NEOTECTONICS OF THE ROUBIDEAU CREEK FAULT, UNCOMPAHGRE PLATEAU, COLORADO; A PRELIMINARY ASSESSMENT

Submitted to:
Vince Matthews
Colorado Geological Survey
1313 Sherman St., Room 715
Denver, CO 80302

Submitted by:
James P. McCalpin
GEO-HAZ Consulting, Inc.
P.O. Box 837
Crestone, CO 81131
mccalpin@geohaz.com

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ABSTRACT

The Roubideau Creek fault on the Uncompahgre Plateau west of Montrose has been classified as a late Quaternary fault by some authors and as an old fault exhumed by landsliding by other authors. I examined the fresh, 25 m-high south-facing scarp in Roubideau Canyon which lies at the center of the controversy, and conclude that it is a fault-line scarp exhumed by Holocene landsliding, as suggested by West (1997). However, west of Roubideau Canyon the surface of the Plateau is displaced 60 m by a broad topographic escarpment underlain by a faulted monocline. Subsequent to the Laramide (?) ductile folding of the Dakota and Morrison Formations here, the monocline has been faulted in a brittle fashion and a 1.5 km-long graben has formed at the base of the escarpment. The southern margin of this graben is marked by steep, young-looking fault scarps 4-13 m high that displace Quaternary colluvium and alluvium. Abrupt decreases in scarp height across younger inset surfaces indicate recurrent faulting. The morphology of these compound scarps suggest several surface-faulting events in the mid to late Quaternary. However, at present Quaternary age control is lacking so slip rates and recurrence estimates are poorly constrained. Preliminary estimates of slip rate range from 0.1-0.2 mm/yr, which is similar to the 0.2 mm/yr estimated by Ake et al. (2002). It is not presently possible to estimate recurrence of characteristic magnitude with confidence, because the fault exhibits the "short, fat fault" syndrome of large scarps coupled with an anomalously short fault length. This discrepancy can only be resolved by a trenching study which could directly determine the number and ages of surface rupturing events. Several potential trench sites were located which are accessible to excavating machinery.

INTRODUCTION

Scope of Work

This report describes a reconnaissance study of the Roubideau Creek fault, with emphasis on determining whether the fault has moved in the late Quaternary and thus should be considered as an active seismic source. In this study I present surficial geologic mapping and description of the tectonic landforms along the fault trace that bear on the question of late Quaternary activity. This geomorphic data is subject to some uncertainty for interpreting tectonics, because similar scarps can be created by recent surface faulting (a fault scarp) or by differential erosion along an older fault trace (a fault line scarp). Several aspects of fault-zone geomorphology indicate recent faulting, but definitive proof of late Quaternary fault activity would be best obtained from fault trenching investigations which are beyond the scope of this study. Therefore, the final recommendation of this study is where to locate future fault trenches that would yield the best paleoseismic data.

The study was composed of five tasks, outlined below in Table 1. Task 1 was completed in August, 2003 and the remaining tasks in September, 2003.

Acknowledgments

Terry Hughes (Soil Scientist, USDA Forest Service, Delta, CO) lent me the USDA color aerial photographs used for detailed field mapping. Dean Ostenaa (U.S. Bureau of Reclamation, Denver, CO) lent me the latest USBR report on the seismic setting of Ridgway Dam and vicinity (Ake et al., 2002).

Table 1. List of tasks undertaken in this study.

Task No.	Description
1	Detailed mapping of tectonic geomorphology and Quaternary deposits along the 26 km-long Roubideau Creek fault, using aerial photographs and GPS
2	Produce a digital geologic/tectonic strip map, using the USGS 7.5' topographic map as the base and deliver Arc shapefiles to CGS
3	Measure fault scarp profiles and soil profiles and submit profiles and soil pit results to CGS
4	Make a preliminary calculation of slip rates, recurrence intervals, and displacements per event based on geomorphic data
5	Prepare report and prioritize potential sites for trenching studies

Location and Physiography

The Roubideau Creek fault is located about 40 km west of Montrose, Colorado, on the west flank of the Uncompahgre Plateau of western Colorado (Fig. 1). The fault is located in (from west to east) the central parts of the Moore Mesa, Davis Point, and Dry Creek Basin 7.5' topographic quadrangles and trends on average N74°W. The Uncompahgre Plateau is dominantly a gigantic dip slope underlain by the resistant Dakota Sandstone and Burro Canyon Formation. The Plateau strikes about N30°W, is roughly 50 km wide and 160 km long, and slopes northeastwards from a high elevation of 10,000 feet on the west to 5000 feet on the east. The Roubideau Creek fault lies about in the center of the Uncompahgre Plateau, and crosses terrain with an average elevation of about 8500 to 9000 feet.

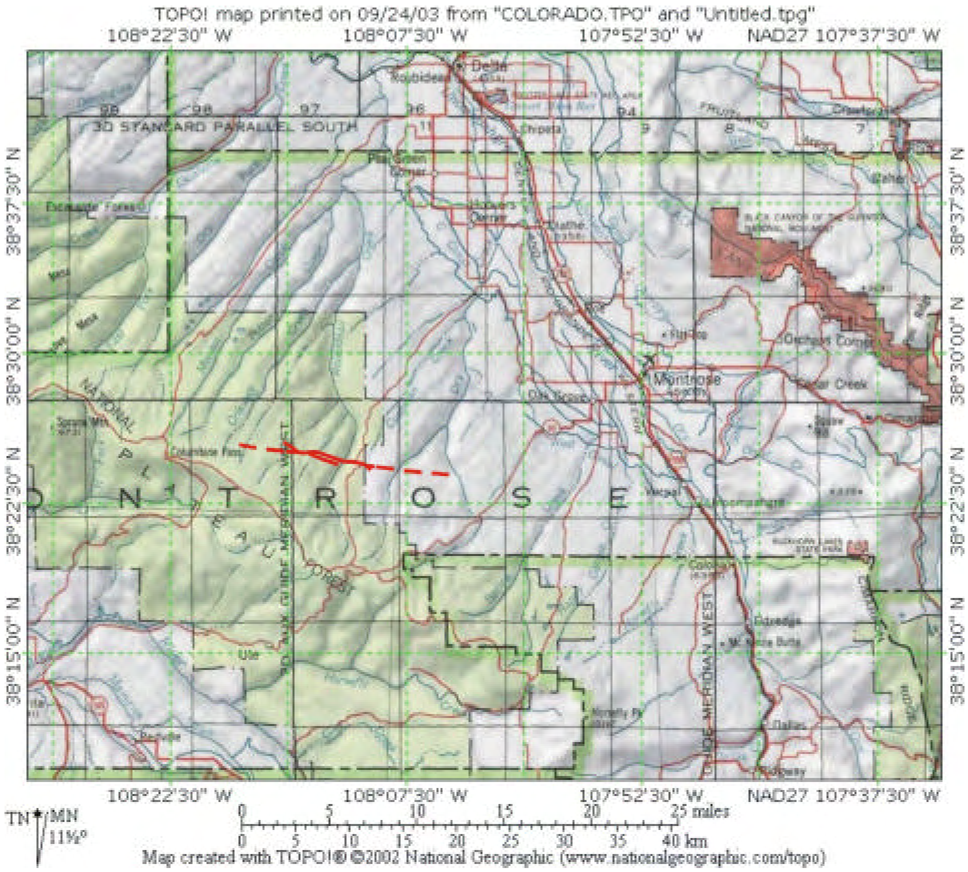

Fig. 1. Location map of the Roubideau Creek fault (red lines at left center, from the CGS Quaternary Fault and Fold Database; Widmann et al., 1998)). The fault can be easily accessed from Montrose on State Highway 90 and County Road 90, or from Olathe on Transfer Road, which crosses the fault approximately in its center. The key fault scarps described in this study lie west of Transfer Road and the 300 m-deep canyon of Roubideau Creek, and are accessed from Divide Road (parallels the label "National Forest" west and south of the fault) and several Forest Roads (not shown on this map) that extend northeast from Divide Road.

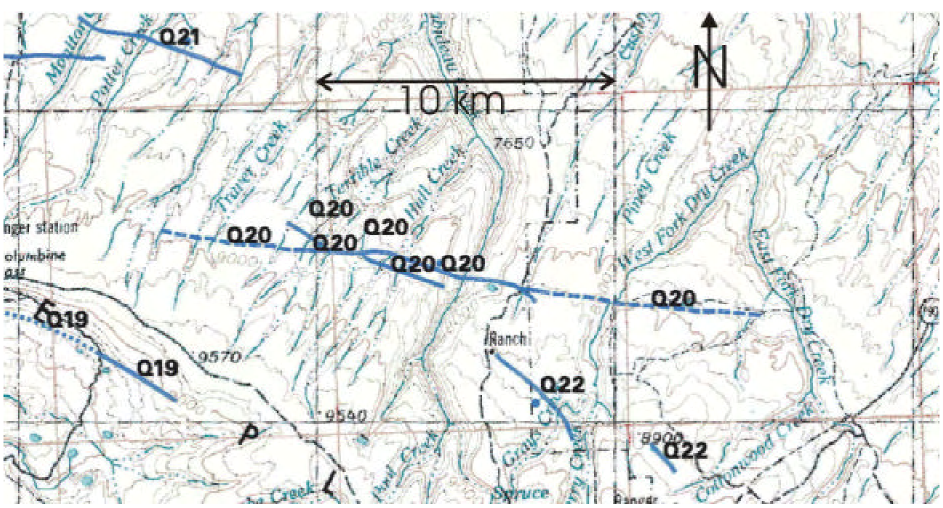

Fig. 2. Trace of the Roubideau Creek fault (Q20) and nearby faults Q19, Q21, and Q22, from the on-line CGS Quaternary Fault and Fold Database of Colorado. The solid line part of the Roubideau Creek fault trace is from Williams (1964), except for the westernmost part. The dashed parts of the trace are presumably taken from a later source, such as Lettis et al. (1996). On fault Q22 the bar and ball should be on the northeastern (downthrown) side of the fault.

The Colorado Geological Survey on-line Database of Quaternary Faults and Folds (Widmann et al., 1998) lists the fault's end-to-end length as 20.47 km (Fig. 2), with the fault trace "taken from Williams (1964)." However, the fault trace shown in Williams (1964) is only 10 km long**.** Presumably, the additional 10.47 km of fault length shown by Widmann et al. (1998), which is dashed lines on the east and west ends, was taken from Lettis et al. (1996).

Regional Geology and Tectonics

The Uncompahgre Plateau is dominantly a gigantic northeast-dipping dip slope underlain by the resistant Dakota Sandstone and Burro Canyon Formation. Major streams flow northeast and have incised canyons up to 300 m deep into the surface of the Plateau. These canyons, such as at Roubideau Creek (Fig. 2), expose the underlying Jurassic (Morrison) and Triassic (Chinle) Formations. The deepest canyons, such as Roubideau Creek, expose in their bottoms Precambrian basement rocks.

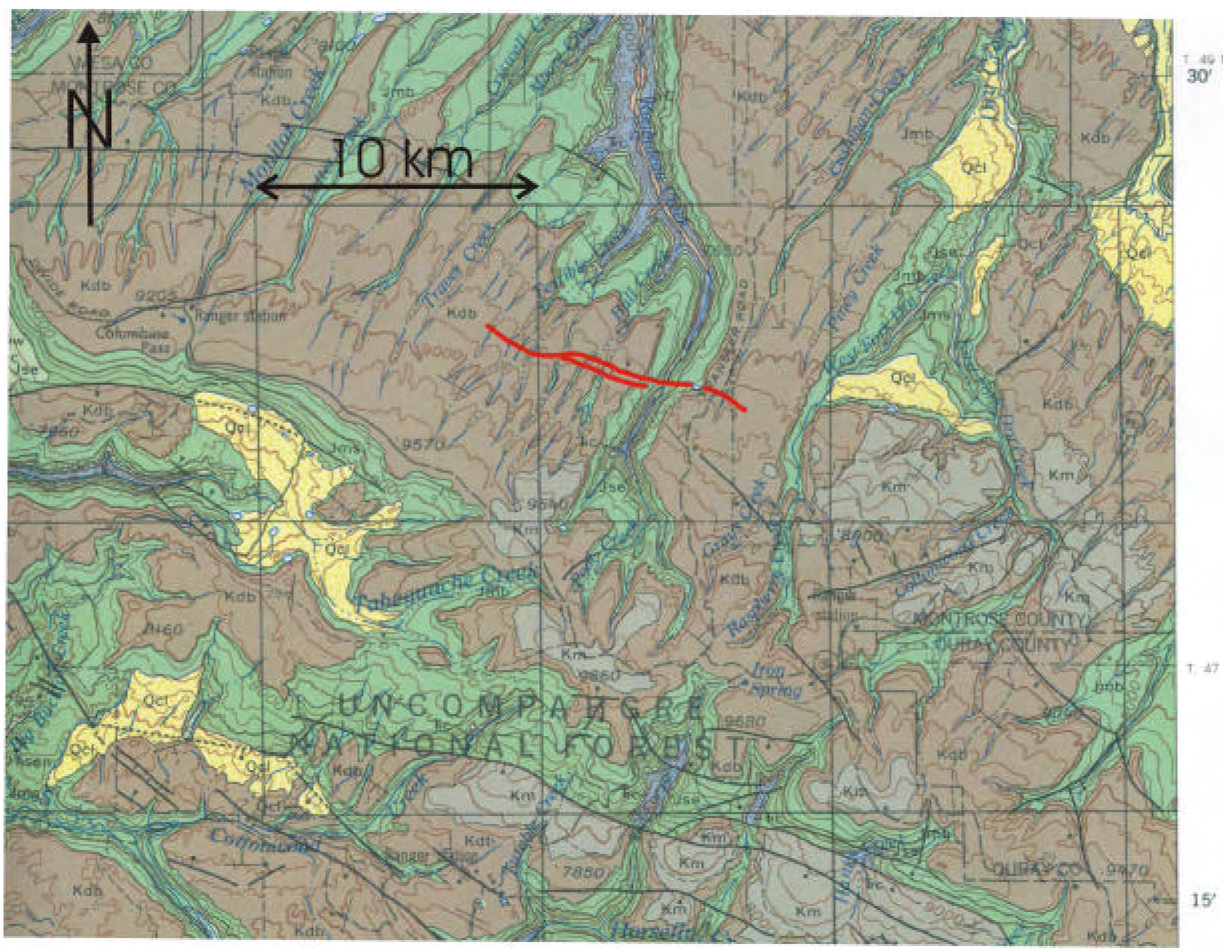

Fig. 3. Portion of the geologic map of the Moab 1° by 2° quadrangle (Williams, 1964; original scale 1:250,000). The Roubideau Creek fault is highlighted in red; note that its original mapped length is only half that shown in Fig. 1 (from Widmann et al., 1998). Most of the Plateau surface is underlain by map unit Kdb (in brown; resistant sandstones of the Dakota-Burro Canyon Formations), but small patches of the overlying Mancos Shale (unit Km, in gray) are preserved south and east of the fault. Incised canyons expose successively older rocks, including the Morrison Formation (in green; unit Jmb, Brushy Basin Member of the Morrison Formation; unit Jms, Salt Wash Member of the Morrison Formation: unit Jse, Entrada Sandstone; in blue, unit Trc, Chinle Formation). The Chinle Formation is directly underlain by Precambrian basement (unit PC, in pink).

The following summary of the geologic history of the Uncompahgre Plateau is taken from Kirkham and Rogers (1981):

" The Uncompahgre uplift rose during the Neogene from the crest of an older, much larger highland that was a prominent structural feature during the late Paleozoic (Cater, 1966). Distribution and thickness of late Paleozoic sedimentary formations derived from the highland suggest the ancient upwarp was bounded by large faults on the southwest, while the northeast limb, which extended farther east than the present uplift, gently dipped to the northeast (Cater, 1970). Structural relief along the southwestern flank during the Paleozoic may have been as great as 2440 m………."

"The modern Uncompahgre uplift is a northeast-tilted block, structurally similar to its predecessor but much smaller. The southwestern flank and part of the northeastern flank near Grand Junction are bounded by abrupt, locally faulted monoclines (Lohman, 1965; Cater, 1970). Cater (1966, 1970) presents evidence suggesting the modern Uncompahgre uplift has experienced considerable movement during the Pliocene and Quaternary, and that many of the faults and monoclines which bound the uplift were activated during this period."

Williams (1964) maps numerous faults on the Uncompahgre Plateau, most of which trend NW-SE or WNW-ESE and dip very steeply (Fig. 3). The Roubideau Creek fault is mapped as being downthrown to the northeast, and presumably has a near-vertical dip, based on its straight mapped trace across Roubideau Canyon. The surface of the Plateau drops about 60 m down-to-the-northeast across the fault. If the Plateau surface is underlain by the same bed of the Dakota-Burro Canyon Fm. on both sides of the fault, then the Cretaceous beds are displaced about 60 m down-to-the-northeast.

Previous Work

Kirkham and Rogers (1981) were the first to suggest Quaternary movement on the Roubideau Creek fault, which they referred to as fault 82 (the fault was later named by Lettis et al., 1996). They wrote *"Fault number 82 lies in T48N, R13W and T48N, R12W and trends N70°W. Bedrock in the area consists of gently northeast-dipping Dakota Sandstone and Burro Canyon Formation, underlain by the Brushy Basin Member of the Morrison Formation. In places where the Brushy Basin Member lies at the surface, it is covered by abundant landslides, earthflows, and other types of slope failures largely of Quaternary age. Fault number 82 passes through the Brushy Basin Member and overlying Quaternary deposits at Roubideau Creek. Near the creek there is a scarp in the surficial landslide deposits that suggests fault movement since development of the Quaternary landslide complex* (Fig. 4 of this report).

Recent movement on this fault appears to be downward on the southwest side. However, apparent drag in the bedrock suggests down-to-the-north displacement. This anomaly may be the result of a change in direction of movement or possibly due to scissors-type movement."

Fig. 4. Vertical aerial photograph of the Roubideau Creek fault, from Kirkham and Rogers (1981, p. 90). The original caption reads: *"Vertical aerial photograph of fault 82 (solid arrows) where it crosses Roubideau Creek. Note hummocky landslide-covered terrain (Qls) on the Brushy Basin Member of the Morrison Formation. An apparent scarp (open arrows) is developed in these Quaternary landslide deposits along fault 82. (photograph by Army Map Service; held by U.S. Geological Survey).*"

Kirkham and Rogers (1981) made several observations which have been the subject of controversy in later publications.

First, they observed "a scarp in the surficial landslide deposits" of Roubideau Canyon. This fresh-looking, sparsely vegetated scarp, which is about 25 m high, exists only within Roubideau Canyon on two benches composed of landslide deposits.

Second, this scarp "suggests fault movement since the development of the Quaternary landslide complex."

Third, the scarp faces south to southwest, opposite to the direction of the 60 m-high Roubideau Creek fault escarpment as a whole.

Fourth, they admit that "apparent drag in the bedrock suggests down-to-the-north displacement" on the main Roubideau Creek fault, as does the geometry of the 60 m-high escarpment on the Plateau surface east and west of Roubideau Canyon.

Fifth, they explain the discrepancy in scarp geometry as "the result of a change in direction of movement or possibly due to scissors-type movement."

The next geologist to work on the fault in any detail was Michael W. West of M.W. West and Associates (Englewood, CO; www.m-west-assoc.com). Mr. West became aware of the Roubideau Creek fault in the late 1970s when he worked for the U.S. Bureau of Reclamation in Denver on the seismotectonic setting of Ridgway Dam (Sullivan et al., 1980). In 1979 Mr. West taught the engineering geology week of the Summer Field Camp for the Department of Geology, Colorado School of Mines, and he had the students do an exercise on the fresh-looking scarp described by Kirkham and Rogers (1981), to determine whether it was formed by landslide or tectonic processes (he concluded the former). In the mid-1990s Dr. West taught a course in Neotectonics and Paleoseismology at the Colorado School of Mines in Golden, Colorado. One of his class exercises involved having the students perform field mapping of the Roubideau Creek fault and determining if it displayed evidence of Quaternary movement. Dr. West has told me that he used the Roubideau Creek fault as a "textbook example of how you can be misled" by mistaking a landslide scarp for a tectonic fault scarp (pers. comm., 2003).

West (1997; also posted at http://www.m-west-assoc.com/faults_&_landslides.htm) addressed the general problem of landslide landforms mimicking tectonic landforms, and concluded that *"The Roubideau Creek fault, also interpreted [by others] to be a seismogenic structure displacing Holocene landslide deposits, alternatively, is a fault-line scarp in resistant Jurassic sandstone exhumed by mass movement in overlying shales."* Table 2 shows some of Dr. West's salient points as presented in a PowerPoint slide presentation he prepared on this subject.

Table 2. Contents of M.W. West's unpublished PowerPoint presentation concerning the Roubideau Creek fault. Courtesy of the author.

Item No.	Contents
1	Normal fault on northeast flank of the Uncompahgre Plateau
2	Complex displacement history; Ancestral Rocky Mountains (Permian-Pennsylvanian) to Neogene uplift
3	Interpreted as seismogenic normal fault displacing Holocene landslide deposits (Kirkham and Rogers, 1981)
4	Apparent seismogenic fault scarp is a fault-line scarp exhumed by landsliding
5	Relief on the apparent scarp is created by fault throw in K-J bedrock and juxtaposition

	of resistant sandstone against soft. Low strength clay-shale
6	Late Quaternary mass movement exhumed the fault-line scarp leading to interpretation that fault displaced landslide deposits
7	Bedrock stratigraphy is consistent with fault-line scarp interpretation
8	Roubideau Canyon geomorphology is consistent with bedrock stratigraphy and fault-line scarp interpretation
9	Continuity and scale of mapped late Quaternary displacement is limited to clay-shale juxtaposed against fault-line scarp
10	Landsliding in clay shale can be explained by mechanical considerations including low shear strength and high pore pressures

In the early 1990s William Lettis & Associates of Walnut Creek, California, performed a regional seismotectonic evaluation of western Colorado for the US Bureau of Reclamation's Colorado River storage project (Lettis et al., 1996). Concerning the Roubideau Creek fault, they concluded that *"… based on the scarp height, there must have been multiple Quaternary surface-faulting events. The height of the scarp (~80 m) and a minimum estimate of the age of the Uncompahgre surface (~500 ka or more) implies a rate of vertical separation of about 0.2 mm/yr or less. Lettis et al. (1996) further note that the fault aligns with a southwest-facing linear scarp in late Pleistocene to Holocene landslide deposits in Roubideau Creek. A sag pond is located along the fault scarp on the southeast wall of Roubideau Creek. Although these features could be related to mass wasting processes, they may be evidence of late Quaternary activity. In the absence of additional field data, Lettis et al. (1996) concluded the Roubideau Creek fault is a potentially active structure and assigned an MCE of M 6½.."* (Ake et al., 2002).

The most recent report that mentions the Roubideau Creek fault is that of Ake et al. (2002). This report summarizes the conclusions of 3 previous reports that address the Quaternary activity of the fault (Kirkham and Rogers, 1981; Sullivan et al., 1980; Lettis et al., 1996), but does not present any new field data, nor does it reference the abstract by West (1997) nor the unpublished material on West's website.

Ake et al. (2002) state: *"The Roubideau Creek fault is a `22 km-long, northwest-striking, northeast-dipping normal fault that displaces Mesozoic units (Williams, 1964; Sullivan et al., 1980; Kirkham and Rogers, 1981; Lettis et al., 1996). Kirkham and Rogers (1981) report the fault apparently cuts Quaternary landslide deposits in Roubideau Creek with an opposite sense of displacement. Based on that observation, Kirkham and Rogers (1981) conclude that the fault is a potentially active late Cenozoic structure. Sullivan et al. (1980) concluded the observed scarp in the landslide could be interpreted as non-tectonic in origin, but did not specify a conclusion regarding the seismic potential of the fault. Lettis et al. (1996) evaluated the existing literature and performed a topographic and aerial photographic interpretation of the fault in their study…...*

We concur with the evaluation of Lettis et al. (1996) and assign a probability of activity of 1.0 to this fault. A maximum magnitude of 6.5 is assigned to the fault based on fault length. Based on the estimate of a maximum vertical separation rate of 0.2 mm/yr, we estimate a broad range of slip rates, from 0.005-0.2 mm/yr."

In summary, the one report published by Colorado Geological Survey (Kirkham and Rogers (1981) and the three reports created by the US Bureau of Reclamation (Sullivan et al., 1980; Lettis et al., 1996; Ake et al., 2002) all conclude that the fault has experienced late

Quaternary movement. However, Bob Kirkham was the only one of these authors to visit the site, and he spent less than one day in the vicinity of the fault. In contrast, Mike West has spent much more time in the Roubideau Canyon area, and he considers the southeast-facing scarp in the canyon to be a fault-line scarp exhumed by landsliding. Therefore, Dr. West does not think the fault has moved in the late Quaternary. One of the main goals of this study was to determine the origin of this short scarp in Roubideau Canyon, and to look elsewhere along the mapped fault trace for evidence of late Quaternary movement.

GEOMORPHOLOGY OF THE FAULT ZONE

The Roubideau Creek fault trace as depicted by Widmann et al. (1998) can be subdivided into four geomorphic sections, which are discussed separately below. From west to east, these sections are the Traver Mesa section (7.3 km long), the Bull Creek section (4.2 km long), the Roubideau Canyon section (2.1 km), and the Roubideau Ranch section (4.9 km). The total length (18.5 km) does not include an additional 2+ km east of the West Fork of Dry Creek, where Widmann et al. (1998) mapped the fault as a dashed line. In the description below, I start with the Roubideau Canyon section, because it contain the controversial south-facing scarp, then the Bull Creek section, because it contains the best-preserved tectonic landforms. The two end sections are discussed last.

The Roubideau Canyon Section

The Roubideau Canyon section stretches 2.1 km from rim to rim across the 300 m-deep canyon of Roubideau Creek. The section is shown in two parts on Fig. 5, with the western part shown in Fig. 5a and the eastern part in Fig. 5b. The canyon cross-section consists of steep 60 m-high cliffs on both canyon walls underlain by the Dakota and Burro Canyon Formations, a 500 m-wide bench on each side of the creek underlain by the Brushy Basin Member of the Morrison Formation, and a 180 m-deep inner canyon underlain by (from top to bottom) the Salt Wash Member of the Morrison Formation, the Chinle Formation, and Precambrian basement rocks.

The Brushy Basin Member is composed of weak mudstones and evaporates and is prone to landsliding throughout the Uncompahgre Plateau. At Roubideau Canyon landsliding in the Brushy Basin Member has undermined the overlying Dakota-Burro Canyon Formations, such that the cliff band is essentially a series of scalloped landslide headscarps. The benches are entirely covered with Quaternary landslide deposits (Fig. 6), according to my photogeologic and field mapping. These deposits are composed of a matrix of ground-up Brushy Basin Fm. mudstones, and large blocks of Dakota-Burro Canyon Fm. Sandstones. The landslides have flowed over the rim of the inner canyon in most places, and thus mantle the slopes of the inner canyon down to stream level over about 75% of the area.

I have subdivided landslides into 3 age categories, following McCalpin (1984). Young landslides have fresh, sparsely-vegetated headscarps and closed depressions (Fig. 7), and have pushed the stream to the opposite valley wall. Intermediate-age landslides have more subdued headscarps, and closed depressions and ponds have been filled in to more level meadows. The axial stream has restablished its course around their toes. Old landslides have very subdued topography and no closed depressions. The drainage network has integrated itself onto their surfaces.

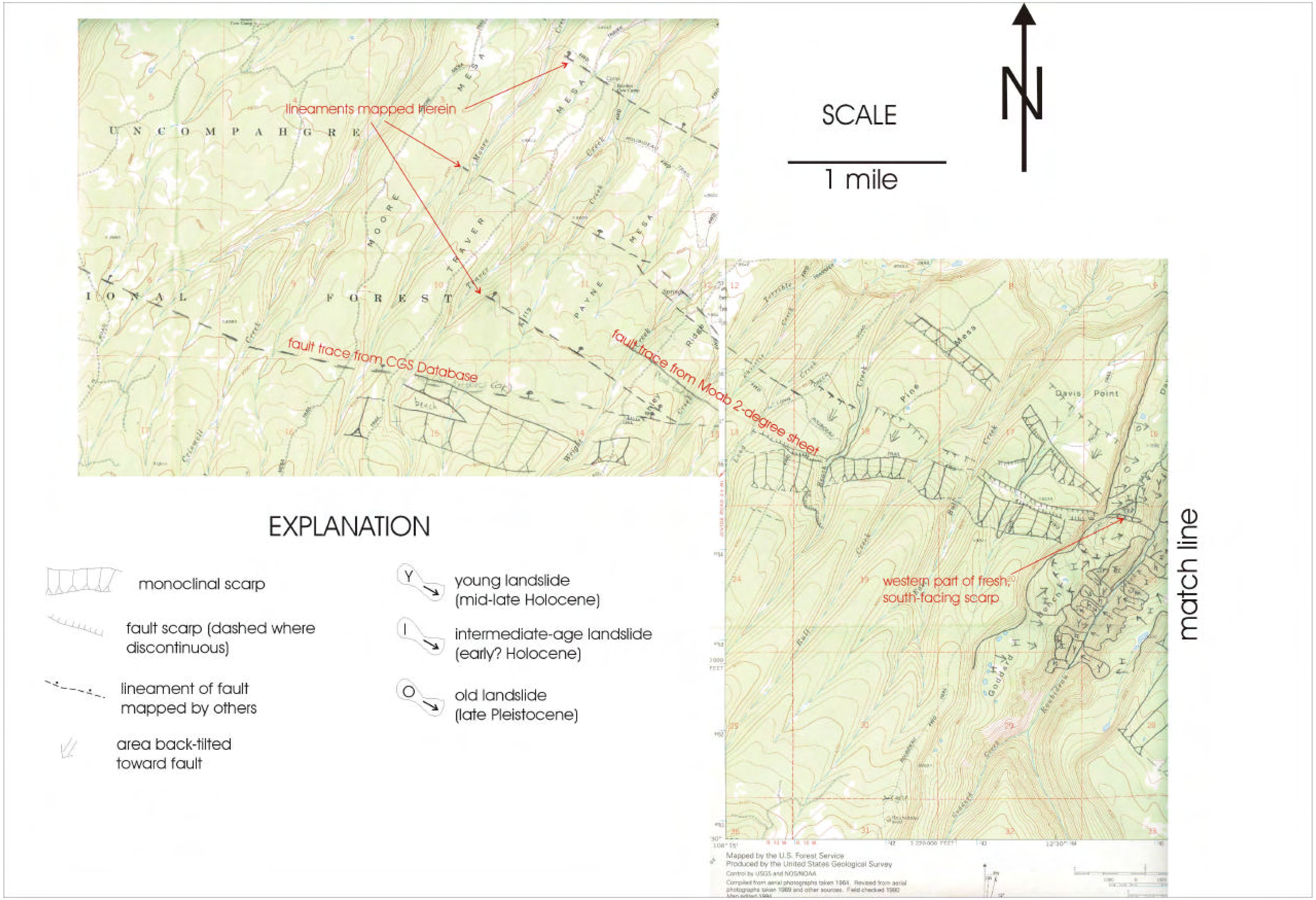
lineaments mapped herein
fault trace from CGS Database
fault trace from Moab 2-degree sheet
western part of fresh, south-facing scarp
SCALE
1 mile
N
match line
EXPLANATION
monoclinal scarp
fault scarp (dashed where discontinuous)
lineament of fault mapped by others
area back-tilted toward fault
young landslide (mid-late Holocene)
intermediate-age landslide (early? Holocene)
old landslide (late Pleistocene)
Mapped by the U.S. Forest Service
Produced by the United States Geological Survey

Fig. 5a.

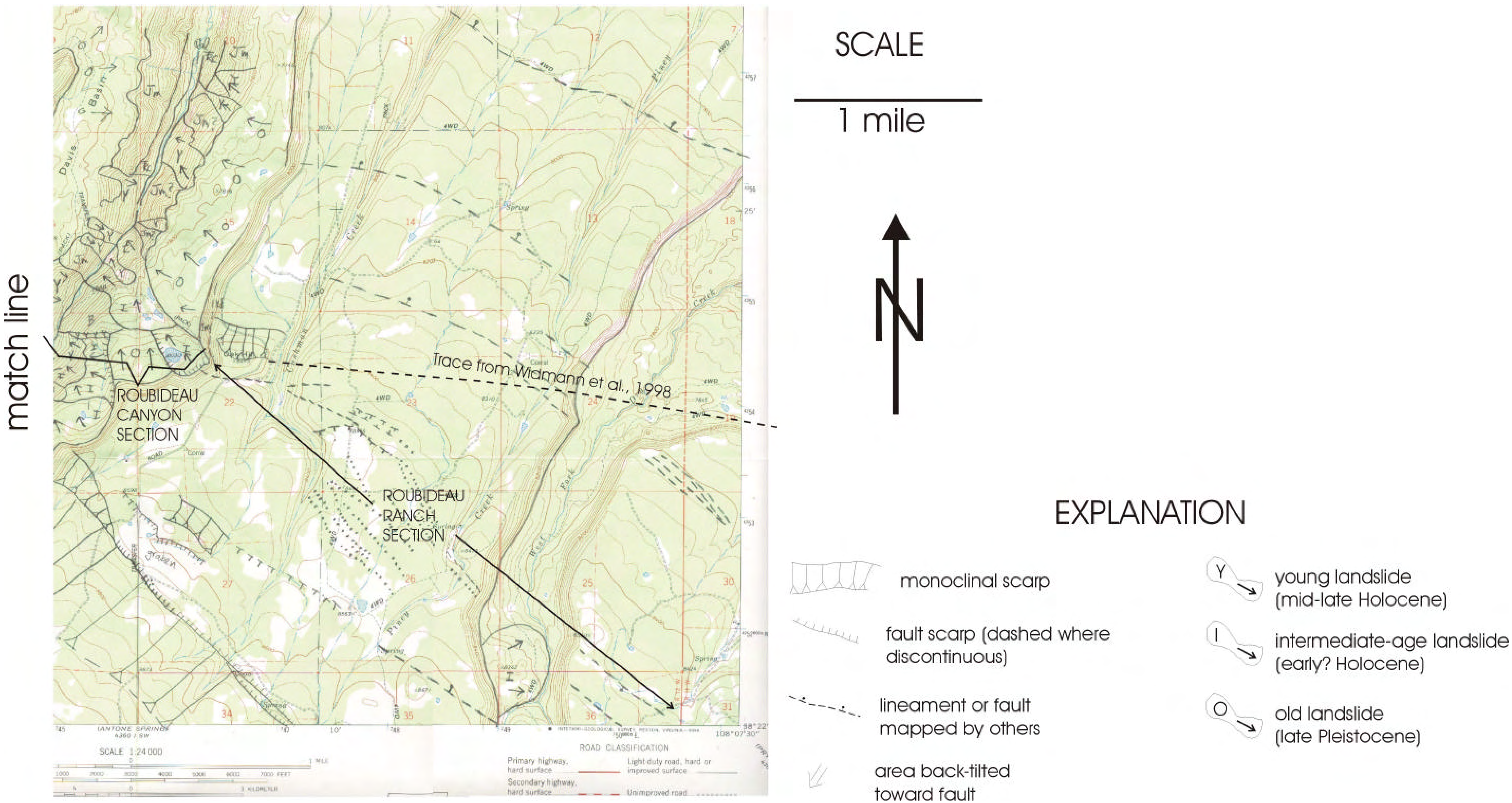
match line
ROUBIDEAU CANYON SECTION
Trace from Widmann et al., 1998
ROUBIDEAU RANCH SECTION
SCALE
1 mile
N
EXPLANATION
monoclinal scarp
fault scarp (dashed where discontinuous)
lineament or fault mapped by others
area back-tilted toward fault
Y
young landslide (mid-late Holocene)
I
intermediate-age landslide (early? Holocene)
O
old landslide (late Pleistocene)

Fig. 5b.

Fig. 6. Panorama mosaic photograph of Roubideau Canyon from Oak Hill, looking west. The Roubideau Creek fault is at upper left center, where a forested gully breaks the line of cliffs. The foreground is all Quaternary landslide deposits.

Fig. 7. Photograph of the largest closed depression in the Roubideau Canyon landslide complex, east of the creek; view is to the south. The landslide mass detached from the cliff in the background and slid toward the viewer.

The Roubideau Creek fault is expressed in this section as a steep, sparsely-vegetated, 20-25 m-high south-facing scarp on the benches east and west of the Creek. This scarp is the one that Kirkham and Rogers (1981) and all subsequent authors have used as evidence for late Quaternary faulting. However, as the landslide mapping shows (Fig. 5), this scarp is bounded by young landslides on its southern ("downthrown") side on both sides of Roubideau Creek. In addition, field checking shows that the material exposed in the top of the scarp face east of the Creek is sandstone bedrock of the Salt Wash Member (Fig. 8), and not landslide debris (I did not field check the scarp on the western side of the Creek).

Therefore, my photogeologic mapping of landslides and field observations indicate that the south-facing scarp does not "displace late Quaternary landslide deposits". That is, it does not cut through and disrupt an individual landslide deposit on either bench. Instead, as concluded by West (1997), young landsliding originating on the bench and flowing down the inner canyon has lowered the inner canyon wall south of the Roubideau Creek fault relative to the area north of it, and thus "exhumed" the fault-line scarp. This interpretation explains why this scarp appears to be downthrown in an opposite sense to the bedrock displacement along the fault. I think this scarp is a fault line scarp exhumed by Holocene landsliding, and does not provide any evidence for or against late Quaternary faulting on the Roubideau Creek fault.

Fig. 8. Photograph of the crest of the steep south-facing scarp in the Roubideau Canyon landslide complex, on the east side of the creek; view is to the east. This scarp exposes in-situ sandstone bedrock of the Morrison Formation, not landslide debris. Therefore, the scarp does not appear to displace Pleistocene or Holocene landslide deposits as stated by Kirkham and Rogers (1981).

The Bull Creek Section

The Bull Creek section extends from the western rim of Roubideau Canyon, 7.3 km to the west across East Bull Creek, Bull Creek, Bench Creek, and to Long Creek (Fig. 5a). This section contains the highest (>60 m) and steepest north-facing escarpment in the Uncompahgre Plateau surface along the Roubideau Creek fault. The section also contains a well-developed graben at the base of the escarpment, which grades westward into a 500 m-wide backtilted area.

Because the escarpment is covered by a dense spruce-fir-aspen forest, the best places to observe its geomorphology is where jeep roads and trails cross the escarpment. The best road exposure is formed by Forest Road 545 (Fig. 9), which transects the entire width of the escarpment. The escarpment here is 62 m high, but represents only 35 m of vertical surface offset (vertical separation) of the northeast-sloping Plateau surface. The concave toeslope of the escarpment is disrupted by a steep 10 m-high scarp.

Fig. 9. Telephoto photograph of Forest Road 545 ascending the scarp of the Roubideau Creek fault; view is to the south. Base of scarp is marked by one red arrow, top of scarp by one orange arrow. Two red arrows mark top of the lower rejuvenated scarp, which appears much larger than its true size relative to the remainder of the scarp (compare with the scarp profile, Fig. xx). Total scarp height here is 62 m (vertical separation 35 m). The lower rejuvenated scarp has a scarp height of about 10 m and a vertical separation of 5.5 m.

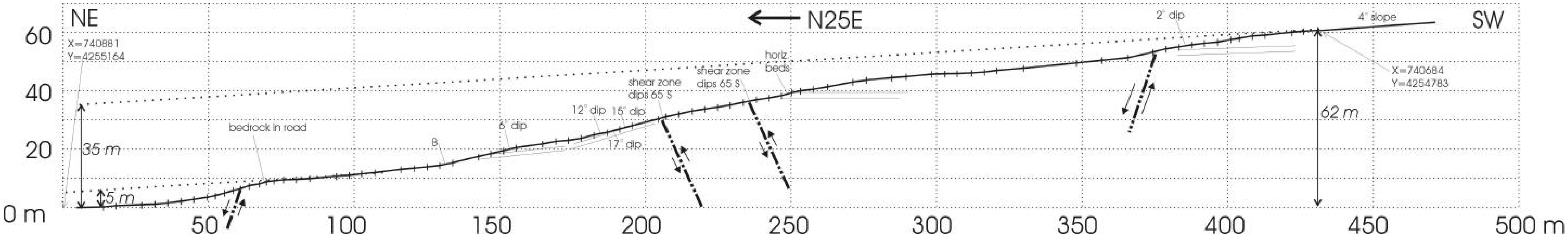

Fig.10. Scarp profile at Forest Road 545, measured with a stadia rod and Abney level after the method of Bucknam and Anderson (1979). Far-field slope angle is 3.5° on upthrown and downthrown ground surfaces, but these may not be the same surface if there has been significant slopewash deposition on the downthrown surface. Coordinates at the ends of the profile are UTM Zone 13, NAD 27, meters. Where in-situ bedrock outcrops in the road bed, dips are shown. Shear zones beneath the center of the profile are plotted at their measured dip angles, as exposed in the road bed. The normal faults at the base and head of the scarp are schematic, since the fault is not exposed in the road bed. The structural interpretation of the Roubideau Creek fault escarpment is discussed in detail in a following section, but at this location and elsewhere in the Bull Creek section, it is thought to be a faulted monocline.

East of Bench Creek the escarpment maintains about the same height and slope, but the 10 m-high (rejuvenated?) scarp climbs higher on the escarpment and appears nearly at the head of the escarpment between Bull Creek and East Bull Creek(Figs. 11, 12). Here the scarp displaces a colluvial apron at the base of the escarpment, is 9 m high, surface offset of 5.1 m, and slope angles up to 28°. Bedrock is not exposed on the scarp face, which appears to be underlain by colluvium.

Fig. 11. Photograph of the rejuvenated scarp between Bull Creek and East Bull Creek; view is to the south. The stadia rod leaning against the tree at right is 4.5 m long. According to a scarp profile measured to the right of the stadia road, scarp height is 9 m, vertical separation is 5.1 m, and maximum slope angle is 28°.

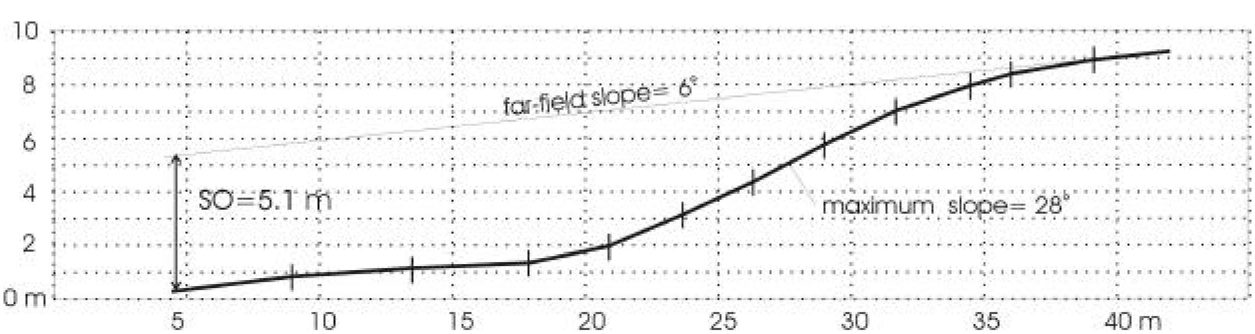

Fig. 12. Profile of the rejuvenated scarp between Bull Creek and East Bull Creek.

To the east of East Bull Creek a 50 to 100 m-wide graben lies at the base of the escarpment (Fig. 13). The northern boundary of the graben is an 2-3 m-high antithetic scarp that exposes Dakota Fm. Sandstone over most of its length (Fig. 14).

Fig. 13. Photograph of the western graben between Roubideau Canyon and Long Creek; view is to the southeast. In the foreground a jeep road ascends the antithetic scarp (see also Fig. 14).

Fig. 14. Photograph of the antithetic scarp on the northern margin of the western graben; view is to the north. Stadia rod in the jeep road is 1.5 m long.

The graben extends about 1.5 km from East Bull Creek eastwards to the western rim of Roubideau Canyon (Fig. 5a). The southern boundary of the graben is a 5-10 m-high, steep (rejuvenated?) scarp that lies at the base of the larger 60 m-high escarpment. This scarp has the best geomorphic evidence for recurrent, mid-to-late Quaternary fault movement.

The best fault scarp locality along the southern margin of the graben is where it crosses an unnamed drainage that parallels the Roubideau Trail (Forest Road 547). This drainage bisects the interfluve between East Bull Creek and Roubideau Canyon, and has eroded a 100-200 m-wide, 10-30 m deep valley into the Plateau both upstream and downstream of the graben. A large stock pond has been excavated in the valley floor about 100 m south of the graben. The basal rejuvenated fault scarp crosses this incised valley and maintains a relatively constant scarp height of 4-6 m (Figs. 15, 16) and a surface offset of 4.2 m. Sandstone bedrock is exposed in the bed of FR 547 in the upper half of the scarp.

Fig. 15. Photograph of the rejuvenated fault scarp as it crosses Forest Road 547 just north of the stock pond, south of the eastern graben; view is to the south. Stadia rod lying in the road at mid-scarp position is 1.5 m long. Scarp height here is 7.0 m, vertical separation is 4.2 m. Maximum scarp slope angle is about 30° in the forested slopes, but only 15° on the roadway. Dakota-Burro Canyon sandstone bedrock crops out in the road bed on the upper half of the scarp, but the lower half of the scarp only exposes rubbly colluvium.

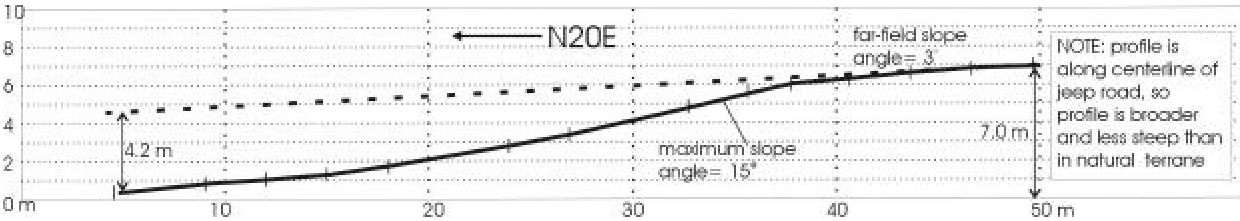

Fig. 16. Profile of the rejuvenated fault scarp as it crosses Forest Road 547 just north of the stock pond, south of the eastern graben.

When traced to the east beyond the limits of the incised drainage, the scarp rises quickly in height to 13-14 m (Figs. 17, 18). This higher scarp is a compound scarp composed of the steeper 4 m-high scarp at the base, and a gentler 10 m-high scarp above it.

Fig. 17. Telephoto photograph of the lower rejuvenated fault scarp on the southern margin of the eastern graben, about 100 m east of the stock pond; view is to the south. The scarp here is composed of a steep basal scarp (between the red and orange dotted lines) that has a scarp height of 4 m, vertical separation of 3.6 m, and maximum slope angle of 35°. The upper part of the scarp (between the orange and pink dotted lines) is higher but less steep. Total scarp height here is 13 m, vertical separation is 9.1 m. When this scarp is traced westward into the incised valley containing the stock pond, the upper part of the scarp has been eroded away but the lower part offsets the incised valley by 4 m (see Figs. 15, 16).

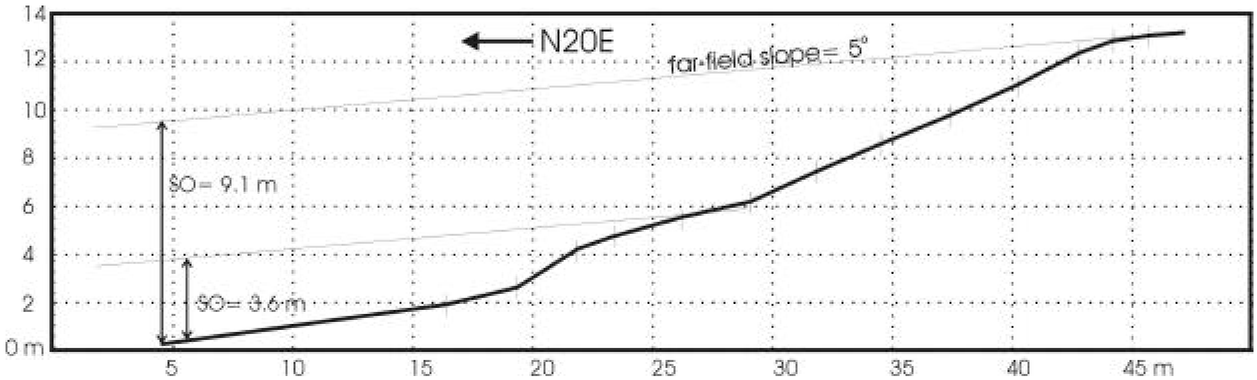

Fig. 18. Profile of the lower rejuvenated fault scarp on the southern margin of the eastern graben, about 100 m east of the stock pond.

The 13-14 m-high steep scarp continues eastward along the base of the 60 m-high escarpment to the western rim of Roubideau Canyon (Figs. 19, 20), but slowly decreases in height to 10 m and then to 8 m. Just west of the canyon rim the scarp appears to step to the left (north) in an en-echelon fashion and merge with the steep gully sideslopes that cut through the cliff band on the rim of Roubideau Canyon.

Fig. 19. Photograph of the lower rejuvenated scarp of the Roubideau Creek fault, on the southeastern margin of the eastern graben; view is to the south. Scarp height here is approximately 10 m.

Fig. 20. Telephoto photograph of Forest Road 300 ascending the lower rejuvenated scarp of the Roubideau Creek fault, just west of the western rim of Roubideau Canyon. View is to the southeast. Scarp height here is approximately 8 m.

In addition to the main 60 m-high escarpment and the graben, there is a smaller, parallel northeast-facing escarpment 0.2-1.5 km north of the graben. This escarpment is about 25 m high and trends N50°W, or about 20° more northerly than the main fault escarpment. I did not field check this secondary scarp. However, examination of aerial photographs along the unnamed creek that contains the stock pond indicates that similar tectonic terraces exist in that valley where it crosses the base of this smaller escarpment. On the downthrown side of the escarpment the Plateau surface has an anomalously low gradient and may be backtilted, as occurs along the main escarpment. Aerial photographs show a faint down-to-the-southwest on the northeast margin of the backtilted area, which could be a degraded antithetic fault scarp.

The secondary escarpment abruptly ends 2.8 km northwest of the edge of Roubideau Canyon. However, the backtilted area fronting the main escarpment continues west to Long Creek. With the exception of the main scarp, which trends N75°W, all other scarps in this section trend N50-60W, which is parallel to most of the fault traces mapped in the Traver Mesa section to the west and the Roubideau Ranch section to the east.

The Traver Mesa Section

The Traver Mesa section lies west of the Bull Creek section and extends for 7.3 km west of Long Creek (Forest Road 520). Most of the 7.3 km length of this section was not mapped as a fault by Williams (1964), but was inferred by photogeologic interpretation by Lettis et al. (1996), and thereafter compiled by Widmann et al. (1998) as an approximately located fault (dashed line).

The main escarpment of the Roubideau Creek fault zone is much less prominent in the Traver Mesa section than in the Bull Creek section. In fact, the easternmost interfluve of the Traver Mesa section between Long Creek and Christie Creek does not display an escarpment along the fault trace, but the ground only slightly steepens from 3.5° to 5° where the fault zone would project across Long Creek. Farther west between Terrible Creek and Traver Creek the escarpment reappears and is up to 60 m high, but is more than twice as broad as in the Bull Creek section.

I observed only one zone of fresh-looking scarps in the Traver Mesa section, near the eastern end between Terrible Creek and Wright Creek (UTM Zone 13, NAD 27, X=739157 m, Y=4255438 m). The most prominent scarp is 150 m long, trends about N80°W, and lies on the fault trace mapped by Lettis et al. (1996) and Widmann et al. (1998) just east of its intersection with Payne Mesa Road. This scarp lies at the base of a broad, steepened zone of the Plateau surface that contains several similar short (but less steep) scarps. The zone is probably a subdued continuation of the steeper escarpment in the Bull Creek section.

The prominent basal scarp is developed in sandstone bedrock of the Dakota-Burro Canyon Formations (Fig. 21), is 1.5-2.7 m high, and has slope angles up to 35°. However, the basal scarp has a peculiar morphology that includes an antithetic (south-facing) slope 0.5 m high just behind the crest of the scarp. Furthermore, in-situ bedrock slabs on the uppermost scarp face dip 30° N, and slabs just above the scarp midpoint dip 50° N. The scarp thus has a cross-section and internal structure reminiscent of an oversteepened anticlinal pressure ridge, that might be related to landsliding and crumpling of rock at the toe of a landslide, rather than to tectonics. However, the far-field slope in this part of the Plateau is only about 5°, which seems too gentle for slab-type landsliding.

My preferred interpretation is that the scarp represents some type of complex tectonic-gravitational rupture in a broad zone of bedrock shattering that accompanied a late Quaternary displacement event.

Fig. 21. The steepest, basal scarp in the Traver Mesa section; view is to south. Rod is 1.5 m long. Bedrock blocks behind the top of the rod dip 30° N (toward the viewer) and slabs at mid-scarp position dip 50° N.

The Roubideau Ranch Section

The Roubideau Ranch section extends for 4.9 km east of Roubideau Canyon. In this section of the fault my mapping differs considerably from that of Lettis et al. (1996) and Widmann et al. (1998). Those authors map a single trace of the Roubideau Creek fault trending about N80°W from Transfer Road east for about 8 km, merging with the headscarp of a large landslide complex east of the West Fork of Dry Creek (Fig. 2). I do not recognize any fault scarps or lineaments in that location or with that trend. Rather, as shown in Fig. 5, the Roubideau Ranch section is dominated by a broad zone of northwest-trending lineaments and small scarps that trend N40°-50°W (Fig. 5b).

The largest of these scarps is labeled Q22 by Widman et al. (1998) and is thus not considered by them as part of the Roubideau Creek fault proper. This fault is marked by a compound north-facing escarpment (Fig. 22)of similar height to the main 60 m-high escarpment on the Roubideau Creek fault in the Bull Creek section. At the base of the escarpment is a 500-800 m-wide graben (Fig. 23) that contains the lush hay meadows of the Roubideau Ranch.

Fig. 22. Wide-angle photograph of the scarp of fault Q22 (between red arrows) along Transfer Road, east of Roubideau Canyon; view is to the south. The entrance to the Roubideau Ranch is at the base of the scarp left of the road. The scarp here is composed of two sub-scarps of roughly equal height, but the lower one appears higher in this wide-angle photograph.

Fig. 23. Panoramic photograph of fault Q22 in the Roubideau ranch section (red line at right) and the graben (bounded by antithetic fault in red, at left). View is to southeast.

The recency of activity of fault Q22 and its associated lineaments is difficult to determine, because the Plateau here is underlain by Cretaceous bedrock with no mappable Quaternary deposits that interact with the fault scarps. Based on analogy with the main escarpment of the Roubideau Creek fault and the steep scarps at its base, there may be similar steep scarps hidden in the dense forest along scarp Q22. This fault was not field checked except west of Transfer Road, because it lay 2.5 to 3.5 km south of the Roubideau Creek fault. However, there may be a small incised valley like the one in the Bull Creek section displaced by a small (3-4 m-high) scarp that would not be visible from aerial photographs in the dense forest. Any future investigations should seek permission from the Ranch owner to investigate this possibility.

STRUCTURE OF THE FAULT ZONE

All studies of the Roubideau Creek fault cited previously have called it a down-to-the-north normal fault, with possibly some Quaternary reverse movement. But none of these studies have described the folding of Dakota-Burro Canyon Formation strata exposed in the cliffs on the west side of Roubideau Canyon. (Fig. 24).

Fig. 24. Photograph of the Roubideau Creek faulted monocline, looking west from Oak Hill on Transfer Road. The Roubideau Creek fault is at center, where a forested gully cuts through the band of cliffs. Monoclinal folding of the Dakota-Burro Canyon Formation can be clearly seen to the left and right of the gully.

Both from a distant perspective (Fig. 24) and a close perspective (Fig. 25), the Roubideau Creek fault appears to be a faulted monocline. Strata on the upthrown side are dragged down into the fault, while strata on the downthrown side are drug up toward the fault. Dips measured on cliff outcrops on the western wall of Roubideau Canyon range from 21° to 38° N (Table 2).

Fig. 25. Panorama mosaic photograph of cliffs on the western side of Roubideau Canyon, in the center of the Roubideau Creek monocline; view is to the west. Sandstone bedrock of the Dakota-Burro Canyon Formations dips between 21° and 38° to the north (right). Bedrock promontories are separated by joints or faults that trend perpendicular to the cliff band.

Table 3. Strikes and dips of bedding and fault zones exposed on the cliffs on the west wall of Roubideau Canyon, in the core of the Roubideau Creek faulted monocline.

Feature	UTM X coord.	UTM Y coord.	Strike	Dip
Bedding	744006	4254375	N60W	25N
Bedding	744053	4254419	N75W	21N
Bedding	744100	4254443	N45W	38N
Fault	744100	4254443	N80W	65S
Fault	744053	4254419	N55W	85S

The monocline is disrupted by several high-angle faults and shear zones, some of which are expressed as gullies cutting through the cliff band, and some of which are inferred to underlie the large gully that leads to the graben west of Roubideau Canyon. One fault plane exposed on the west side cliffs exhibited well-preserved slickensides on a fault plane that dipped 65 south, while bedding in the fault-bounded pinnacle dipped 38° north (Fig. 26).

Fig. 26. Photograph of a fault plane in the center of the Roubideau Creek monocline, looking west approximately along strike. The fault plane is to the left of the stadia rod (1.5 m long), and strikes N80W and dips 65°S. Bedding in this fault-bounded block strikes N45W and dips 38°N, or approximately perpendicular to the fault plane.

On another cliff promontory a shear zone was exposed at the top of the cliff (Fig. 27). This zone is about 1 m wide and consists of closely spaced fractures on the centimeter to decimeter scale. Where fractures are closer than 1 cm apart the rock has a cataclastic texture. Fracture-bounded blocks in the zone typically display Lisegang banding, which is not seen elsewhere in the sandstone outcrop. Like the fault plane mentioned above, these shear zones dip steeply to the west, or toward the upthrown block.

Fig. 27. Photograph of a shear zone in the Roubideau Creek fault, exposed at the edge of cliffs along the western rim of Roubideau Canyon; view is to the east.

The structures exposed on the Roubideau Canyon cliff band can help explain the less well exposed structures previously described in the road bed of Forest Road 545 (Figs. 9, 10). There, two shear zones at mid-scarp dip 65 south (Fig. 28). In addition, bedding planes exposed in the roadbed dipped as much as 17 N, roughly parallel to the ground slope (Fig. 29).

Fig. 28. Zone of crushed rock exposed in the bed of Forest Road 545 on the upper part of the larger fault scarp. Dominant fractures strike N70W (approximately perpendicular to the road) and dip 85°N. For scale, field notebook is 15 cm tall and 10 cm wide. This zone is very similar in size and orientation to a shear zone exposed on the west rim of Roubideau Canyon (Fig. 27).

Fig. 29. In-situ Dakota-Burro Canyon sandstone beds (light brown slabs at center) exposed in the bed of Forest Road 545, on the upper part of the larger scarp; view is to the south. Purple sandstone rubble in foreground is colluvium. Kdb beds strike N30°W and dip 17°NE at this location, approximately parallel to the ground surface.

These two areas of exposure suggest that the Roubideau Creek "fault scarp" is actually a faulted monocline. Most of the 60 m height of the escarpment can be attributed to plastic warping of Dakota sandstone down-to-the-north, with only 5-15 m of the height attributable to brittle normal faulting associated with the basal rejuvenated fault scarp and graben. Kirkham and Rogers (1981, p. 86-88) describe numerous monoclines and suspected Quaternary faults farther north on the flank of the Uncompahgre Plateau neat Grand Junction. In many places the monoclines graded into normal faults along strike.

A more classic interpretation of faulted monoclines comes from Powell (1873) who described a spectrum of fault-fold deformation from the Colorado Plateau (Fig. 30). Powell distinguished simple monoclines (Fig. 30a) and normal faults (Fig. 30b) from hybrids that combine both folding and faulting (Fig. 30c). In the latter case, multiple high-angle faults disrupt the core of the monocline, and the fault-bounded blocks rotate forward, as if toppling forward toward the downthrown block.

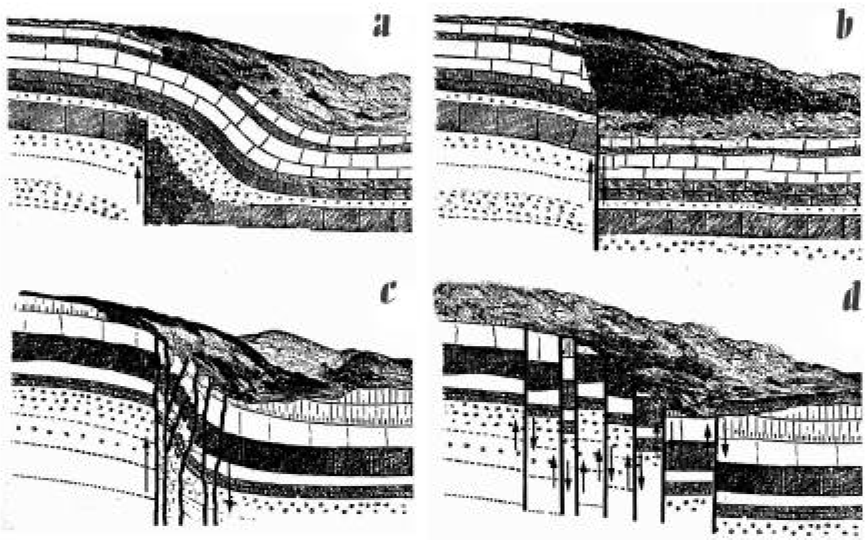

Fig. 30. Schematic cross-sections of faults and monoclines on the Colorado Plateau, from Powell (1873). (a) monoclinal (drape) fold overlying a vertical fault at depth; (b) single vertical fault; (c) faulted monocline with 5 major fault strands. Note the rotation of discrete fault-bounded blocks toward the downthrown block (toppling); (d) multiple vertical faults. The Roubideau Creek fault most resembles diagram (c).

Although Powell was describing faults believed to be Laramide in age, similar structures were documented by McCalpin (in press) on the 50-120 m-high fault escarpment of the Pajarito fault in northern New Mexico (Fig. 31). The Pajarito fault “scarp” was found to be mainly an articulated monocline with a basal graben, which had formed since deposition of the 1.2 Ma Bandelier Tuff. This peculiar structural style was attributed to the rheology of a hard, dense welded tuff at the surface (beds B5 and B4) overlying weaker, unwelded tuffs. Faults propagating upward were expressed as diffuse ductile deformation in the unwelded tuffs, but were forced to break through the brittle caprock along discrete faults.

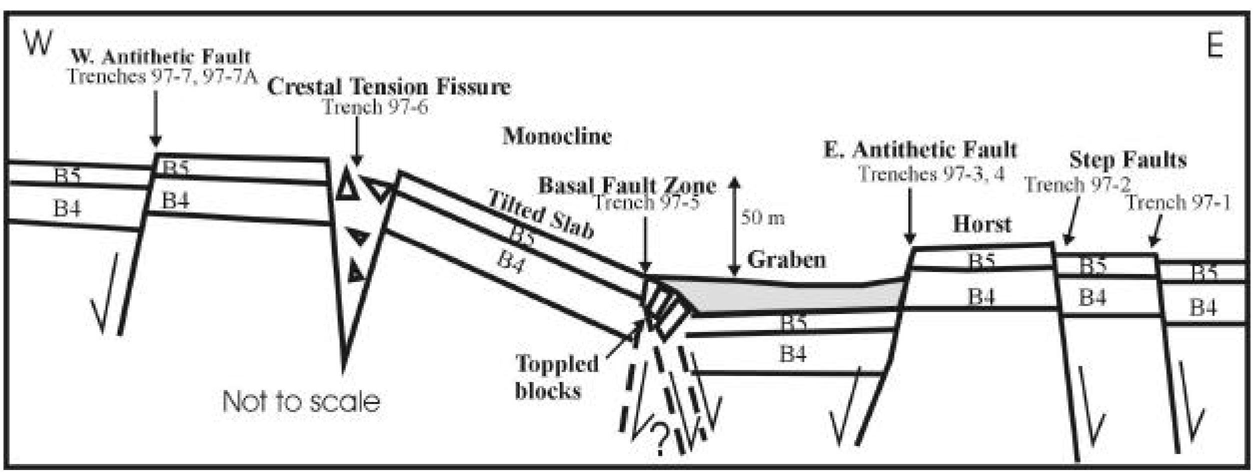

Fig. 31. Schematic cross-section through the Pajarito fault west of Los Alamos, New Mexico. This articulated monocline dismembers the 1.2 Ma Bandelier Tuff (units B5, B4). Locations of trenches are shown, and described in McCalpin (in press).

A similar rheological argument could be made for the Roubideau Creek fault, which cuts hard Dakota sandstone overlying soft, ductile Morrison Formation.

However, at Roubideau Creek the contrast between ductile bending of hard sandstone strata versus formation of steep fault scarps and graben seems to great to accomplish simultaneously. A more reasonable explanation is that the monoclinal folding occurred as drape folding when the strata were buried to considerable depths, perhaps in the Laramide origeny. Thus the majority of the 60 m escarpment height could be explained as simple erosional stripping of a structural datum that was folded 50 million years ago. In contrast, the graben at the base of the escarpment clearly cuts the monocline and represents a younger deformation episode of completely different style.

One piece of evidence supporting this interpretation is an outcrop of Dakota sandstone north of the graben in the Bull Creek section. Here bedding dips 25° north (Fig. 32), similar to the steepest dips measured in the core of the monocline elsewhere. Clearly this location was once in the core of the monocline, but has now been detached from beds of similar dip south of the graben by formation of the graben itself.

Fig. 32. Photograph of north-dipping beds of Dakota-Burro Canyon sandstone on the northern rim of the eastern graben; view is to the southeast. Beds here strike N55W and dip 25°N. These beds were presumably part of the older north-dipping monocline here that was dismembered by later Neogene normal faulting and the development of the graben.

PRELIMINARY ESTIMATES OF SLIP RATE, RECURRENCE, AND CHARACTERISTIC EARTHQUAKE MAGNITUDE

Slip Rate

Preliminary slip rates can be estimated from the height of north-facing fault scarps in the Bull Creek section and from the ages of surfaces they displace. The smallest fault scarps on the southern margin of the graben display vertical surface offsets of 3.6 to 5.1 m, on Quaternary deposits or surfaces that are scarcely dissected by subsequent erosion. These colluvial deposits and incised valley levels probably date from the last major geomorphic reorganization of the landscape on the Uncompahgre Plateau, which in turn probably correlates with the latest glacial maximum of ca. 15-35 ka (Pinedale glaciation). In Table 3 below I use a conservative estimate of age of 25-35 ka for these displaced surfaces, which yields averaged vertical slip rates of 0.1 to 0.2 mm/yr.

Table 4. Scarp heights and slip rates for the Bull Creek section of the Roubideau Creek fault.

No.	Location	Scarp Height (m)	Surface Offset (m)	Maximum Scarp Angle (degrees)	Age of Faulted Surface (ka)	Slip Rate (average), mm/yr
1	**Between Bull and E. Bull Creeks**	**9.0**	**5.1**	**28**	**25-35**	**0.15-0.20**
2	**North of stock pond**	**7.0**	**4.2**	**30**	**25-35**	**0.12-0.17**
3	**East of stock pond**	**-**	**3.6**	**32**	**25-35**	**0.10-0.14**
4	**East of stock pond**	**13**	**9.1**	**26**	**150**	**0.06**

As is often the case, average slip rates estimated for older scarps are slightly lower than for younger scarps. If the 8-13 m-high scarps all along the base of the escarpment displace deposits correlatibe with the penultimate glaciation of the Rocky Mountains at ca. 150 ka (Bull Lake glaciation), then average slip rates are only 0.06 mm/yr.

Recurrence

Recurrence time between surface-rupturing earthquakes is difficult to estimate merely from geomorphic data, because the number of such events represented by a 3.6 m-high scarp, 5.1 m-high scarp, or 9.1 m-high scarp is unknown. One way to estimate the likely displacement per event on the Roubideau Creek fault is to measure the likely length of surface rupture and correlate that with a displacement per event. It seems very likely that several late Quaternary events ruptured the surface in at least the the Bull Creek section, the easternmost 1 km of the Traver Mesa section, and possibly the Roubideau Canyon section. That equates to a minimum distance of 5.2 km and a maximum of 7.3 km. It seems unlikely these same late Quaternary surface ruptures extended into the Roubideau Ranch, based on the lack of continuity of scarps. The upper bound of length is the 20.5 km listed by Widmann et al. (1998).

According to Wells and Coppersmith (1994), normal fault surface ruptures 5.2-7.3 km long correlate with average displacements of only 0.08-0.12 m and maximum displacements of only 0.13-0.21 m. These displacements are so small in relation to the scarp heights of 5-14 m that I suspect the ruptures were longer than 5-7 km, and the additional length of rupture has been obscured by the dense forest. By comparison, surface ruptures 20.5 km long correlate with average displacements of 0.43 m and maximum displacements of 1.0 m.

If we assume that the scarps associated with the graben in the Bull Creek section were formed by near-maximum displacements, then roughly 4 displacement events are required since 25-35 ka and 9 events since ca. 150 ka. These values yield average recurrence intervals of 6.25-8.75 ky and 16.7 ky, respectively. These recurrence values are very high for Colorado, being as short or shorter than those on the Sangre de Cristo fault, the state's most active fault (Widmann et al., 1998). Due to this apparent discrepancy, I suspect that the per-event displacements were significantly larger than 1 m.

Characteristic Earthquake Magnitude

The magnitude of characteristic earthquakes on the Roubideau Creek fault can be estimated from surface rupture lengths or from per-event displacements, but our estimates of those variables are highly uncertain and co-dependent. Ake et al. (2002) estimated the following: "*A maximum magnitude of 6.5 is assigned to the fault based on fault length. Based on the estimate of a maximum vertical separation rate of 0.2 mm/yr, we estimate a broad range of slip rates, from 0.005-0.2 mm/yr.*" A magnitude of 6.5 is just barely above the surface rupture threshold for normal faults, and seems like a reasonable first approximation for a fault with a mapped length of Quaternary scarps of only 5-7 km. This magnitude estimate could be refined by site-specific data on per-event displacements, to be obtained by trenching.

Recommendations for Future Research

This reconnaissance study has uncovered new information about the structural style and deformation history of the Roubideau Creek fault, and has described tantalizing evidence for late Quaternary fault rupture. However, due to the ambiguous nature of some geomorphic evidence such as scarp heights, there is large uncertainty in our estimates for characteristic earthquake magnitude and recurrence interval. In particular, the Roubideau Creek fault seems to present a classic example of a "short, fat fault", that is, a fault that has high fault scarps that extend over a relatively short distance.

The uncertainties cited above can only be reduced or eliminated by a detailed trenching study. Fortunately, this study has identified promising sites for trenching along the southern edge of the graben in the Bull Creek section, particularly near the stock pond. Here fault scarps are 5-7 m high and can be reached with excavating equipment via jeep roads. The graben itself has probably acted as a sediment trap since the initiation of Neogene normal faulting, and might yield datable material going back several hundred kyr. From a logistical standpoint, there are no major impediments to a trenching study other than obtaining permission from the US Forest Service. In that regard, Mr. Terry Hughes of the Uncompahgre National Forest has already indicated his interest in supporting these types of studies.

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Appendix 1
Summary of data compiled for the Roubideau Creek fault, from the Colorado Geological Survey's on-line Late Quaternary Faults and Fold Database

Roubideau Creek Fault

Alpha ID: RBDF

Structure type: Simple fault

Structure name: Roubideau Creek Fault

Comments: The Roubideau Creek Fault is a west-northwest-striking fault northeast of the Uncompahgre Uplift, and southwest of Delta. The fault extends from near Traver Creek on the west end nearly to the East Fork of Dry Creek on the east end. Roubideau Creek is the dominant drainage between these two creeks. Lettis and others (1996) referred to this fault as the Roubideau Creek Fault.

Previous structure identifiers:

Comments: Fault 82 in Kirkham and Rogers (1981); fault 2270 in the U.S. Geological Survey Quaternary fault and fold database; fault Q20 in Widmann and others (1998).

Synopsis:

The Roubideau Creek Fault is on the northeast flank of the Uncompahgre Uplift. It is marked by a northeast facing 80-m-high scarp, a southwest-facing scarp, and a sag pond (Lettis and others, 1996). The fault dips northeast (Lettis and others, 1996), but sense of movement is not well understood. Late Pleistocene to Holocene landslide deposits are offset by the fault near Roubideau Creek (Kirkham and Rogers, 1981; Lettis and others, 1996).

Compiler and affiliation:
Beth L. Widmann, Colorado Geological Survey

Revised by:

Date of revisions:

Cumulative length (km): 26.06

Date of compilation: 07/09/1997

State: Colorado

End to end length (km): 20.47

County: Montrose

1°x2° Sheet: Moab

Average Strike: N74W

Province: Colorado Plateaus

Number of traces: 7

Township and Range: T48N,R11W- - T48N,R13W

Geologic setting:

The Robideau Creek Fault is a northeast-dipping normal fault (Lettis and others, 1996). Quaternary offset, however, seems to suggests down-to-the-southwest movement on the fault (Kirkham and Rogers, 1981), implying reverse faulting at least during the Quaternary. The fault lies on the northeast flank of the Uncompahgre Uplift which is a northwest-striking, east-tilted fault block that has been uplifted as much as 640 m during the mid-Pliocene to Pleistocene (Cater, 1966).

Reliability of location: Good

Comments: The Robideau Creek Fault was mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996), 1:250,000 and 1:500,000 by Widmann and others (1998), 1:500,000 by Kirkham and Rogers (1981), and 1:1,000,000 by Colman (1985). The trace used herein is from Williams (1964).

Sense of movement: R

Comments: Lettis and others (1996) defined the fault as northeast-dipping and normal, but Kirkham and Rogers (1981) suggested reactivation during the Quaternary in a reverse sense.

Dip:

Comments: Lettis and others (1996) defined the fault plane as northeast-dipping.

Dip direction:

NE

Geomorphic expression:

The Robideau Creek Fault is marked by an 80-m-high northeast-facing scarp. The fault also aligns with another smaller scarp that is southwest-facing, and a sag pond is located against this fault scarp. The smaller scarp and sag pond may be evidence of Quaternary activity on an antithetic fault in the hanging wall of the Robideau Creek Fault (Lettis and others, 1996).

Age of faulted deposits:

Quaternary landslide deposits of late Pleistocene to Holocene age are offset along the fault trace (Sullivan and others, 1980; Kirkham and Rogers, 1981; Lettis and others, 1996). Williams (1964) shows no offset of Quaternary deposits. The majority of the fault extends through Jurassic and Cretaceous bedrock.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (1) Holocene and post glacial (<15ka)

Comments: Sullivan and others (1980) and Lettis and others (1996) mapped late Pleistocene to Holocene deposits as displaced by this fault.

Recurrence interval: ND

Comments:

Slip rate: (D) <0.2 mm/yr

Comments: Lettis and others (1996) calculated a slip rate of 0.2 mm/yr or less based on a scarp height of 80 m and an age of about 500 ka or older.

Earthquake notes:

References:

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