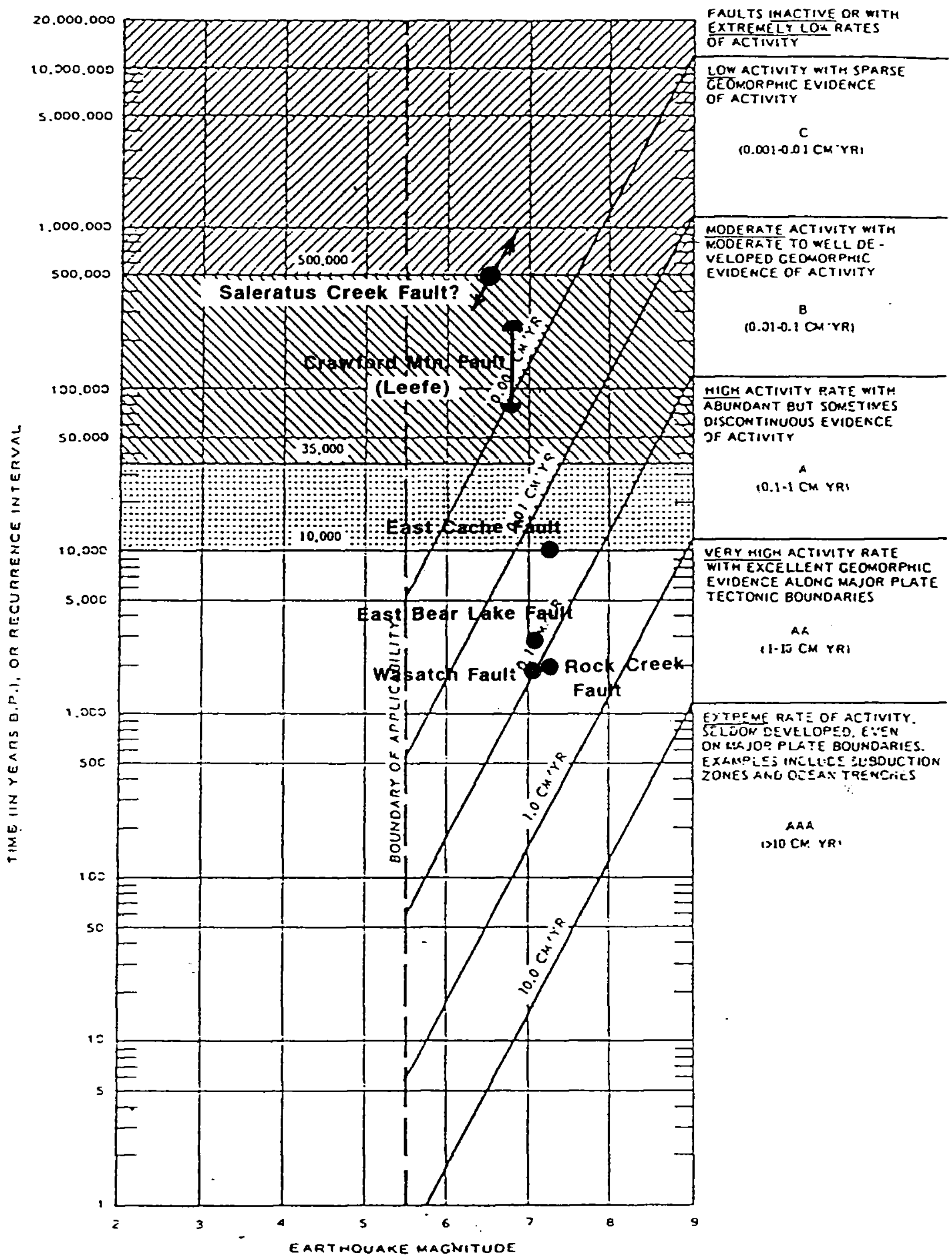


from Baer, 1980, Figure 4

Generalized cross sections across the Crawford Mountains.

Figure 3

Figure 4



Relation between time or recurrence interval (in years), strain rates across fault zones (in cm/yr), and earthquake magnitude.

From: Slemmons, 1977, Fig. 2