OPEN-FILE REPORT 98-8

Preliminary Quaternary Fault and Fold Map and Database of Colorado

By

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INTRODUCTION

The preliminary Quaternary fault and fold database of Colorado contains information about faults and folds that are known or suspected to have been active during the Quaternary. Structures previously reported as Quaternary in age that have subsequently been discounted in the literature are also described in the database. The report includes a paper copy of the database, a paper copy of a map showing Quaternary faults and folds in Colorado at a scale of 1:500,000, and an optional CD-ROM containing the fault and fold traces shown on 1° x 2° (1:250,000-scale) Army Map Service topographic base maps. We recommend at least a 486 processor with 16 MB of RAM to view the files contained on the CD-ROM. Individual 1° x 2° maps can be viewed using either the Windows or Macintosh version of Adobe® Acrobat Reader®, both of which have been included on the CD-ROM in accordance with Adobe® licensing agreements. The report is available for purchase with or without the CD-ROM.

The information contained herein was compiled from available literature. Previous summaries of Quaternary structures in Colorado by Witkind (1976), Kirkham and Rogers (1981), and Colman (1985) served as an initial basis for the compilation of this database. More recent and in many cases more detailed studies provided the updated information used to characterize many of the structures. We have attempted to accurately summarize only what is contained in these written documents and not introduce any personal bias. Fault traces were compiled from the references, hand transferred onto 1° x 2° (1:250,000-scale) Army Map Service base maps, and digitized by the U.S. Geological Survey.

This preliminary version of the Quaternary fault and fold database is being released as an open-file report to satisfy customers who have immediate needs for this data. The Colorado Geological Survey will continue compiling data on Neogene (late Tertiary) faults and folds in our database and will release that information in the near future.

Users of this database are encouraged to submit comments, corrections, and additions to the Colorado Geological Survey staff who have authored this report. This database will be revised as needed after review comments have been received and will periodically be updated as new information on Quaternary fault and fold activity in Colorado becomes available. In the future the Colorado Geological Survey will produce an interactive CD-ROM which will include a compilation of the Quaternary fault and fold database and the Neogene fault and fold database with associated maps in digital form. The preliminary Quaternary fault and fold database of Colorado has also been submitted to the U.S. Geological Survey as the deliverable for a grant that in part supported this project, and it will be included in their U.S. Quaternary fault and fold database.

The format of this database generally follows the guidelines set by Haller and others (1993) for the U.S. Quaternary fault and fold database, although we have added a few or our own field headings such as "Earthquake notes" and "Township and Range". Each field heading is defined in a later section of the introduction. A field entry that is blank indicates published data was not available at the time of this compilation.

Overview

There are 92 faults and 6 folds described in this database. The majority of these structures are considered simple faults or folds. Four faults, the Southern Sangre de Cristo Fault, the Cimarron Fault, the Sawatch Fault, and the Northern Sangre de Cristo Fault, are herein considered to be sectioned faults based on detailed investigations which suggest different parts of the faults may have ruptured independently in the past. Although several faults in Colorado have been trenched and dated, we feel that none have been studied in sufficient detail to warrant designation herein as a segmented fault.

Two faults, the Golden Fault and Valmont Fault, and one fold, the Grand Hogback monocline, are considered as features with suspected but not proven Quaternary activity. Twelve faults that were at one time described in the literature as having Quaternary movement, but have since been discredited by more recent investigations, are herein classified as discounted Quaternary faults.

The most recent paleoevent for each fault and fold was generally determined from offset or deformation of Quaternary deposits either in direct contact with or close proximity to the fault or fold. The timing of the most recent paleoevent for each structure has been assigned to one of four age categories which define the maximum age of the last paleoevent on the structure. The categories include Holocene and post glacial (<15 ka), late Quaternary (<130 ka), middle and late Quaternary (<750 ka), and Quaternary (<1.6 Ma). The last paleoevent on the structure may have occurred at any time during the assigned age category (fig. 1).

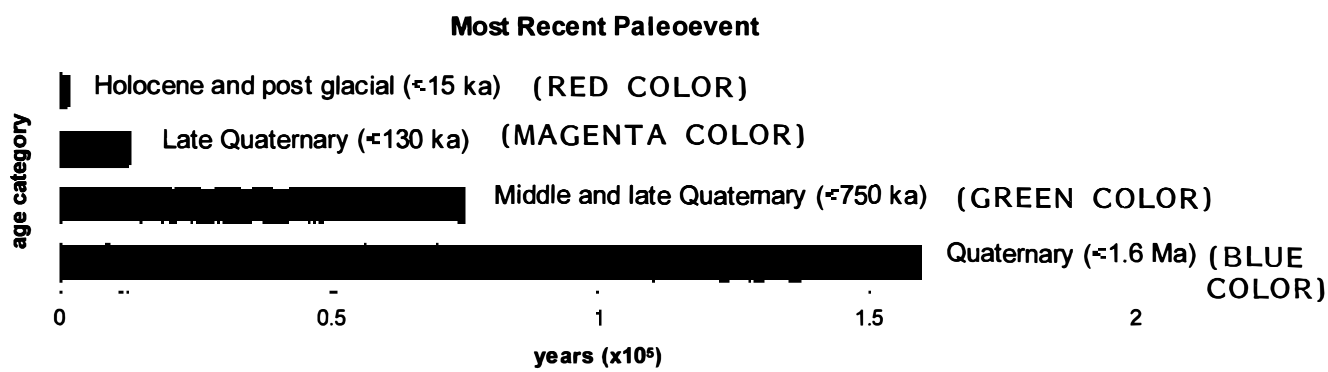

Figure 1: Graph showing the time interval covered by each age category used to describe the timing of the last paleoevent.

The most recent paleoevent on the majority of the structures in the database occurred during the Quaternary age category (<1.6 Ma). There are seven faults that show evidence of middle and late Quaternary movement (<750 ka), and fifteen faults classified as last moving during the late Quaternary (<130 ka). Holocene and post glacial movement (<15 ka) has been demonstrated for only eight faults: the Northern Sangre de Cristo Fault zone, the Cheraw Fault, the Sawatch Fault, the Villa Grove Fault zone, the Williams Fork Mountains Fault, the Cimarron Fault, the Roubideau Creek Fault, and unnamed faults along the Grand Hogback monocline near Fourmile Creek. The Cattle Creek anticline is the only fold known to have been active during the Holocene and post glacial age period.

In some cases where there are no reported Quaternary landforms or deposits in contact with or in close proximity to a specific fault, Quaternary movement has been based on indirect evidence. For example, faults associated with the Uncompahgre Plateau in western Colorado are considered to have been active during the Quaternary even though crosscutting relationships with Quaternary deposits are generally not described in the literature. However, Cater (1966) suggested Quaternary movement on many of these faults based on mid-Pliocene through Pleistocene uplift of the Uncompahgre Plateau which is inferred from the apparent abandonment of drainages on the plateau during the Quaternary. Witkind (1976) described these structures as Quaternary faults, and subsequent investigators have usually followed this interpretation. Faults of the Uncompahgre Plateau are therefore herein considered to have been active during the Quaternary.

Detailed investigations have been conducted on several faults in Colorado. Multiple trenches have been excavated across eleven Quaternary structures, the Northern Sangre de Cristo Fault zone, Cheraw Fault, Sawatch Fault, Villa Grove Fault zone, East-side Chase Gulch Fault, West-side Chase Gulch Fault, Rampart Range Fault, graben near Golden, Golden Fault, Cimarron Fault, and Red Rocks Fault. Additionally, scarp profiles have been measured on the Northern Sangre de Cristo Fault zone, Sawatch Fault, Villa Grove Fault zone, Mesita Fault, and faults near Monte Vista.

All but two of the structures in this database are considered as having a slip rate of less than 0.2 mm/yr. The Williams Fork Mountains Fault is the only fault with a reported slip rate of 0.2 to 1 mm/yr. A similar slip rate was herein estimated for the Frontal Fault based on reported offset of age-constrained Quaternary deposits. Very few recurrence intervals have been published for the faults included in this database; recurrence intervals ranging from 5 ka to 100 ka are cited in the literature for only nine faults.

Definitions of Database Terms

Age of faulted or folded deposits – Ages of the deposits, at the surface or within trench exposures, that are faulted or folded. The timing of the most recent paleoevent is generally considered as occurring after deposition of the youngest deformed deposit.

Compiler and affiliation – The name and affiliation of the person(s) responsible for compiling the data for each structure.

County – The county in which the majority of the fault is located is listed first, followed by other counties in which the fault is located.

Cumulative length – The cumulative length of all solid traces associated with a particular structure, as determined from GIS data. Dashed and dotted traces are not included in this measurement.

Date – The date of compilation.

Detailed studies – Studies that include site specific investigations such as trenching, radio isotopic dating, and close examination of scarp morphology and stratigraphic relationships are synthesized in this field.

Dip – The dip angle of the fault plane as reported in the literature or measured from published cross sections.

Dip direction – The dip direction of the fault as reported in the literature.

Earthquake notes – Information on historic seismicity and maximum credible earthquake reported in the literature for a particular fault.

End to end length – The distance between the endpoints of a particular structure, as determined from GIS data.

Geologic setting – An overview of the regional geologic setting of the structure.

Geomorphic expression – Description of geomorphic features associated with a specific fault or fold, such as scarps, lineaments, deflected streams, ponded sediments, etc.

Number of sections – Numeric value indicating the number of sections comprising a sectioned fault.

Number of traces – In several cases there is more than one fault or fold trace associated with a given structure number. This field term indicates the number individual traces associated with a particular structure as shown on the map that accompanies this database.

1° x 2° sheet – The 1° x 2° Army Map Service base map (1:250,000-scale) on which the majority of the fault occurs is listed first, followed by the other maps on which the fault lies.

Province – The provinces used herein were outlined by Fenneman and Johnson (1946). The physiographic province in which the majority of the fault occurs is listed first, followed by the other provinces in which the fault lies.

Recurrence interval – The time interval between rupture or fold events. Recurrence intervals were included only if reported in the literature or where sufficient data allowed for calculation of a recurrence interval. Where a recurrence interval could not be determined, the compiler entered "ND" for not determined.

References Cited – All references cited for each structure are listed in this field.

Reliability of location – (Good or Poor) The reliability of the location of each structure is based on the scale of map(s) used to compile the digital map that accompanies this database. Reliability is considered good if the structure has been mapped at a scale of 1:250,000 or larger.

Section name – The most commonly used name for a specific section of a fault or fold. Alternative names and a brief description of the location of the section are listed under "Comments".

Section number – Each section of a fault is assigned an alpha character. Section labeling begins with the northern- or western-most section and proceeds to the south and east. For example, the Cimarron Fault (structure number Q40) has four sections: Q40a, Q40b, Q40c, Q40d.

Sense of Movement – The following letters are used to indicate sense of movement on Quaternary faults: N = normal, R = reverse, T = thrust, D= dextral (right lateral), and S = sinistral (left lateral). Oblique-slip faults are described by combinations of letters, with the first letter indicating the principal sense of movement. For example, "NS" indicates a normal left-lateral strike slip fault with more vertical than horizontal slip.

Slip-rate – Slip rates for each structure are assigned to one of four categories: >5 mm/yr, 5-1 mm/yr, 0.2-1 mm/yr, and <0.2 mm/yr. If the slip rate for a particular structure was not reported in the literature, the compiler entered "unknown" and then estimated a probable slip rate for the structure.

State – The state in which the majority of the fault is located is listed first, followed by the other states in which the fault lies.

Strike – The average strike of the trace of the fault or fold as determined from GIS data.

Structure name – Most commonly used name for a specific structure. Alternative names and a brief description of the location of the fault are given under the "Comments" section.

Structure number – Each structure has been given a unique alphanumeric number. Numbering, in general, begins in the northwestern-most part of the state and proceeds to the south and east. Number designations used for the same structure in other publications and databases are listed under "Comments".

Structure type – Quaternary faults are herein defined as having demonstrable or interpreted offset of Quaternary deposits. Faults that appear to be active based solely upon their historic seismic activity are not included in the database. Faults described in the database are subdivided into four types or categories that characterize the faults more specifically. A *simple fault* is a fault that appears to consist of a single section all of which ruptured during the last paleoevent. The term *simple fault* also serves as a default category for faults that have not been studied in enough detail to warrant designation as a sectioned or segmented fault. A *sectioned fault* is a fault that appears to consist of two or more sections that have ruptured independently, but each section has not been carefully evaluated in detail to accurately characterize the rupture history of each section. A *segmented fault* is similar to a sectioned fault but has been studied in sufficient detail such that the rupture history of each segment is well understood. None of the faults in Colorado are herein considered to be segmented faults. A *discounted fault* is a fault that was previously described in the literature as having been active during the Quaternary but more recent investigations have disproved Quaternary activity on the fault. Quaternary folds are herein similarly defined as showing demonstrable or interpreted deformation of Quaternary deposits. All Quaternary folds in this database are considered simple folds. Faults or folds are described as s*uspect features* when the literature is not conclusive or when it leaves doubt as to the structure's Quaternary activity.

Synopsis – A short summary of the data compiled for each structure.

Timing of most recent paleoevent – There are four age categories that describe the timing of the last paleoevent: Holocene and post glacial (<15 ka), late Quaternary (<130 ka), middle and late Quaternary (<750), and Quaternary (<1.6 Ma). The last paleoevent on the structure is no older than, but may have occurred at anytime during, the age period to which it was assigned.

Township and Range – The location of the structure based on township and range.

Acknowledgments

This project was funded jointly by the Colorado Geological Survey, the U.S. Geological Survey National Earthquake Hazards Reduction Program through Award No. 1434-HQ-97-GR-02985, and the Colorado Office of Emergency Management. Part of the funding provided by the Colorado Geological Survey is from mineral severance taxes collected from producers of oil, gas, coal, and minerals. We thank Kathy Haller and Michael Machette, U.S. Geological Survey, for their professional support and guidance in setting up the framework for this database. John Ake, U.S. Bureau of Reclamation, Susan Steele-Weir, Denver Water Department, Ivan Wong, Woodward-Clyde Federal Services, John Nicholl, Woodward-Clyde Consultants, and Katherine Hanson, Geomatrix Consultants, provided copies of reports prepared by their respective organizations. Gary Christiansen, Utah Geological Survey, shared knowledge and provided reports about faults along the Colorado-Utah border. Initial digitization of all faults and folds was carried out by Richard Dart, U.S. Geological Survey. The final map and digital product was completed by Matt Morgan, Colorado Geological Survey.

References Cited in Introduction

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, in Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Fenneman, N.M., and Johnson, D.W., 1946, Map of physical divisions of the United States: U.S. Geological Survey, Physiographic Committee, Washington, D.C.

Haller, K.M., Machette, M.N., and Dart, R.L., 1993, Guidelines for U.S. database and map: U.S. Geological Survey Open-file Report 93-338, 45 p.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

SIMPLE QUATERNARY FAULTS

A *simple fault* is a fault that appears to consist of a single section all of which ruptured during the last paleoevent. The term *simple fault* also serves as a default category for faults that have not been studied in enough detail to warrant designation as a sectioned or segmented fault.

Structure type: Simple fault

Structure number: Q1

Comments: Fault 75 in Kirkham and Rogers (1981); fault 281 in Witkind (1976); fault 2251 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Little Dolores River Fault

Comments: The majority of the Little Dolores River Fault is in Utah. This northwest-trending fault extends southeast from Utah into Colorado along the northeast flank of Snyder Mesa. The fault crosses the Little Dolores River just before entering Colorado. The fault lies on the northeast flank of the Uncompahgre Uplift. This description focuses on the part of the fault that extends into Colorado.

Synopsis:

The Little Dolores River Fault extends from Utah into Colorado on the northeast flank of the Uncompahgre Uplift. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along the Little Dolores River Fault, it has been classified as a Quaternary fault (Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/11/97

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

State: Colorado, Utah

County: Mesa

1° x 2° Sheet: Grand Junction

Province: Colorado Plateaus

Township and Range: T12S,R104W-T20S,R25E

Strike: N55W

Number of traces: 1

End to end length: 15.73 km

Cumulative length: 15.89 km

Reliability of location: Good

Comments: The fault was mapped by Cashion (1973) at a scale of 1:250,000.

Geologic setting:

This fault lies on the northeast margin of the Uncompahgre Uplift along the Utah/Colorado border near the Little Dolores River. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. The Little Dolores River Fault is a high-angle fault that is down to the northeast.

Sense of movement: R

Comments: Heyman (1983) mapped this fault as down to the northeast on a fault plane dipping 85°SW. Kirkham and Rogers (1981) listed this fault as normal.

Dip: 85°SW

Comments: Heyman (1983) measured a dip of 85°SW for the Little Dolores River Fault in Utah in the vicinity of T20S, R24E.

Dip direction: SW

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The Salt Wash Sandstone Member of the Jurassic Morrison Formation is the youngest deposit known to be offset by this fault. The majority of the fault lies in Precambrian to lower Mesozoic bedrock, and about 5% of the fault is concealed by Quaternary deposits (Cashion, 1973).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for Quaternary movement, this fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: (D) <0.2 mm/yr

Comments: Based on the lack of geomorphic features in Quaternary deposits and on calculations of an overall uplift rate of .4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this fault.

Earthquake notes:

References Cited:

Cashion, W.B., 1973, Geologic and structure map of the Grand Junction quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-736.

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Heyman, O.G., 1983, Distribution and structural geometry of faults and folds along the northwestern Uncompahgre Uplift, western Colorado and eastern Utah, 'in' Averett, W., ed., Northern Paradox Basin - Uncompahgre Uplift: Grand Junction Geological Society, p. 45-57.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q2 - Redlands Fault Complex

Structure type: Simple fault

Structure number: Q2

Comments: Fault 65 in Kirkham and Rogers (1981); fault 283 in Witkind (1976); fault 2252 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Redlands Fault Complex

Comments: The Redlands Fault complex forms the northeast margin of the Uncompahgre Uplift and consists of three faults and two monoclines, all of which show a general northwest trend. The fault complex is located in the Colorado National Monument southwest of Grand Junction. It extends along the northeast boundary of the Monument then bends west toward Horsethief and Mee Canyons. Features included in this complex include from west to east, the Flume Canyon Fault, an unnamed monocline, the Kodel's Canyon Fault, the Lizard Canyon Monocline, and the Redlands Fault (Lohman, 1963).

Synopsis:

The Redlands Fault complex forms the northeast margin of the Uncompahgre Uplift and consists of three faults and two monoclines. Evidence for Quaternary movement on this fault complex is cited in Witkind (1976), based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated the Uncompahgre Plateau began to rise in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along the Redlands Fault complex, the fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/12/97

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

State: Colorado

County: Mesa

1° x 2° Sheet: Grand Junction

Province: Colorado Plateaus

Township and Range: T1N,R3W-T1S,R1W

Strike: N54W

Number of traces: 1

End to end length: 21.08 km

Cumulative length: 22.07 km

Reliability of location: Good

Comments: This fault and fold complex was mapped at a scale of 1:31,680 by Lohman (1963; 1965). Cashion (1973) showed this structure in much less detail at a scale of 1:250,000. The trace used herein is from Lohman (1965).

Geologic setting:

The Redlands Fault complex forms the northeast flank of the Uncompahgre Uplift near Grand Junction. The Uncompahgre Uplift is a northwest-trending east-tilted fault block. Faults in the northwest-trending Redlands Fault complex are generally high-angle normal, but in some areas reverse. The faults commonly transition into faulted monoclines. The Kodel's Canyon Fault extends to Fruita Canyon and gradually becomes the Lizard Canyon Monocline. Near the mouth of Monument Canyon, the Lizard Canyon Monocline merges with the Redlands Fault. Maximum displacement on the Flume Canyon and Kodel's Canyon Faults is about 100 m, and maximum displacement on the Redlands Fault is 244 m (Lohman, 1965). This fault complex occurs in a tectonically weakened area above the ancestral Garmesa and Douglass Creek Fault zones (Stone, 1977).

Sense of movement: NR

Comments: Kirkham and Rogers (1981), Lohman (1965) and Witkind (1976) reported both normal and reverse movement on the faults. The Flume Creek Fault was mapped as a reverse fault by Heyman (1983).

Dip: 45°SW

Comments: Measurements of reverse movement on the Redlands Fault are from two locations at the mouths of Gold Star Canyon and a smaller canyon, both located in the SE 1/4 SW 1/4 of sec. 30, T1S, R1W (Lohman, 1965). Heyman (1983) measured a dip of 75°-80° on the Flume Creek Fault in the vicinity of T11S, R101W.

Dip direction: SW

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The Upper Triassic Kayenta Formation is the youngest deposit offset across this fault complex, with up to 240 m of throw (Lohman, 1965). Quaternary deposit are absent along the fault trace and the entire fault lies in Paleozoic to lower Mesozoic bedrock.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Quaternary deposits are generally absent in this area, making it difficult to recognize Quaternary movement on the faults. Faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement is cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for Quaternary movement, the Redlands Fault complex has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cashion, W.B., 1973, Geologic and structure map of the Grand Junction quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-736.

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

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Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Simple fault

Structure number: Q3

Comments: The Jacobs Ladder Fault complex was described as a potentially active fault by Kirkham and Rogers (1981), but due to the complexity and short length of the fault complex, they did not show it on their accompanying map. This is also fault 2253 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Jacobs Ladder Fault Complex

Comments: The Jacobs Ladder Fault complex consists of about 20 generally northwest- and northeast-trending faults and some associated minor folds. The structure is on the northeast margin of the Uncompahgre Uplift and lies southeast of the Redlands Fault complex and north of the Glade and Ladder Faults. This structue name is probably based on the intricate and seemingly conjugate pattern of the faults

Synopsis:

The Jacobs Ladder Fault complex consists of several northeast- and northwest-trending minor faults and folds. Jurassic and Cretaceous bedrock is offset by the fault, but Quaternary deposits have not been mapped in the vicinity of the fault complex (Lohman, 1963; 1965; Williams, 1964; Cashion, 1973). The fault complex is herein classified as a Quaternary fault due to its association with the Uncompahgre Uplift, which is considered to have been active into the Pleistocene (Cater, 1966; Lettis and others, 1996).

Date of compilation: 6/25/98

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

State: Colorado

County: Mesa

1° x 2° Sheet: Grand Junction, Moab

Province: Colorado Plateaus

Township and Range:

Strike: N8E

Number of traces: 23

End to end length: 5.14 km

Cumulative length: 22.10 km

Reliability of location: Good

Comments: The fault complex was mapped at a scale of 1:31,680 by Lohman (1963; 1965) and 1:250,000 by Williams (1964) and Cashion (1973). The trace used herein is from Williams (1964) and Cashion (1973).

Geologic setting:

The Jacobs Ladder Fault complex is on the northeast margin of the Uncompahgre Uplift southwest of Grand Junction. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. The fault complex lies in a tectonically weakened area above the ancestral

Garmesa and Douglass Creek Fault zones (Stone, 1977). Throw on the faults is variable. Lohman (1965) indicated that fault offsets are minor and suggested that the fault complex may be related in some way to the Ladder Creek Monocline.

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The faults lie entirely within the Cretaceous to Jurassic bedrock (Lohman, 1963; 1965; Williams, 1964; Cashion, 1973). Since Quaternary deposits do not occur in the vicinity of the fault complex, the activity of the fault complex during the Quaternary cannot be directly assessed.

Detailed studies:

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: There are no mapped Quaternary deposits along these faults, so it is difficult to document the Quaternary history of the fault complex. However, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated the Uncompahgre Uplift began ro rise in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. The Jacobs Ladder Fault complex is classifed as a potentially active fault by Kirkham and Rogers (1981). There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for faulted Quaternary deposits, the most recent paleoevent on the Jacobs Ladder Fault complex is herein considered to have occurred during the Quaternary based on its association with the Uncompahgre Uplift.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Cashion, W.B., 1973, Geologic and structure map of the Grand Junction quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-736.

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado in Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Lohman, S.W., 1963, Geologic map of Grand Junction area, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-404.

Lohman, S.W., 1965, Geology and artesian water supply of the Grand Junction area, Colorado: U.S. Geological Survey Professional Paper 451, 149 p.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, in Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q4 - Glade Park Fault

Structure type: Simple fault

Structure number: Q4

Comments: Fault 66 in Kirkham and Rogers (1981); fault 282 in Witkind (1976); fault 2254 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Glade Park Fault

Comments: The Glade Park Fault is an east-west oriented fault that extends through Glade Park, which is southwest of Grand Junction. The fault lies on the northeast flank of the Uncompahgre Uplift. Witkind (1976) mapped faults Q4-Q6, Q8, Q10, and Q11 (this database) as a single fault which he referred to as the Glade Park Fault. Williams (1964) showed faults Q4 and Q5 as a single fault. More detailed mapping by Lohman (1963; 1965) revealed that the faults are not connected at the surface. Lohman (1963) labeled fault Q4 as the Glade Park Fault.

Synopsis:

The Glade Park Fault lies on the northeast flank of the Uncompahgre Uplift southwest of Grand Junction. Williams (1964) mapped this fault as a solid line through Quaternary alluvium, but Lohman (1963; 1965) showed this fault as being covered by Quaternary alluvium. Evidence for Quaternary movement on this fault was cited in Witkind (1976), based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along the Glade Park Fault, it has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/11/97

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

State: Colorado

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T12S,R102W-T12S,R101W

Strike: N80W

Number of traces: 1

End to end length: 10.09 km

Cumulative length: 10.14 km

Reliability of location: Good

Comments: This fault was mapped at a scale of 1:31,680 by Lohman (1963; 1965) and 1:250,000 by Williams (1964). The trace used herein is from Lohman (1965).

Geologic setting:

The Glade Park Fault is part of the northeast margin of the Uncompahgre Uplift southwest of Grand Junction. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. Displacement on this fault is down to the south on either a normal fault (Lohman, 1965; Kirkham and Rogers, 1981) or a reverse fault (Heyman, 1983). Witkind (1976) suggested throw is down to the northeast but showed faults Q4-Q6, Q8, Q10, and Q11 (this database) as a single fault. Portions of this fault complex are in fact down to the northeast (faults Q6 and Q8), but the remainder of the faults, including the Glade Park Fault are down to the south (Lohman, 1963; 1965; Kirkham and Rogers, 1981; Colman, 1985). Throw on the fault is opposite to local topography. This fault lies in a tectonically weakened area above the ancestral Garmesa and Douglass Creek Fault zones (Stone, 1977).

Sense of movement: R

Comments: Heyman (1983) mapped this fault as down to the south on a north-dipping reverse fault with a dip of 75°. Kirkham and Rogers (1981) described this fault as normal but did not provide measurement or discussion that supports normal movement.

Dip: 75°N

Comments: Heyman (1983) mapped the Glade Park Fault as down to the south on a north-dipping plane in the vicinity of T12S, R101W.

Dip direction: N

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Williams (1964) mapped this fault as a solid line through Quaternary alluvial deposits, which indicates the deposit is offset by the fault. More detailed mapping by Lohman (1963; 1965), however, showed the fault as being overlain by unfaulted Quaternary alluvial deposits, and less than 7.5 m of throw in pre-Quaternary deposits. The upper Jurassic Morrison and Summerville Formations are the youngest deposits faulted according to Lohman (1963). More than 95% of the fault lies in lower Mesozoic bedrock.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Quaternary deposits are generally absent in this area, making it difficult to recognize Quaternary movement on the faults. Williams (1964) showed the fault trace as a solid line through Quaternary deposits (indicating the deposits are faulted), while Lohman (1965) showed the fault as overlain by unfaulted Quaternary deposits. Faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on the fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift began in the mid-Pliocene and continued into the Pleistocene resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for Quaternary movement, the Glade Park Fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Heyman, O.G., 1983, Distribution and structural geometry of faults and folds along the northwestern Uncompahgre Uplift, western Colorado and eastern Utah, 'in' Averett, W., ed., Northern Paradox Basin - Uncompahgre Uplift: Grand Junction Geological Society, p. 45-57.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lohman, S.W., 1963, Geologic map of Grand Junction area, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-404.

Lohman, S.W., 1965, Geology and artesian water supply of the Grand Junction area, Colorado: U.S. Geological Survey Professional Paper 451, 149 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

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Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Simple fault

Structure number: Q5

Comments: Fault 67 in Kirkham and Rogers (1981); fault 282 in Witkind (1976); fault 2255 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Ladder Creek Fault

Comments: The Ladder Creek Fault is an east-west oriented fault on the northeast margin of the Uncompahgre Uplift. It is southwest of Grand Junction and east of Glade Park. The fault extends eastward from just east of the east end of the Glade Park Fault to the head of Ladder Canyon. Williams (1964) showed faults Q4-Q5 (this database) as single fault. Witkind (1976) mapped faults Q4-Q6, Q8, Q10, and Q11 as a single fault which he referred to as the Glade Park Fault. More detailed mapping by Lohman (1963; 1965) revealed that the faults are not connected at the surface. Lohman (1963) labeled fault Q5 as the Ladder Creek Fault.

Synopsis:

The Ladder Creek Fault lies on the northeast flank of the Uncompahgre Uplift southwest of Grand Junction. Williams (1964) mapped Quaternary deposits abutting against the fault, but Lohman (1965) showed this fault as being covered by Quaternary landslide deposits. Evidence for Quaternary movement on the fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along the Ladder Creek Fault, it has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/11/97

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

State: Colorado

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T12S,R100W

Strike: N75W

Number of traces: 1

End to end length: 4.16 km

Cumulative length: 4.20 km

Reliability of location: Good

Comments: This fault was mapped at a scale of 1:31,680 by Lohman (1963; 1965) and 1:250,000 by Williams (1964). The trace used herein is from Lohman (1965).

Q5 - Ladder Creek Fault

Geologic setting:

The Ladder Creek Fault is part of the northeast margin of the Uncompahgre Uplift southwest of Grand Junction. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. Lohman (1963) and Kirkham and Rogers (1981) indicated the fault is scissored with throw down to the south at the west end, and down to the north at the east end. Witkind (1976) suggested throw is down to the north but showed faults Q4-Q6, Q8, Q10, and Q11 (this database) as a single fault. Throw on the fault is opposite to local topography. This fault lies in a tectonically weakened area above the ancestral Garmesa and Douglass Creek Fault zones (Stone, 1977).

Sense of movement: NR

Comments: Kirkham and Rogers (1981) described this fault as a dip-slip fault, but were uncertain as to normal or reverse.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Williams (1964) mapped Quaternary deposits as abutting against the fault, but Lohman (1963; 1965) showed the fault as being overlain by unfaulted Quaternary landslide deposits with no more than 7.5 m of throw in pre-Quaternary deposits. The Jurassic Entrada Formation is the youngest deposit faulted according to Lohman (1963). About 95% of the fault lies in Paleozoic to lower Mesozoic bedrock and the remaining 5% is concealed beneath landslide deposits (Lohman, 1963).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Quaternary deposits are generally absent in this area making it difficult to recognize Quaternary movement on the faults. Williams (1964) showed Quaternary deposits as abutting against the fault trace, while Lohman (1963; 1965) showed the fault as overlain by unfaulted Quaternary landslide deposits. Faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on the fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for Quaternary movement, the Ladder Creek Fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lohman, S.W., 1963, Geologic map of Grand Junction area, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-404.

Lohman, S.W., 1965, Geology and artesian water supply of the Grand Junction area, Colorado: U.S. Geological Survey Professional Paper 451, 149 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q6 - Bangs Canyon Fault

Structure type: Simple fault

Structure number: Q6

Comments: Fault 68 in Kirkham and Rogers (1981); fault 282 in Witkind (1976); fault 2256 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Bangs Canyon Fault

Comments: The Bangs Canyon Fault is a northwest-trending fault on the northeast margin of the Uncompahgre Uplift. The fault lies between the towns of Whitewater and Glade Park and is perpendicular to Bangs Canyon. It extends southeast from the Ladder Creek Monocline (which is an extension of the Ladder Creek Fault) and dies out and becomes the East Creek faulted monocline. Witkind (1976) mapped faults Q4-Q6, Q8, Q10, and Q11 (this database) as a single fault which he referred to as the Glade Park Fault. More detailed mapping by Lohman (1963; 1965) revealed that the faults are not connected at the surface. Lohman (1963) labeled fault Q6 as the Bangs Canyon Fault.

Synopsis:

The Bangs Canyon Fault lies on the northeast flank of the Uncompahgre Uplift south of Grand Junction. Williams (1964) mapped Quaternary deposits abutting against the fault, but Lohman, 1965 showed this fault as being covered by Quaternary landslide deposits. Evidence for Quaternary movement on the fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along the Bangs Canyon Fault, it has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/11/97

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

State: Colorado

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T12S,R100W-T12S,R100W

Strike: N32W

Number of traces: 1

End to end length: 6.29 km

Cumulative length: 6.40 km

Reliability of location: Good

Comments: This fault was mapped at a scale of 1:31,680 by Lohman (1963; 1965) and 1:250,000 by Williams (1964). The trace used herein is from Lohman (1965).

Geologic setting:

This fault is part of the northeast margin of the Uncompahgre Uplift south of Grand Junction. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the northeast. This fault lies in a tectonically weakened area above the ancestral Garmesa and Douglass Creek Fault zones (Stone, 1977).

Sense of movement: N

Comments: Heyman (1983) mapped this fault as down to the northeast on a northeast dipping-plane. Kirkham and Rogers (1981) also described this as a normal fault.

Dip:

Comments:

Dip direction: NE

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Williams (1964) mapped Quaternary deposits as abutting against the fault, but Lohman (1963; 1965) showed the fault as being overlain by unfaulted Quaternary landslide deposits. The Cretaceous Dakota and Burro Formations are the youngest deposits faulted according to Lohman (1963). About 95% of the fault lies in Paleozoic to lower Mesozoic bedrock, and the remaining 5% is concealed beneath landslide deposits (Lohman, 1963).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Quaternary deposits are generally absent in this area making it difficult to recognize Quaternary movement on the faults. Williams (1964) showed Quaternary deposits as abutting against the fault trace, while Lohman (1963; 1965) showed the fault as overlain by unfaulted Quaternary landslide deposits. Faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on the fault was cited in Witkind (1976) based on personal communication with Fred Cater. There is no other published evidence that Quaternary deposits are offset by this structure. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence for Quaternary movement, the Bangs Canyon Fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lohman, S.W., 1963, Geologic map of Grand Junction area, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-404.

Lohman, S.W., 1965, Geology and artesian water supply of the Grand Junction area, Colorado: U.S. Geological Survey Professional Paper 451, 149 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q7 - Unnamed Fault East of Whitewater

Structure type: Simple fault

Structure number: Q7

Comments: Fault 69 in Kirkham and Rogers (1981); fault 2257 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault East of Whitewater

Comments: This unnamed northwest-trending fault lies on the northeast margin of the Uncompahgre Uplift west of the town of Whitewater. The fault is perpendicular to and between Ladder and Bangs Canyons.

Synopsis:

This fault lies on the northeast margin of the Uncompahgre Uplift. It was mapped as a Quaternary fault by Kirkham and Rogers (1981) because of its structural relationship to other faults on the northeast margin of the Uncompahgre Uplift postulated as having Quaternary movement. Colman (1985) also mapped this as a Quaternary fault but cited Kirkham and Rogers (1981) for this age assignment.

Date of compilation: 6/11/97

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

State: Colorado

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T12S,R99W-T12S,R100W

Strike: N39W

Number of traces: 1

End to end length: 1.88 km

Cumulative length: 1.86 km

Reliability of location: Good

Comments: Williams (1964) mapped the fault at 1:250,000.

Geologic setting:

This fault is part of the northeast margin of the Uncompahgre Uplift south of Grand Junction. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This is a high-angle normal fault that is down to the northeast. This fault lies in a tectonically weakened area above the ancestral Garmesa and Douglass Creek Fault zones (Stone, 1977).

Sense of movement: N

Comments: Kirkham and Rogers (1981) described this fault as normal.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The fault lies entirely in lower Mesozoic bedrock (Lohman, 1963).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Kirkham and Rogers (1981) mapped this as a Quaternary fault based on its structural relationship to other faults along the northeast margin of the Uncompahgre Uplift that are considered to be Quaternary faults. Colman (1985) cited Kirkham and Rogers (1981) for his Quaternary age assignment to the fault. There is not any published evidence of Quaternary deposits being offset by this fault. However, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence of Quaternary movement for several of the faults assoicated with the Uncompahgre Uplift was cited in Witkind (1976), based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Assuming this fault is related to the Neogene Uncompahgre Uplift, a slip rate of <0.2 mm/yr is estimated for this fault based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989).

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q8 - Cactus Park Fault

Structure type: Simple fault

Structure number: Q8

Comments: Fault 70 in Kirkham and Rogers (1981); fault 282 in Witkind (1976); fault 2258 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Cactus Park Fault

Comments: The Cactus Park Fault is a northwest-trending fault on the northeast margin of the Uncompahgre Uplift southeast of Grand Junction. The fault extends from near the south end of the Bangs Canyon Fault southeastward to the east side of Highway 141 in Unaweep Canyon. The west end of the fault dies out and becomes the North East Creek Monocline which connects to the southeast end of the Bangs Canyon Fault. Witkind (1976) mapped faults Q4-Q6, Q8, Q10, and Q11 (this database) as a single fault which he referred to as the Glade Park Fault. More detailed mapping by Lohman (1963) revealed that the faults are not connected at the surface. He labeled fault Q8 as the Cactus Park Fault.

Synopsis:

The Cactus Park Fault lies on the northeast margin of the Uncompahgre Uplift southeast of Grand Junction. Lohman (1963) showed Quaternary alluvial deposits as offset by the fault. Later mapping by Lohman (1965) however, showed the fault as being concealed beneath Quaternary alluvium. Evidence for Quaternary movement on the fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along the Cactus Park Fault, it has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/11/97

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

State: Colorado

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T14S,R99W-T13S,R100W

Strike: N72W

Number of traces: 1

End to end length: 1.85 km

Cumulative length: 1.88 km

Reliability of location: Good

Comments: This fault was mapped at a scale of 1:31,680 by Lohman (1963; 1965) and 1:250,000 by Williams (1964). The trace used herein is from Lohman (1965).

Geologic setting:

The Cactus Park Fault is part of the northeast margin of the Uncompahgre Uplift south of Grand Junction. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the northeast. It lies in a tectonically weakened area above the ancestral Garmesa and Douglass Creek Fault zones (Stone, 1977).

Sense of movement: N

Comments: Kirkham and Rogers (1981) described this fault as normal.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Quaternary alluvial deposits were shown as faulted by Lohman (1963), but later mapping by Lohman (1965) showed the fault as concealed by Quaternary alluvial deposits. Holocene deposits are not offset by the fault according to Kirkham and Rogers (1981). The fault lies almost entirely in lower Mesozoic bedrock with less than 5% of the fault extending through Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Lohman (1963) showed Quaternary alluvial deposits offset by the Cactus Park Fault, but the fault was mapped by Lohman (1965) as concealed by Quaternary deposits. Faults associated with the Uncompahgre Uplift, however, are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on the fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Other than Lohman (1963), there is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for Quaternary movement, the Cactus Park Fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lohman, S.W., 1963, Geologic map of Grand Junction area, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-404.

Lohman, S.W., 1965, Geology and artesian water supply of the Grand Junction area, Colorado: U.S. Geological Survey Professional Paper 451, 149 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Simple fault

Structure number: Q9

Comments: Fault 71 in Kirkham and Rogers (1981); fault 2259 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault near Bridgeport

Comments: This unnamed northwest-trending fault lies on the the northeast margin of the Uncompahgre Uplift near the town of Bridgeport, southeast of Grand Junction. The west end of the fault grades into the Deer Run Monocline (Lohman, 1963).

Synopsis:

This fault lies on the northeast margin of the Uncompahgre Uplift southeast of Grand Junction. Quaternary deposits may be offset by this fault across the Gunnison River valley according to Williams (1964). Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996).

Date of compilation: 6/11/97

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

State: Colorado

County: Mesa, Delta

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T14S,R98W-T14S,R2E

Strike: N72W

Number of traces: 1

End to end length: 10.99 km

Cumulative length: 11.06 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:31,680 by Lohman (1963; 1965), and at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The trace used herein is from Williams (1964).

Geologic setting:

This fault is part of the northeast margin of the Uncompahgre Uplift south of Grand Junction. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the north, and it grades westward into a faulted monocline. The fault lies in a tectonically weakened area above the ancestral Garmesa and Douglass Creek Fault zones (Stone, 1977).

Q9 - Unnamed Fault near Bridgeport

Sense of movement: N

Comments: Kirkham and Rogers (1981) described this fault as normal.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Williams (1964) mapped this fault trace as a solid line through a narrow finger of Quaternary alluvium along the Gunnison River valley, suggesting offset of the Quaternary deposits. The Cretaceous Mancos Shale is the next youngest deposit offset by the fault. The majority of the fault lies in lower Mesozoic bedrock and only extends beneath a thin sliver of Quaternary deposits across the Gunnison River valley.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Williams (1964) showed a very small finger of Quaternary alluvium as offset by the fault. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. This structure was mapped as a Quaternary fault by Kirkham and Rogers (1981) and Colman (1985). Lettis and others (1996) suggested Quaternary movement on many of the faults associated with the Uncompahgre Uplift and map the structure as a fault with known or suspected late Quaternary movement, but they do not discuss this particular fault specifically in the text of their report.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Lohman, S.W., 1963, Geologic map of Grand Junction area, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-404.

Lohman, S.W., 1965, Geology and artesian water supply of the Grand Junction area, Colorado: U.S. Geological Survey Professional Paper 451, 149 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q10 - Unnamed Fault at Big Dominguez Creek

Structure type: Simple fault

Structure number: Q10

Comments: Fault 72 in Kirkham and Rogers (1981); fault 282 in Witkind (1976); fault 2260 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault at Big Dominguez Creek

Comments: This unnamed northwest-trending fault lies on the northeast margin of the Uncompahgre Uplift southeast of Grand Junction and southwest of Bridgeport. The fault is perpendicular to Big Dominguez Creek. Witkind (1976) mapped faults Q4-Q6, Q8, Q10, and Q11 (this database) as a single fault which he referred to as the Glade Park fault. Other references (e.g. Williams, 1964; Kirkham and Rogers, 1981; Lettis and others, 1996) showed that the faults are not connected at the surface.

Synopsis:

This fault lies on the northeast margin of the Uncompahgre Uplift southeast of Grand Junction. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence for Quaternary movement, this fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Date of compilation: 6/11/97

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

State: Colorado

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T14S,R99W

Strike: N53W

Number of traces: 1

End to end length: 3.92 km

Cumulative length: 3.91 km

Reliability of location: Good

Comments: The fault was mapped at 1:250,000 by Williams (1964) and Lettis and others (1996). The trace used herein is from Williams (1964).

Geologic setting:

This fault is part of the northeast margin of the Uncompahgre Uplift southeast of Grand Junction. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the southwest. Witkind (1976) suggested throw is down to the northeast but showed faults Q4-Q6, Q8, Q10, and Q11 (this database) as a single fault. Parts of this fault complex are in fact down to the northeast (faults Q6 and Q8), but the remainder of the faults, including this unnamed fault, are down to the southwest (Williams, 1964; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996). Throw on the fault is opposite to local topography. The fault lies in a tectonically weakened area above the ancestral Garmesa and Douglass Creek fault zones (Stone, 1977).

Sense of movement: N

Comments: Kirkham and Rogers (1981) described this fault as normal.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The Cretaceous Dakota Sandstone and Burro Canyon Formation are the youngest deposits mapped as offset by this fault. Quaternary deposits are absent in this area, and the fault lies entirely within Precambrian to lower Mesozoic bedrock (Williams, 1964).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for Quaternary movement, this fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Simple fault

Structure number: Q11

Comments: Fault 73 in Kirkham and Rogers (1981); fault 282 in Witkind (1976); fault 2261 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault at Little Dominguez Creek

Comments: This northwest-trending fault lies on the northeast margin of the Uncompahgre Uplift southeast of Grand Junction. The fault crosses and is perpendicular to Little Dominguez Creek and extends southeast into Escalante Creek. Witkind (1976) mapped faults Q4-Q6, Q8, Q10, and Q11 (this database) as a single fault which he referred to as the Glade Park fault. Other references (e.g. Williams, 1964; Kirkham and Rogers, 1981; Lettis and others, 1996) showed that the faults are not connected at the surface.

Synopsis:

This fault lies on the northeast margin of the Uncompahgre Uplift southeast of Grand Junction. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Date of compilation: 6/11/97

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

State: Colorado

County: Mesa, Delta

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T15S,R99W

Strike: N57W

Number of traces: 1

End to end length: 14.23 km

Cumulative length: 14.29 km

Reliability of location: Good

Comments: The fault was mapped at 1:250,000 by Williams (1964) and Lettis and others (1996). The trace used herein is from Williams (1964).

Geologic setting:

This fault is part of the northeast margin of the Uncompahgre Uplift southeast of Grand Junction. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the southwest. Witkind (1976) suggested throw is down to the northeast but showed faults Q4-Q6, Q8, Q10, and Q11 (this database) as a single fault. Parts of this fault complex are in fact down to the northeast (faults Q6 and Q8), but the remainder of the faults, including this unnamed fault, are down to the southwest (Williams, 1964; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996). Throw on the fault is opposite to local topography. The fault lies in a tectonically weakened area above the ancestral Garmesa and Douglass Creek fault zones (Stone, 1977).

Sense of movement: N

Comments: Kirkham and Rogers (1981) listed this fault as normal.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The Cretaceous Dakota Sandstone and Burro Canyon Formation are the youngest deposits offset by this fault. Quaternary deposits are absent in this area, and the fault lies entirely within Precambrian to lower Mesozoic bedrock (Williams, 1964).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. There is no other published evidence that Quaternary deposits are offset by this structure. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence for Quaternary movement, this fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q12 - Unnamed Fault near Escalante

Structure type: Simple fault

Structure number: Q12

Comments: Fault 74 in Kirkham and Rogers (1981); fault 2262 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault near Escalante

Comments: This is a generally east-west oriented fault on the northeast margin of the Uncompahgre Uplift northwest of the town of Huff. The fault is exposed in a roadcut on Highway 50 about 14 km west of Delta, but there does not appear to be any surface expression of the fault. The fault was first described by Klein and Osterwald (1974) and mapped as a Quaternary fault by Kirkham and Rogers (1981).

Synopsis:

This fault lies on the northeast margin of the Uncompahgre Uplift west of Delta. Exposure of the fault in a roadcut reveals offset of about 1.2 m at the base of a pre-Bull Lake gravel deposit. Although the fault is exposed in roadcut on Highway 50 west of Delta, there is no reported surface expression of the fault (Kirkham and Rogers, 1981).

Date of compilation: 6/11/97

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

State: Colorado

County: Delta

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T4S,R3E

Strike: N85W

Number of traces: 1

End to end length: 1.56 km

Cumulative length: 1.57 km

Reliability of location: Poor

Comments: The fault was shown only at a scale of 1:500,000 by Kirkham and Rogers (1981).

Geologic setting:

This fault lies on the northeast margin of the Uncompahgre Uplift west of Delta. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This is a high-angle normal fault that is down to the south. The south-dipping fault plane contains clay gouge up to 1 cm thick, the hanging wall is marked by a 1.5-cm-thick brecciated zone, and gravel clasts are rotated in accordance with fault movement (Kirkham and Rogers, 1981). The fault lies in a tectonically weakened area above the ancestral Garmesa and Douglass Creek fault zones (Stone, 1977).

Sense of movement: N

Comments: Kirkham and Rogers (1981) listed this fault as normal.

Dip: 49°SW

Comments: Kirkham and Rogers (1981) reported a dip of 49°SW in the roadcut on Highway 50.

Dip direction: SW

Geomorphic expression:

Although the fault is exposed in roadcut on Highway 50 west of Delta, there is no reported surface expression of the fault.

Age of faulted deposits:

Pre-Bull Lake gravel deposits are offset by about 1.2 m across the fault (Kirkham and Rogers, 1981).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Pre-Bull Lake gravel deposits are offset by the fault (Kirkham and Rogers, 1981).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on 1.2 m of offset in pre-Bull Lake Quaternary deposits (Kirkham and Rogers, 1981), a slip rate of <0.2 mm/yr is estimated for this fault.

Earthquake notes:

References Cited:

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Klein, Ira, and Osterwald, Frank, 1974, Field trip road log for Excursion II - Rock Mechanics: International Society of Rock Mechanics, 3rd International Congress.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Q13 - Ryan Creek Fault Zone

Structure type: Simple fault

Structure number: Q13

Comments: Fault 76 in Kirkham and Rogers (1981); fault 349 in Witkind (1976); fault 2263 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Ryan Creek Fault Zone

Comments: The Ryan Creek Fault zone trends east-west along the southwest margin of the Uncompahgre Uplift. About half of the fault length is in Utah. The fault extends east into Colorado from the flank of the Haystack Peaks parallel to Ryan Gulch, then bends southwest toward Unaweep Canyon. The fault forms the northeast margin of the Ute Creek Graben. This description focuses on the portion of the fault that extends into Colorado.

Synopsis:

The Ryan Creek Fault zone lies on the southeast margin of the Uncompahgre Uplift near the Colorado/Utah border. Evidence for Quaternary movement on this fault zone was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along the Ryan Creek Fault zone, it has been classified as a Quaternary fault (Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/11/97

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

State: Colorado, Utah

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T14S,R103W-T22S,R24E

Strike: N63W

Number of traces: 1

End to end length: 16.33 km

Cumulative length: 17.52 km

Reliability of location: Good

Comments: The fault was mapped by Williams (1964) at 1:250,000.

Geologic setting:

The Ryan Creek Fault zone lies on the northeast margin of the Uncompahgre Uplift along the Utah/Colorado border near the Little Dolores River. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the south and southwest. The fault lies in a tectonically weakened area above the ancestral Uncompahgre Fault zone (Stone, 1977) and may merge at depth with a major uplift-bounding reverse fault (Ely and others, 1986).

Sense of movement: N

Comments: Heyman (1983) mapped this fault as down to the southwest on a southwest-dipping fault plane. Kirkham and Rogers (1981) also listed this fault as normal. Ely and others (1986) suggested it merges with a major uplift-bounding reverse fault at depth.

Dip: 75°SW

Comments: Heyman (1983) measured a dip of 75°SW for part of the Ryan Creek Fault zone in Utah in the vicinity of T22S, R26E.

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The Cretaceous Dakota Sandstone and Burro Canyon Formation are the youngest deposits offset by the fault. The fault lies entirely within Precambrian and lower Mesozoic bedrock and Quaternary deposits are absent along the trace of the fault (Williams, 1964).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on this fault zone was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for Quaternary movement, this fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

The 1985 Gateway earthquakes are believed to have occurred at a depth of 8 km beneath Lost Horse Basin at the western end of the Ute Creek Graben, which is bounded on the north by the Ryan Creek Fault zone (Ely and others, 1986).

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Ely, R.W., Wong, I.G., and Chang, P., 1986, Neotectonics of the Uncompahgre Uplift, eastern Utah and western Colorado, 'in' Rogers, W.P., and Kirkham, R.M., eds., Contributions to Colorado tectonics and seismicity - A 1986 update: Colorado Geological Survey Special Publication 28, p. 75-92.

Heyman, O.G., 1983, Distribution and structural geometry of faults and folds along the northwestern Uncompahgre Uplift, western Colorado and eastern Utah, 'in' Averett, W., ed., Northern Paradox Basin - Uncompahgre Uplift: Grand Junction Geological Society, p. 45-57.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q14 - Unnamed Fault of Lost Horse Basin

Structure type: Simple fault

Structure number: Q14

Comments: Fault 77 in Kirkham and Rogers (1981); fault 2264 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault of Lost Horse Basin

Comments: This unnamed northwest-trending fault extends from Utah into Colorado through Lost Horse Basin on the southwest flank of the Uncompahgre Uplift. Lost Horse Basin lies at the northwest end of the Ute Creek Graben.

Synopsis:

This fault lies on the southeast margin of the Uncompahgre Uplift near the Colorado/Utah border. Williams (1964) mapped Quaternary deposits as both concealing the fault and as abutting against the fault. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (e.g., Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/12/97

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

State: Utah, Colorado

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T14S,R104W-T22S,R26E

Strike: N36W

Number of traces: 1

End to end length: 8.08 km

Cumulative length: 8.23 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Williams (1964).

Geologic setting:

This fault lies on the northeast margin of the Uncompahgre Uplift near Lost Horse Basin and the Utah/Colorado border. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the northeast. The fault lies in a tectonically weakened area above the ancestral Uncompahgre Fault zone (Stone, 1977).

Sense of movement: N

Comments: Heyman (1983) and Kirkham and Rogers (1981) showed this fault as normal.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Williams (1964) mapped Quaternary deposits as both concealing the fault and as abutting against the fault at its northern extent. The Jurassic Summerville Formation is the youngest deposit mapped as offset by the fault (Williams, 1964) . The fault lies primarily in Jurassic and Triassic bedrock with about 15% of the fault extending adjacent to or beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Offset of Quaternary deposits is inconclusive, since Williams (1964) showed Quaternary deposits as abutting against the fault and concealing the fault. However, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicate uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for Quaternary movement, this fault has been classified as a Quaternary fault (e.g., Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Heyman, O.G., 1983, Distribution and structural geometry of faults and folds along the northwestern Uncompahgre Uplift, western Colorado and eastern Utah, 'in' Averett, W., ed., Northern Paradox Basin - Uncompahgre Uplift: Grand Junction Geological Society, p. 45-57.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q15 - Granite Creek Fault Zone

Structure type: Simple fault

Structure number: Q15

Comments: Fault 78 in Kirkham and Rogers (1981); fault 2265 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Granite Creek Fault Zone

Comments: This northwest-trending fault extends from Utah into Colorado north of Steamboat Mesa on the southwest flank of the Uncompahgre Uplift. This fault forms the southwest margin of the Ute Creek Graben. The fault was named by Heyman (1983) after Granite Creek, which flows through eastern Utah and crosses the west end of the fault trace in Utah.

Synopsis:

This fault lies on the southeast margin of the Uncompahgre Uplift near the Colorado/Utah border. Williams (1964) mapped Quaternary deposits as both concealing the fault and as abutting against the fault. Based on the timing of abandonment of Unaweep Canyon by the Gunnison River, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along the Granite Creek Fault zone, it has been classified as a Quaternary fault (e.g., Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/12/97

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

State: Utah, Colorado

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T15S,R104W-T23S,R25E

Strike: N54W

Number of traces: 1

End to end length: 9.19 km

Cumulative length: 9.33 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Williams (1964).

Geologic setting:

This fault lies on the northeast margin of the Uncompahgre Uplift along the Utah/Colorado border near Steamboat Mesa. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the northeast. Throw on the fault is opposite to local topography. The fault lies in a tectonically weakened area above the ancestral Uncompahgre Fault zone (Stone, 1977).

Sense of movement: N

Comments: Heyman (1983) and Kirkham and Rogers (1981) showed this fault as normal.

Dip: 60°NE

Comments: Heyman (1983) measured a dip of 60° on a northeast-dipping fault plane. The measurement was taken in the general vicinity of T14S, R104W near the Colorado/Utah border.

Dip direction: NE

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Williams (1964) mapped Quaternary deposits as both concealing the fault and as abutting against the fault. The Jurassic Summerville Formation is the youngest deposit that is clearly offset by the fault. The fault lies primarily in Jurassic and Triassic bedrock with about 15% of the fault extending adjacent to or beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Offset of Quaternary deposits is inconclusive since Williams (1964) showed Quaternary deposits as abutting against the fault and concealing the fault. However, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for Quaternary movement, this fault has been classified as a Quaternary fault (e.g., Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

The 1985 Gateway earthquakes are believed to have occurred at a depth of 8 km beneath Lost Horse Basin at the western end of the Ute Creek Graben, which is bounded on the south by the Granite Creek Fault zone (Ely and others, 1986).

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Ely, R.W., Wong, I.G., and Chang, P., 1986, Neotectonics of the Uncompahgre Uplift, eastern Utah and western Colorado, 'in' Rogers, W.P., and Kirkham, R.M., eds., Contributions to Colorado tectonics and seismicity - A 1986 update: Colorado Geological Survey Special Publication 28, p. 75-92.

Heyman, O.G., 1983, Distribution and structural geometry of faults and folds along the northwestern Uncompahgre Uplift, western Colorado and eastern Utah, 'in' Averett, W., ed., Northern Paradox Basin - Uncompahgre Uplift: Grand Junction Geological Society, p. 45-57.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Structure type: Simple fault

Structure number: Q16

Comments: Fault 79 in Kirkham and Rogers (1981); fault 350 in Witkind (1976); fault 2266 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault near Wolf Hill

Comments: This northwest-trending fault begins south of the Ryan Creek Fault zone and continues southeast to Cow Creek. The fault forms the northeast margin of the Ute Creek Graben on the southwest flank of the Uncompahgre Uplift.

Synopsis:

This fault lies on the southeast margin of the Uncompahgre Uplift. Quaternary deposits were shown as being offset by the fault by Williams (1964). Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Cater (1970) indicated the fault is concealed by Quaternary deposits. Despite the the contradictory mapping, the fault has been classified as a Quaternary fault (e.g., Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/12/97

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

State: Colorado

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T51N,R17W-T14S,R103W

Strike: N33W

Number of traces: 2

End to end length: 15.23 km

Cumulative length: 17.06 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:24,000 by Cater (1955i), 1:62,500 by Cater (1970) and 1:250,000 by Williams (1964). The trace used herein is from Williams (1964) and Cater (1970).

Geologic setting:

This fault forms the northeast margin of the Ute Creek Graben and lies on the southwest flank of the Uncompahgre Uplift. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. The fault lies in a tectonically weakened area above the ancestral Uncompahgre Fault zone (Stone, 1977).

Q16 - Unnamed Fault near Wolf Hill

Sense of movement: N

Comments: Cater (1970), Heyman (1983), Kirkham and Rogers (1981), and Witkind (1976) showed this as a normal fault.

Dip: 78°SW

Comments: A cross section by Cater (1970) showed a dip of 78°SW for this fault.

Dip direction: SW

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Cater (1955i) documented a maximum throw of about 305 m on this fault which bounds the northeast margin of the Ute Creek Graben, but did not map Quaternary deposits as offset by the fault. Williams (1964) mapped Quaternary deposits as offset by the fault, but more detailed mapping by Cater (1970) showed the fault as concealed by Quaternary deposits. About 80% of the fault lies in Precambrian to lower Mesozoic bedrock, while the remaining 20% extends into or beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Offset of Quaternary deposits is inconclusive since Williams (1964) showed Quaternary deposits as offset by the fault, whereas Cater (1970) mapped the fault as concealed by Quaternary deposits. However, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. This fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1955i, Geology of the Pine Mountain quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-60.

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Cater, F.W., Jr., 1970, Geology of the salt anticline region in southwestern Colorado, with a section on stratigraphy by F.W. Cater and L.C. Craig: U.S. Geological Survey Professional Paper 637, 80 p.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Heyman, O.G., 1983, Distribution and structural geometry of faults and folds along the northwestern Uncompahgre Uplift, western Colorado and eastern Utah, 'in' Averett, W., ed., Northern Paradox Basin - Uncompahgre Uplift: Grand Junction Geological Society, p. 45-57.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q17 - Unnamed Fault near Pine Mountain

Structure type: Simple fault

Structure number: Q17

Comments: Fault 80 in Kirkham and Rogers (1981); fault 351 in Witkind (1976); fault 2267 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault near Pine Mountain

Comments: This northwest-trending fault begins southeast of the Granite Creek Fault zone on the northeast flank of The Palisade northeast of the town of Gateway, and extends southeast to the northwest side of Uncompahgre Butte. The fault forms the southwest margin of the Ute Creek Graben on the southwest flank of the Uncompahgre Uplift.

Synopsis:

This fault lies on the southeast margin of the Uncompahgre Uplift. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Williams (1964) mapped Quaternary deposits as abutting against the fault. Cater (1970) mapped the fault as being concealed by Quaternary deposits. The fault has been classified as a Quaternary fault (Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 6/12/97

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

State: Colorado

County: Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T50N,R16W-T15S,R103W

Strike: N52W

Number of traces: 2

End to end length: 30.56 km

Cumulative length: 34.11 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:24,000 by Cater (1955i), 1:62,500 by Cater (1970) and 1:250,000 by Williams (1964). The trace used herein is from Williams (1964) and Cater (1970).

Geologic setting:

This fault forms the southwest margin of the Ute Creek Graben and lies on the southwest flank of the Uncompahgre Uplift. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the northeast. Witkind (1976) showed the fault as down to the southwest, but all other references indicated the fault is down to the northeast (Williams, 1964; Cater, 1966; Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985). Throw on the fault is opposite to local topography. The fault lies in a tectonically weakened area above the ancestral Uncompahgre Fault zone (Stone, 1977).

Sense of movement: N

Comments: Cater (1970), Heyman (1983) and Kirkham and Rogers (1981), showed this fault as normal.

Dip: 81°NE

Comments: Cater (1970) showed a dip of 81°NE for this fault on his cross section.

Dip direction: NE

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Cater (1955i) documented a maximum throw of about 260 m on this fault which bounds the southwest margin of the Ute Creek Graben, but did not map Quaternary deposits as being offset by the fault. Williams (1964) mapped Quaternary deposits as both concealing the fault and as abutting against the fault. Cater (1970) mapped the fault as concealed by Quaternary deposits. The Salt Wash Sandstone Member of the Jurassic Morrison Formation is the youngest deposit offset by this fault according to Cater (1970). The fault lies primarily in Precambrian and lower Mesozoic bedrock with about 20% of the fault extending into or beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Offset of Quaternary deposits is inconclusive since Williams (1964) showed Quaternary deposits as abutting against the fault, whereas Cater (1970) mapped the fault as concealed by Quaternary deposits. However, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on this fautl was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. This fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1955i, Geology of the Pine Mountain quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-60.

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Cater, F.W., Jr., 1970, Geology of the salt anticline region in southwestern Colorado, with a section on stratigraphy by F.W. Cater and L.C. Craig: U.S. Geological Survey Professional Paper 637, 80 p.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Heyman, O.G., 1983, Distribution and structural geometry of faults and folds along the northwestern Uncompahgre Uplift, western Colorado and eastern Utah, 'in' Averett, W., ed., Northern Paradox Basin - Uncompahgre Uplift: Grand Junction Geological Society, p. 45-57.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q18 - Monitor Creek Fault

Structure type: Simple fault

Structure number: Q18

Comments: Fault 2268 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Monitor Creek Fault

Comments: This fault is referred to as the Monitor Creek Fault by Lettis and others (1996). It is comprised of four generally east-west-trending faults on the northeast side of the Uncompahgre Uplift. The faults extend from the Middle Fork of the Escalante to near Cushman Creek south of the town of Delta.

Synopsis:

The Monitor Creek Fault lies on the northeast margin of the Uncompahgre Uplift. The fault is marked by a southwest-facing scarp. Based on the timing of abandonment of Unaweep Canyon from the Uncompahgre plateau Cater (1966) indicated uplift began in the mid-Pliocene and continued into the Pleistocene resulting in as much as 640 m of differential uplift. Lettis and other (1996) suggested the fault is similar in age to other faults which offset the Pliocene to middle Pleistocene Uncompahgre Plateau surface but concluded that the fault has not been active during the Holocene. Despite the lack of definitive evidence of Quaternary offset, the most recent movement on the fault is herein considered to have occurred during the Quaternary.

Date of compilation: 1/6/98

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

State: Colorado

County: Montrose, Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T50N,R14W-T50N,R11W

Strike: N86W

Number of traces: 4

End to end length: 30.13 km

Cumulative length: 31.40 km

Reliability of location: Good

Comments: The faults were mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The fault trace used herein is from Lettis and others (1996).

Geologic setting:

These faults lie on the northeast margin of the Uncompahgre Uplift, which is a northwest-trending, east-tilted fault block. The faults are downthrown to the south.

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

The main fault trace is marked by a southwest-facing scarp in the Cretaceous Dakota Sandstone (Lettis and others, 1996)

Age of faulted deposits:

The Monitor Creek Fault offsets Jurassic to Cretaceous bedrock (Williams, 1964), but Quaternary deposits are not mapped along the fault. Lettis and others (1996) suggested the fault is similar in age to other faults which offset the Pliocene to middle Pleistocene Uncompahgre Plateau surface but concluded that the fault has not been active during the Holocene.

Detailed studies:

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Although there is no direct evidence of Quaternary offset along this fault, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Based on the timing of abandonment of Unaweep Canyon from the Uncompahgre plateau Cater (1966) indicated uplift began in the mid-Pliocene and continued into the Pleistocene resulting in as much as 640 m of differential uplift. Lettis and other (1996) suggested the fault is similar in age to other faults which offset the Pliocene to middle Pleistocene Uncompahgre Plateau surface but concluded that the fault has not been active during the Holocene.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on the lack of geomorphic features in Quaternary deposits and on calculations of an uplift rate of .4 m/1000 yr since 1.8 Ma for the Uncompahgre Plateau (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this fault.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado in Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q19 - Unnamed Faults East of Atkinson Mesa

Structure type: Simple fault

Structure number: Q19

Comments: Fault 81 in Kirkham and Rogers (1981); fault 352 in Witkind (1976); fault 2269 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults East of Atkinson Mesa

Comments: This structure is made up of a series of nine northwest- to west- trending faults on the southwest flank of the Uncompahgre Uplift. The faults are east of Atkinson Mesa and extend from Moon Mesa to Round Mountain then bend east to the west side of Tabeguache Creek.

Synopsis:

This fault series lies on the southeast margin of the Uncompahgre Uplift. Evidence for Quaternary movement on these faults was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. The fault has been classified as a Quaternary fault (Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Date of compilation: 7/8/97

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

State: Colorado

County: Montrose, Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T48N,R13W-T49N,R16W

Strike: N63W

Number of traces: 4

End to end length: 41.09 km

Cumulative length: 48.80 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Williams (1964). The northwest end of the fault was mapped at a scale of 1:62,500 by Cater (1970). The trace used herein is from Williams (1964).

Geologic setting:

This fault series lies on the southwest flank of the Uncompahgre Uplift east of Atkinson Mesa. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the south and southwest. The fault lies in a tectonically weakened area above the ancestral Uncompahgre Fault zone (Stone, 1977).

Sense of movement: N

Comments: Kirkham and Rogers (1981) and Witkind (1976) listed this as a normal fault.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Williams (1964) mapped these faults as concealed by Quaternary deposits. The youngest deposits that he maps as offset by the fault are the Cretaceous Dakota Sandstone and Burro Canyon Formation. The fault lies primarily in Precambrian to lower Mesozoic bedrock with only about 5% of the fault extending beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on these faults was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence for Quaternary movement, this fault has been classified as a Quaternary fault (e.g. Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Cater, F.W., Jr., 1970, Geology of the salt anticline region in southwestern Colorado, with a section on stratigraphy by F.W. Cater and L.C. Craig: U.S. Geological Survey Professional Paper 637, 80 p.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Stone, D.S., 1977, Tectonic history of the Uncompahgre Uplift, 'in' Veal, H.K., ed., Exploration Frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, 1977 Field Conference Guidebook, p. 23-30.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Simple fault

Structure number: Q20

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

Structure name: Roubideau Creek Fault

Comments: The Roubideau Creek Fault is a west-northwest-trending 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 beetween these two creeks. Lettis and others (1996) referred to this fault as the Roubideau Creek Fault.

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).

Date of compilation: 7/9/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T48N,R11W-T48N,R13W

Strike: N74W

Number of traces: 4

End to end length: 20.47 km

Cumulative length: 26.06 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The trace used herein is from Williams (1964).

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-trending, east-tilted fault block.

Sense of movement: RN

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: Kirkham and Rogers (1981) designated the fault as Quaternary. Colman (1985) mapped the fault as an inferred Pleistocene fault. Sullivan and others (1980) and Lettis and others (1996) indicated late Pleistocene to Holocene movement on the 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 Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Sullivan, J.T., Meeder, C.A., Martin, R.A., and West, M.W., 1980, Seismic hazard evaluation-Ridgway dam and reservoir site-Dallas Creek project, Colorado: unpublished report prepared by U.S. Water and Power Resources Service, Seismotectonic Section, 43 p.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q21 - Unnamed Faults South of Love Mesa

Structure type: Simple fault

Structure number: Q21

Comments: Fault 2271 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults South of Love Mesa

Comments: These two generally east-west-trending faults on the Uncompahgre Uplift begin northeast of Windy Point on the west and extend to Criswell Creek on the east. The faults are southwest of the town of Delta.

Synopsis:

These faults lie on the Uncompahgre Uplift southwest of the town of Delta. Although there was no reported evidence of Quaternary offset along these faults they were mapped as Quaternary faults by Lettis and others (1996; plate 2). They attributed fault activity to salt tectonism. The most recent movement on the faults herein considered to have occurred during the Quaternary based on the work of Lettis and others (1996).

Date of compilation: 1/6/98

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T49N,R14W-T49N,R13W

Strike: N80W

Number of traces: 2

End to end length: 17.59 km

Cumulative length: 18.91 km

Reliability of location: Good

Comments: The faults were mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The fault trace used herein is from Lettis and others (1996).

Geologic setting:

These faults lie on the south end of the Uncompahgre Uplift, which is a northwest-trending, east-tilted fault block. Both faults are down to the north.

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Faults in this series offset Jurassic to Cretaceous bedrock (Williams, 1964), but Quaternary deposits are not mapped along the faults. Although there is no evidence of faulted Quaternary deposits along these faults, Lettis and others (1996) concluded they moved during the Quaternary.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Although there is no direct evidence for offset of Quaternary deposits along these faults, they were mapped as Quaternary faults related to salt tectonism by Lettis and others (1996; plate 2). Faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Based on the timing of abandonment of Unaweep Canyon from the Uncompahgre plateau Cater (1966) indicated uplift began in the mid-Pliocene and continued into the Pleistocene resulting in as much as 640 m of differential uplift.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q22 - Unnamed Faults East of Roubideau Creek

Structure type: Simple fault

Structure number: Q22

Comments: Fault 2272 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults East of Roubideau Creek

Comments: This series of unnamed faults includes five faults that generally trend northwest at the southeast end of the Uncompahgre Uplift.

Synopsis:

This series of faults lies on the south end of the Uncompahgre Uplift. Although there was no reported evidence of Quaternary offset along these faults they were mapped as Quaternary faults by Lettis and others (1996; plate 2). They attributed fault activity to salt tectonism. The most recent movement on the faults herein considered to have occurred during the Quaternary based on the work of Lettis and others (1996).

Date of compilation: 1/6/98

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T47N,R12W-T48N,R11W

Strike: N50W

Number of traces: 5

End to end length: 11.72 km

Cumulative length: 18.68 km

Reliability of location: Good

Comments: The faults were mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The fault traces used herein are from Lettis and others (1996).

Geologic setting:

This fault series lies on the southeast end of the Uncompahgre Uplift, which is a northwest-trending, east-tilted fault block. Faults in this series are down to the northeast and southwest and are considered to be salt-related rather than tectonic features (Lettis and others, 1996).

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Faults in this series offset Jurassic to Cretaceous bedrock (Williams, 1964), but Quaternary deposits are not mapped along the faults. Although there is no evidence of faulted Quaternary deposits along these faults, Lettis and others (1996) concluded they moved during the Quaternary but were related to salt tectonism.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Although there is no direct evidence for offset of Quaternary deposits along these faults, they were mapped as Quaternary faults related to salt tectonism by Lettis and others (1996; plate 2). Faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Based on the timing of abandonment of Unaweep Canyon from the Uncompahgre plateau Cater (1966) indicated uplift began in the mid-Pliocene and continued into the Pleistocene resulting in as much as 640 m of differential uplift.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

A moment magnitude (Mw) 5 maximum credible earthquake was assigned to these faults by Lettis and others (1996).

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q23 - Unnamed Faults Southwest of Montrose

Structure type: Simple fault

Structure number: Q23

Comments: Fault 2273 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults Southwest of Montrose

Comments: This series of unnamed faults includes five generally north-south-trending faults at the south end of the Uncompahgre Uplift. The faults are west of Highway 550 between Montrose and Ridgway.

Synopsis:

This series of faults lies on the south end of the Uncompahgre Uplift. Although there was no reported evidence of Quaternary offset along these faults they were mapped as Quaternary faults by Lettis and others (1996; plate 2). They attributed fault activity to salt tectonism. The most recent movement on the faults herein considered to have occurred during the Quaternary based on the work of Lettis and others (1996).

Date of compilation: 1/6/98

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

State: Colorado

County: Ouray, Montrose

1° x 2° Sheet: Montrose, Moab

Province: Southern Rocky Mountains

Township and Range: T46N,R96W-T47N,R94W

Strike: N7W

Number of traces: 5

End to end length: 19.23 km

Cumulative length: 38.50 km

Reliability of location: Good

Comments: The faults were mapped by Steven and Hail (1989) at a scale of 1:100,000, and by Williams (1964), Tweto and others (1976), and Lettis and others (1996) at 1:250,000. The fault traces used herein are from Lettis and others (1996).

Geologic setting:

This fault series lies on the southeast end of the Uncompahgre Uplift, which is a northwest-trending, east-tilted fault block. Faults in this series are downthrown to the west and southwest and are considered to be salt-related rather than tectonic features (Lettis and others, 1996).

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Faults in this series offset the Cretaceous Dakota Sandstone and Mancos Shale (Williams (1964; Tweto and others, 1976; Steven and Hail, 1989). The faults lie almost entirely within Cretaceous rocks with less than 5% of the fault series extending through or beneath Quaternary deposits. Although there is no evidence of faulted Quaternary deposits along these faults, Lettis and others (1996) concluded they moved during the Quaternary but were related to salt tectonism.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Although there is no direct evidence of faulted Quaternary deposits along these faults, they were considered to be Quaternary faults by Lettis and others (1996; plate 2). They concluded that fault activity is due to salt tectonism.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

A moment magnitude (Mw) 5 maximum credible earthquake was assigned to these faults by Lettis and others (1996).

References Cited:

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Steven, T.A., and Hail, W.J., Jr., 1989, Geologic map of the Montrose 30 x 60 quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1939.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q24 - Busted Boiler Fault

Structure type: Simple fault

Structure number: Q24

Comments: Fault 2274 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Busted Boiler Fault

Comments: The Busted Boiler Fault is a generally north-south oriented fault that extends north from and perpendicular to the Ridgway Fault. The fault dies out to the north between Horsefly Creek and Polores Creek. The fault is northwest of the town of Ridgway and west of highway 550.

Synopsis:

The Busted Boiler Fault lies at the southwest margin of the Uncompahgre Uplift. It extends north (perpendicular) from the Ridgway Fault. The fault is marked by a 5- to 25-m-high fault scarp, abandoned and/or diverted streams, and ponded sediments. Late Quaternary deposits are offset across the fault trace.

Date of compilation: 1/6/98

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

State: Colorado

County: Ouray

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T45N,R9W-T47N,R9W

Strike: N5W

Number of traces: 1

End to end length: 18.01 km

Cumulative length: 18.61 km

Reliability of location: Good

Comments: The fault was mapped by Sullivan and others (1980), Steven and Hail (1989) at a scale of 1:100,000, and Tweto and others (1976) and Lettis and others (1996) at a scale of 1:250,000. The fault trace used herein is from Lettis and others (1996).

Geologic setting:

The Busted Boiler Fault lies on the southeast margin of the Uncompahgre Uplift, which is a northwest-trending, east-tilted fault block. The Busted Boiler Fault is a high-angle normal fault downthrown to the west. It forms the eastern margin of a discontinuous graben.

Sense of movement: N

Comments: Lettis and others (1996) reported normal movement on the fault.

Dip:

Comments: Lettis and others (1981) reported normal movement on a west-dipping fault.

Q24 - Busted Boiler Fault

Dip direction: W

Geomorphic expression:

The fault is marked by a prominent west-facing scarp that is 5- to 25-m-high. Diversion and/or abandonment of local streams is reported, and Holocene sediments are ponded against the fault (Lettis and others, 1996).

Age of faulted deposits:

Sullivan and others (1980) and Lettis and others (1996) reported offset of late Quaternary sediments. The fault lies almost entirely within the Cretaceous Dakota Sandstone with less than 5% of the fault extending through or beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Sullivan and others (1980) and Lettis and others (1996) reported late Pleistocene and possibly even Holocene movement on the fault. Evidence for Holocene movement is non-definitive, therefore, the most recent paleoevent on the fault is herein considered to have occurred during the late Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

A moment magnitude (Mw) 6 1/2 maximum credible earthquake was assigned to this fault by Lettis and others (1996), while Sullivan and others (1980) suggested a moment magnitude (Mw) 6 maximum credible earthquake.

References Cited:

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Steven, T.A., and Hail, W.J., Jr., 1989, Geologic map of the Montrose 30 x 60 quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1939.

Sullivan, J.T., Meeder, C.A., Martin, R.A., and West, M.W., 1980, Seismic hazard evaluation-Ridgway dam and reservoir site-Dallas Creek project, Colorado: unpublished report prepared by U.S. Water and Power Resources Service, Seismotectonic Section, 43 p.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Structure type: Simple fault

Structure number: Q25

Comments: Fault 2275 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Log Hill Mesa Graben

Comments: The Log Hill Mesa Graben is defined by two northwest-trending faults. The graben is northwest of the town of Ridgway and extends diagonally between the Busted Boiler and Ridgway Faults. This structure was named by Lettis and others (1996).

Synopsis:

The Log Hill Mesa Graben lies at the southwest margin of the Uncompahgre Uplift. It extends northwest from the Ridgway Fault. The graben is defined by well developed fault scarps in late Pleistocene fan deposits. Post-Pinedale fan deposits are not offset by the fault. The most recent paleoevent on this graben is herein considered to have occurred during the late Quaternary.

Date of compilation: 1/6/98

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

State: Colorado

County: Ouray

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T46N,R9W-T46N,R8W

Strike: N32W

Number of traces: 2

End to end length: 9.48 km

Cumulative length: 16.72 km

Reliability of location: Good

Comments: Sullivan and others (1980) mapped the western fault of the graben. Steven and Hail (1989) mapped the north half of the western fault at a scale of 1:100,000. Lettis and others (1996) showed both faults at a scale of 1:250,000. The fault trace used herein is from Lettis and others (1996).

Geologic setting:

The Log Hill Mesa Graben lies on the southeast margin of the Uncompahgre Uplift, which is a northwest-trending, east-tilted fault block. The faults that define the graben are high-angle normal faults with throw to the east and west.

Sense of movement: N

Comments: Lettis and others (1996) reported normal movement on the west-dipping eastern fault.

Dip:

Comments: Lettis and others (1996) reported a west-dipping fault plane for the eastern fault.

Dip direction: E, W

Geomorphic expression:

A well expressed fault scarp is associated with the graben-bounding faults according to Lettis and others (1996).

Age of faulted deposits:

Sullivan and others (1980) noted zones of shingled gravel showing up to 3 m of offset. Lettis and others (1996) reported that Pleistocene pediment surfaces are clearly offset by both faults bounding the graben and that a middle to late (?) Pleistocene fan is possibly offset by the eastern fault. Younger post-Pinedale fan deposits are not offset by the eastern fault. The fault lies almost entirely within the Cretaceous Dakota Sandstone, with less than 3% of the fault extending into Quaternary deposits.

Detailed studies:

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: The most recent paleoevent on the faults bounding the Log Hill Mesa Graben occurred after deposition of Pleistocene pediment deposits. The eastern fault may have moved after deposition of middle to late (?) Pleistocene fan deposits but before deposition of post-Pinedale fan deposits. Fault movement is herein considered to have occurred during the late Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Sullivan and others (1980) reported 3 m of offset in Quaternary gravels. A slip rate of <0.2mm/yr is therefore estimated for the graben.

Earthquake notes:

A moment magnitude (Mw) 6 1/4 maximum credible earthquake was assigned to this fault by Lettis and others (1996), while Sullivan and others (1980) suggested a moment magnitude (Mw) 6 maximum credible earthquake.

References Cited:

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Steven, T.A., and Hail, W.J., Jr., 1989, Geologic map of the Montrose 30 x 60 quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1939.

Sullivan, J.T., Meeder, C.A., Martin, R.A., and West, M.W., 1980, Seismic hazard evaluation-Ridgway dam and reservoir site-Dallas Creek project, Colorado: unpublished report prepared by U.S. Water and Power Resources Service, Seismotectonic Section, 43 p

Q26 - Ridgway Fault

Structure type: Simple fault

Structure number: Q26

Comments: Fault 179 in Kirkham and Rogers (1981); fault 2276 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Ridgway Fault

Comments: The Ridgway Fault is an east-west oriented tfault on the southwest margin of the Uncomphagre Uplift. The Ridgway Fault extends east from the Ouray/Montrose county line, runs parallel to and north of Pleasant Valley Creek, and ends northeast of the town of Ridgway.

Synopsis:

The Ridgway Fault is an east-west oriented fault on the southwest margin of the Uncomphagre Uplift. The fault is defined by a 300-m-high fault-line scarp, but there is no observable surface rupture in middle to late Quaternary deposits. Sullivan and others (1980) reported possible offset of Kansan to early Wisconsin glacial deposits. Micorseismic studies in the area reveal a close spatial association of seismicity to the Ridgway Fault. The fault is considered to be potentially active by Kirkham and Rogers (1981), Sullivan and others (1980) and Lettis and others (1996).

Date of compilation: 11/14/97

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

State: Colorado

County: Ouray, Montrose

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains-Colorado Plateaus

Township and Range: T45N,R10W-T45N,R8W

Strike: N87E

Number of traces: 1

End to end length: 23.84 km

Cumulative length: 23.89 km

Reliability of location: Good

Comments: The Ridgway Fault was mapped at a scale of 1:24,000 by Hail (1988; 1989) and Lettis and others (1996), 1:100,000 by Steven and Hail (1989), and 1:250,000 by Tweto and others (1976). The trace used herein is from Lettis and others (1996).

Geologic setting:

The Ridgway Fault lies on the southwest margin of the Uncompahgre Uplift, which is a northwest-trending, east- tilted fault block. The Ridgway Fault is a high-angle normal fault that is down to the south.

Sense of movement: N

Comments: Sullivan and others (1980) and Sullivan and Martin (1986) reported a south-dipping fault plane based on microseismicity studies. Down- to-the-south movement on a south-dipping fault plane indicates normal movement.

Dip:

Comments:

Dip direction: S

Geomorphic expression:

Sullivan and others (1980) described a south-facing, 300-m-high fault-line scarp along the Ridgway Fault. However, Lettis and others (1996) reported that there has not been any observable surface rupture in over 140 ka, which is supported by the general lack of geomorphic features such as scarps or even lineaments along the fault.

Age of faulted deposits:

Sullivan and others (1980) postulated that Kansan to early Wisconsin glacial deposits may be offset by the Ridway Fault. However, Lettis and others (1996) and Ake and others (1997) reported that pre-Bull Lake (middle Pleistocene) to Pinedale (10 to 40 ka) deposits are not offset by the fault. Lettis and others (1996) further stated that Holocene non-glacial deposits are not offset by the fault based on the absense of geomorphic features indicative of youthful faulting. Maxium stratigraphic throw on the Ridway Fault is about 150 m, most of which is believed to have occurred during the Laramide (Sullivan and others, 1980).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Sullivan and others (1980) examined glacial deposits and attempted to correlate them across the fault. They postulated that elevation differences in these glacial deposits across the fault could suggest Quaternary movement on the Ridgway Fault. Microseismicity studies by Sullivan and others (1980) and Martin (1987) reported that seismicity is associated with the Ridgway Fault. Kirkham and Rogers (1981) and Colman (1985) indicated Quaternary movement on the fault. Lettis and others (1996) reported no observable surface rupture since at least 140 ka. They suggested that either the seismicity is being produced by the Ridgway Fault itself but without surface rupture since 140 ka, or that the seismicity is induced by the filling of the Ridgway dam and is occurring on the Ridgway Fault and/or associated branch faults in the region. The most recent paleoevent on the Ridgway Fault is herein conservatively considered to have occurred during the Quaternary (<1.6 Ma) based on possible offset of Quaternary glacial deposits and microseismicity data cited by Sullivan and others (1980).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on the lack of geomorphic evidence to support recent fault activity, and the lack of any observable surface rupture, a slip rate of <0.2 mm/yr is estimated for this fault.

Earthquake notes:

Seismicity on the fault may be related to the filling of the Ridgway Reservoir (Sullivan and others, 1980; Lettis and others, 1996). Sullivan and others (1980) assigned a moment magnitude (Mw) 6 1/2 maximum credible earthquake to this fault. Lettis and others (1996) assigned a moment magnitude (Mw) 6 3/4 maximum credible earthquake to this fault.

References Cited:

Ake, J.P., Vetter, U., and Hawkins, F., 1997, Seismicity and Quaternary faulting near Ridgway, Colorado, 'in' Colorado Geological Survey Geohazards Conference field trip guidebook.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Hail, W.J., Jr., 1988, Reconnaissance geologic map of the Horsefly Peak quadrangle, Ouray, Montrose, and San Miguel Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map, MF-2059.

Hail, W.J., Jr., 1989, Reconnaissance geologic map of the Ridgway quadrangle, Ouray County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map, MF-2100.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Martin, R.A., Jr., 1987, Preliminary results of network operation for the period June 4, 1985 through April 30, 1987, Ridgway seismic network: U.S. Bureau of Reclamation Seismotectonic Report 87-1.

Steven, T.A., and Hail, W.J., Jr., 1989, Geologic map of the Montrose 30 x 60 quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1939.

Sullivan, J.T., and Martin, R.A., 1986, Seismic hazard studies for Ridgway dam site, Colorado, 'in' Colorado tectonics, seismicity and earthquake hazards: Proceedings and field trip guide: Colorado Geological Survey Special Publication 19, p. 30-31.

Sullivan, J.T., Meeder, C.A., Martin, R.A., and West, M.W., 1980, Seismic hazard evaluation-Ridgway dam and reservoir site-Dallas Creek project, Colorado: unpublished report prepared by U.S. Water and Power Resources Service, Seismotectonic Section, 43 p.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Structure type: Simple fault

Structure number: Q27

Comments: Fault 83 in Kirkham and Rogers (1981); fault 353 in Witkind (1976); fault 2277 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults of Pinto Mesa

Comments: This structure consists of a series of about five northwest-trending faults on the southwest flank of the Uncompahgre Uplift. The faults extends from the southwest flank of Pinon Mountain, past Tabequache Creek to Pinto Mesa, and continues southeast to Cottonwood Creek.

Synopsis:

This fault series lies on the southeast margin of the Uncompahgre Uplift. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Date of compilation: 9/4/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T47N,R14W-T48N,R15W

Strike: N43W

Number of traces: 5

End to end length: 19.67 km

Cumulative length: 26.67 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The trace used herein is from Lettis and others (1996).

Geologic setting:

This fault series lies on the southwest flank of the Uncompahgre Uplift. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the southwest.

Q27 - Unnamed Faults of Pinto Mesa

Sense of movement: N

Comments: Kirkham and Rogers (1981) and Witkind (1976) showed this as a normal fault.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The youngest deposits offset by the fault are the Cretaceous Dakota Sandstone and Burro Canyon Formation; Quaternary deposits conceal the fault (Williams, 1964). The fault lies primarily in Jurassic and Cretaceous bedrock with less than 5% of the fault extending beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on the fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (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 Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q28 - Unnamed Faults near Cottonwood Creek

Structure type: Simple fault

Structure number: Q28

Comments: Fault 85 in Kirkham and Rogers (1981); fault 354 in Witkind (1976); fault 2278 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults near Cottonwood Creek

Comments: This unnamed fault system consists of two northwest-trending faults on the southwest flank of the Uncompahgre Uplift near Cottonwood Creek.

Synopsis:

This fault lies on the southeast margin of the Uncompahgre Uplift. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Date of compilation: 9/4/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T46N,R13W-T47N,R14W

Strike: N50W

Number of traces: 3

End to end length: 10.81 km

Cumulative length: 17.10 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The trace used herein is from Williams (1964).

Geologic setting:

This fault lies on the southwest flank of the Uncompahgre Uplift. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the south and southwest.

Sense of movement: N

Comments: Witkind (1976) and Kirkham and Rogers (1981) indicated normal movement on this fault.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The youngest deposits offset by the fault are the Cretaceous Dakota Sandstone and Burro Canyon Formation; there are no Quaternary deposits mapped along the trace of the fault (Williams, 1964). The fault lies entirely within the Cretaceous Dakota and Burro Formations.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

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Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q29 - Unnamed Fault at Red Canyon

Structure type: Simple fault

Structure number: Q29

Comments: Fault 84 in Kirkham and Rogers (1981); fault 355 in Witkind (1976); fault 2279 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault at Red Canyon

Comments: This fault trends east-west on the southwest flank of the Uncompahgre Uplift. The fault extends east from the headwaters of Cottonwood Creek through Red Canyon and terminates near Clear Creek.

Synopsis:

This fault lies on the southeast margin of the Uncompahgre Uplift. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Date of compilation: 9/4/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T46N,R11W-T47N,R13W

Strike: N69W

Number of traces: 1

End to end length: 24.24 km

Cumulative length: 24.66 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The trace used herein is from Williams (1964).

Geologic setting:

This fault lies on the southwest flank of the Uncompahgre Uplift. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the south.

Sense of movement: N

Comments: Kirkham and Rogers (1981) and Witkind (1976) indicated normal movement on this fault.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The Cretaceous Mancos Shale is the youngest deposit offset by the fault; there are no Quaternary deposits mapped along the trace of the fault (Williams, 1964). The fault lies entirely within the Jurassic Brushy Basin Shale Member of the Morrison Formation and the Cretaceous Dakota Sandstone, Burro Canyon Formation, and Mancos Shale.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Howard and others, 1978; Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

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Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q30 - Unnamed Fault north of Horsefly Creek

Structure type: Simple fault

Structure number: Q30

Comments: Fault 86 in Kirkham and Rogers (1981); fault 2280 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault north of Horsefly Creek

Comments: This unnamed fault lies on the southwest flank of the Uncompahgre Uplift north of and generally parallel to Horsefly Creek. The fault trends east-west on its western end and west-northwest on its eastern end. The fault extends from Sheep Creek on the west to Hanks Creek on the east.

Synopsis:

This fault lies on the southeast margin of the Uncompahgre Uplift. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981), and no references have been published that refute this age assignment.

Date of compilation: 9/4/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T46N,R12W

Strike: N78W

Number of traces: 1

End to end length: 8.12 km

Cumulative length: 8.35 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Williams (1964).

Geologic setting:

This fault lies on the southwest flank of the Uncompahgre Uplift. The Uncompahgre Ulift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the south and southwest.

Sense of movement: N

Comments: Kirkham and Rogers (1981) indicated normal movement on this fault.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The Cretaceous Mancos Shale is the youngest deposit offset by the fault; there are no Quaternary deposits mapped along the trace of the fault (Williams, 1964). The fault lies entirely within the Jurassic Brushy Basin Shale Member of the Morrison Formation and the Cretaceous Dakota Sandstone, Burro Canyon Formation and Mancos Shale.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Structure type: Simple fault

Structure number: Q31

Comments: Fault 88 in Kirkham and Rogers (1981); fault 355 in Witkind (1976); fault 2281 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault at Hanks Creek

Comments: This is an arcuate fault at the south end of the southwest flank of the Uncompahgre Uplift. The fault trends north-northwest on its western end and almost due north on ints southeastern end. The fault splays off from an unnamed fault (fault Q29, this database) near Red Canyon, extends east to Clear Creek, then bends south to the Montrose/San Miguel county line.

Synopsis:

This fault lies on the southeast margin of the Uncompahgre Uplift. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Date of compilation: 09/04/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T45N,R11W-T46N,R12W

Strike: N47W

Number of traces: 1

End to end length: 17.48 km

Cumulative length: 21.05 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The trace used herein is from Williams (1964).

Geologic setting:

The fault lies on the southwest flank of the Uncompahgre Uplift. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the south and west.

Q31 - Unnamed Fault at Hanks Creek

Sense of movement: N

Comments: Kirkham and Rogers (1981) and Witkind (1976) indicated normal movement on this fault.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The Cretaceous Mancos Shale is the youngest deposit offset by the fault; there are no Quaternary deposits mapped along the trace of the fault (Williams, 1964). The fault lies entirely within Triassic to Cretaceous bedrock.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

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Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q32 - Unnamed Fault near Johnson Spring

Structure type: Simple fault

Structure number: Q32

Comments: Fault 89 in Kirkham and Rogers (1981); fault 355 in Witkind (1976); fault 2282 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault near Johnson Spring

Comments: This is a east-trending fault that splays from an unnamed fault (fault 2281; this database) south of Clear Creek. The fault lies at the south end of the southwest margin of the Uncompahgre Uplift.

Synopsis:

This fault lies on the southeast margin of the Uncompahgre Uplift. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Date of compilation: 9/4/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab, Montrose

Province: Colorado Plateaus

Township and Range: T46N,R10W- T46N,R11W

Strike: N84E

Number of traces: 1

End to end length: 7.10 km

Cumulative length: 7.26 km

Reliability of location: Good

Comments: The fault ws mapped at a scale of 1:250,000 by Williams (1964) and Tweto and others (1976). The trace used herein is from Williams (1964).

Geologic setting:

The fault lies on the southwest flank of the Uncompahgre Uplift. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. This fault is a high-angle normal fault that is down to the south.

Sense of movement: N

Comments: Kirkham and Rogers (1981) and Witkind (1976) indicated normal movement on this fault.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The Cretaceous Mancos Shale is the youngest deposit offset by the fault; there are no Quaternary deposits mapped along the trace of the fault (Williams, 1964; Tweto and others, 1976). The fault lies entirely within Triassic to Cretaceous bedrock.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Evidence for Quaternary movement on this fault was cited in Witkind (1976) based on personal communication with Fred Cater. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981; Colman, 1985), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado in Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Simple fault

Structure number: Q33

Comments: Fault 87 in Kirkham and Rogers (1981); fault 2283 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault at Clay Creek

Comments: This unnamed fault system consists of two northwest-trending faults on the southwest margin of the Uncompahgre Uplift. The faults are north of Highway 145 and San Miguel Canyon. Williams (1964) showed several faults in this area that offset Mesozoic rocks. Kirkham and Rogers (1981) showed only one Quaternary fault in this area. Lettis and others (1996) indicated Quaternary movement on two faults in this area.

Synopsis:

These faults lie on the southeast margin of the Uncompahgre Uplift. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Date of compilation: 9/4/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T46N,R12W

Strike: N46W

Number of traces: 2

End to end length: 9.24 km

Cumulative length: 13.83 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The trace used herein is from Williams (1964).

Geologic setting:

The faults lie on the southwest flank of the Uncompahgre Uplift. The Uncompahgre Uplift is a northwest-trending, east-tilted fault block. These faults are high-angle normal faults that are down to the southwest.

Sense of movement: N

Comments: Kirkham and Rogers (1981) indicated normal movement on one of these faults.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

The Cretaceous Mancos Shale is the youngest deposit offset by the faults; there are no Quaternary deposits mapped along the trace of the faults (Williams, 1964). The faults lie entirely within the Jurassic Brushy Basin Shale Member of the Morrison Formation and the Cretaceous Dakota Sandstone, Burro Canyon Formation and Mancos Shale.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Despite a lack of evidence for offset in Quaternary deposits, faults associated with the Uncompahgre Uplift are often considered to have experienced Quaternary movement. Based on the timing of abandonment of Unaweep Canyon, Cater (1966) indicated uplift of the Uncompahgre Plateau began in the mid-Pliocene and continued into the Pleistocene, resulting in as much as 640 m of differential uplift. There is no other published evidence that Quaternary deposits are offset by this structure. Despite the lack of evidence of faulted Quaternary deposits along this unnamed fault, it has been classified as a Quaternary fault (Kirkham and Rogers, 1981; Colman, 1985; Lettis and others, 1996), and no references have been published that refute this age assignment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on calculations of an overall uplift rate of 0.4 m/1000 yr since 1.8 Ma for the Uncompahgre Uplift (Perry, 1989), a slip rate of <0.2 mm/yr is estimated for this complex.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Perry, T.W.V., 1989, Tectonic inference and computer simulation in stream longitudinal profile evolution, Unaweep Canyon and vicinity, Colorado and Utah [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 6, p. 269.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q34 - Unnamed Faults near San Miguel Canyon

Structure type: Simple fault

Structure number: Q34

Comments: Fault 2284 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults near San Miguel Canyon

Comments: This unnamed series of faults includes 14 faults that generally trend northwest parallel to the San Miguel River. The faults lie on the southeast end of the Uncompahgre Uplift.

Synopsis:

This series of faults lies on the south end of the Uncompahgre Uplift. Although there was no reported evidence of Quaternary offset along these faults they were mapped as Quaternary faults by Lettis and others (1996; plate 2). They attributed fault activity to salt tectonism. The most recent movement on the faults herein considered to have occurred during the Quaternary based on the work of Lettis and others (1996).

Date of compilation: 1/6/98

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T43N,R13W-T46N,R11W

Strike: N52W

Number of traces: 14

End to end length: 32.06 km

Cumulative length: 100.67 km

Reliability of location: Good

Comments: The faults were mapped at a scale of 1:250,000 by Williams (1964) and Lettis and others (1996). The fault trace used herein is from Lettis and others (1996).

Geologic setting:

This fault series lies on the southeast end of the Uncompahgre Uplift, which is a northwest-trending, east-tilted fault block. Faults in this series are down to the northeast and southwest and are considered to be salt-related rather than tectonic features (Lettis and others, 1996).

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Faults in this series offset Jurassic to Cretaceous bedrock (Williams, 1964). Less than 1% of the fault lengths extend through or beneath Quaternary deposits. Although there is no evidence of faulted Quaternary deposits along these faults, Lettis and others (1996) concluded they moved during the Quaternary but were related to salt tectonism.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Although there is no direct evidence of faulted Quaternary deposits along these faults, they were mapped as Quaternary faults related to salt tectonism by Lettis and others (1996; plate 2).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

A moment magnitude (Mw) 5 maximum credible earthquake was assigned to these faults by Lettis and others (1996).

References Cited:

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q35 - Sinbad Valley Graben

Structure type: Simple fault

Structure number: Q35

Comments: Fault 2285 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Sinbad Valley Graben

Comments: The Sinbad Valley Anticline is a salt-cored structure with a collapsed crest which is defined by the Sinbad Valley Graben. Multiple northwest-trending and arcuate faults, along with a few minor folds, are associated with this graben. Only five faults are shown on the map that accompanies this database. They were generalized from Shoemaker (1956), Williams (1964) and Cater (1970). This structural graben lies north of the Paradox Valley which is a similarly formed collapsed salt anticline. Sinbad Ridge defines the southwest margin of the collapse area, while Sewemup Mesa defines the northeast margin. This structure name was assigned during this compilation.

Synopsis:

The Sinbad Valley Graben lies between the Uncompahgre Plateau and Paradox Valley. The graben formed along the collapsed crest of a salt-cored anticline which developed in response to salt migration and dissolution beneath the area (Cater, 1970). Williams (19964) indicated a few of the faults associated with the graben offset Quaternary deposits. Fault scarps are present along the north margin of the graben and minor folds and faults are reportedly found in Quaternary deposits within the graben (Shoemaker, 1956).

Date of compilation: 6/25/98

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

State: Colorado

County: Montrose, Mesa

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range:

Strike: N37W

Number of traces: 5

End to end length: 14.87 km

Cumulative length: 23.37 km

Reliability of location: Good

Comments: The Sinbad Valley Graben was mapped at a scale of 1:24,000 by Shoemaker (1956), 1:62,500 by Cater (1970), and 1:250,000 by Williams (1964). The trace used herein is generalized from Williams (1964).

Geologic setting:

The Sinbad Valley Anticline is a salt-cored structure with a collapsed crest which is defined by the Sinbad Valley Graben. Formation of the anticline is believed to be controlled by major subsurface faults that displace bedrock beneath the salt-bearing Paradox Formation. The graben is a collapse feature that formed in response to salt migration and dissolution beneath the area. Faults associated with the graben are generally high-angle and downthrown primarily to the northeast; a few faults are downthrown to the southwest (Shoemaker, 1956; Cater, 1970). Sinbad Ridge defines the southwest margin of the collapse area, while Sewemup Mesa defines the northeast margin.

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Prominent fault scarps are present along the north flank of the collapsed graben (Cater, 1970). Shoemaker (1956) reported small faults and folds in Quaternary deposits.

Age of faulted deposits:

Quaternary alluvial and eolian deposits were mapped by Williams (1964; scale 1:250,000) as offset by a few of the faults associated with the Sinbad Valley Graben. However, detailed mapping by Shoemaker (1956; scale 1:24,000) and Cater (1970; scale 1:62,500) indicated that the faults are concealed by Quaternary deposits. Shoemaker (1956) reported small faults and folds in Quaternary deposits but does not specifically map any such features.

Detailed studies:

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Williams (1964) mapped Quaternary deposits as being offset by some of the faults associated with the Sinbad Valley Graben. Although Shoemaker (1956) and Cater (1970) did not map any Quaternary deposits as faulted, accompanying text by Shoemaker stated that small folds and faults were present within the graben. He postulated that the presence of these features in Quaternary deposits indicates recent collapse and readjustment of the system. Therefore, the most recent paleoevent on the Sinbad Valley Graben is herein assumed to have occurred during the Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Shoemaker, E.M., 1956, Geology of the Roc Creek quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-83.

Cater, F.W., Jr., 1970, Geology of the salt anticline region in southwestern Colorado, with a section on stratigraphy by F.W. Cater and L.C. Craig: U.S. Geological Survey Professional Paper 637, 80 p.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q36 - Paradox Valley Graben

Structure type: Simple fault

Structure number: Q36

Comments: Fault 90 in Kirkham and Rogers (1981); fault 2286 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Paradox Valley Graben

Comments: The Paradox Valley Graben is made up of multiple faults on either side of the northwest-trending Paradox Valley. Herein, only about 15 fault traces are shown. They are generalized from Cater (1954; 1955c; 1955h; 1970), Cater and others (1955), and Williams (1964). The faults extend from the Utah/Colorado border southeast to Dry Creek and Naturita Ridge. The Paradox Valley lies on the crest of a salt-cored anticline. Kelley (1955c) refers to this region as the Paradox fold and fault belt.

Synopsis:

The Paradox Valley Graben lies on the crest of a salt-cored anticline. The graben is a collapse feature that formed in response to salt migration and dissolution from beneath the anticline (Cater, 1955h; 1970). Faults are generally downthrown towards the graben, but several are antithetic. Small folds and faults are described as offsetting Quaternary deposits and present-day, small-scale collapse and readjustment of the system is implied by Cater (1955h).

Date of compilation: 9/4/97

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

State: Colorado, Utah

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T48N,R19W-T45N,R16W

Strike: N52W

Number of traces: 20

End to end length: 53.19 km

Cumulative length: 133.45 km

Reliability of location: Good

Comments: Fault locations are fairly well defined by the Paradox Valley Graben. The graben was mapped at a scale of 1:24,000 by Cater (1954; 1955c; 1955h), Cater and others (1955), and Shoemaker (1956). It was also mapped at a scale of 1:62,500 by Cater (1970), and 1:250,000 by Williams (1964). The trace used herein is from Williams (1964).

Geologic setting:

The Paradox Valley Graben is on the crest of a salt-cored anticline. Formation of the anticline is believed to be controlled by major subsurface faults that displace bedrock beneath the evaporitic Paradox Formation (Cater, 1970). The graben is a collapse feature which formed in response to salt migration and dissolution from beneath the area (Cater, 1954; 1955c; 1955h). Faults in this area are generally high-angle normal and downthrown towards the graben, although some faults are antithetic.

Sense of movement: N

Comments: A cross section by Cater (1970) showed these faults as normal.

Dip: 75°-90°

Comments: A cross section by Cater (1970) showed the faults as dipping 75° to 90° to the southwest and northeast.

Dip direction: SW,NE

Geomorphic expression:

Faults are well defined by the margins of the Paradox Valley Graben. Cater (1955h) and Withington (1955) alluded to small faults and folds in Quaternary deposits which may indicate continued collapse and readjustment of the system.

Age of faulted deposits:

The Cretaceous Mancos Shale is the youngest deposit mapped as offset by the fault system according to Cater (1954; 1955c; 1955h). However, in the accompanying text, Cater indicated small folds and faults are present in Quatenary deposits within the graben. The faults lie primarily in Triassic to Cretaceous bedrock and were mapped as concealed beneath Quaternary deposits by Cater (1954; 1955c; 1955h), Cater and others (1955), and Withington (1955).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Although Quaternary deposits are not mapped as being offset, Cater (1954; 1955c; 1955h), Cater and others (1955), and Withington (1955) indicated that small folds and faults are in fact present within this system. They postulated that the presence of these features in Quaternary deposits indicates possible present-day collapse and readjustment of the system. Kirkham and Rogers (1981) suggested possible Holocene movement on these faults, but without more specific evidence the moste recent paleoevent on this fault system is herein considered to have occurred during the Quaternary (<1.6 Ma). Howard and others (1978) and Colman (1985) also indicated the latest movement on thes fault system occurred during the Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on the lack of evidence for offset of Quaternary deposits, a slip rate of <0.2 mm/yr is estimated for this system.

Earthquake notes:

Kirkham and Rogers (1981) suggested that the fault system is probably not capable of generating earthquakes greater than magnitude 4 or 5.

References Cited:

Cater, F.W., Jr., 1954, Geology of the Bull Canyon quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-33.

Cater, F.W., Jr., 1955c, Geology of the Davis Mesa quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-71.

Cater, F.W., Jr., 1955h, Geology of the Naturita NW quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-65.

Cater, F.W., Jr., 1970, Geology of the salt anticline region in southwestern Colorado, with a section on stratigraphy by F.W. Cater and L.C. Craig: U.S. Geological Survey Professional Paper 637, 80 p.

Cater, F.W., Jr., Butler, A.P., Jr., and McKay, E.J., 1955, Geology of the Uravan quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-78.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kelley, V.C., 1955c, Tectonics of the Four Corners region, 'in' Geology of parts of Paradox, Black Mesa, and San Juan Basins: Four Corners Geological Society, Field Conference Guidebook, p. 108-117.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Shoemaker, E.M., 1956, Geology of the Roc Creek quadrangle, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-83.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Withington, C.F., 1955, Geology of the Paradox quadrangle, Montrose County, Colorado: U.S. Geological Survey Quadrangle Map GQ-72.

Q37 - Unnamed Faults at the Northwest End of Paradox Valley

Structure type: Simple fault

Structure number: Q37

Comments: Fault 91 in Kirkham and Rogers (1981); fault 2287 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults at the Northwest End of Paradox Valley

Comments: This unnamed fault system is made up of a series of about eight faults that lie at the northwest end of Paradox Valley, near the end of the Paradox Valley Graben. The Paradox Valley Graben lies on the crest of a salt-cored anticline. Three of these faults are mapped as having evidence of Quaternary offset (Williams, 1964). One Quaternary fault trends northeast and two trend northwest. The fault system is just east of the Utah/Colorado border south of Carpenter Ridge.

Synopsis:

Three faults offset Quaternary landslide deposits at the north end of Paradox Valley (Williams, 1964). The faults are part of a larger group that forms the northwest margin of the Paradox Valley Graben which is herein considered to have experienced Quaternary movement. The graben is a collapse feature that formed in response to salt migration and dissolution associated with a salt-cored anticline that underlies the graben (Cater, 1970).

Date of compilation: 9/4/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T48N,R16W-T48N,R15W

Strike: N2W

Number of traces: 3

End to end length: 5.12 km

Cumulative length: 9.38 km

Reliability of location: Good

Comments: These faults were mapped at a scale of 1:24,000 by Cater (1955h) and 1:250,000 by Williams (1964). The trace used herein is from Williams (1964).

Geologic setting:

Paradox Valley coincides with a graben on the crest of a salt-cored anticline that formed in response to flowage and dissolution of Pennsylvanian evaporitic rocks that underlie the area (Cater, 1955h). This system of faults appears to be made up of high-angle faults that are at or near the northwest margin of the Paradox Valley Graben. The northeast-trending fault is down to the southeast, and the northwest-trending faults are down to the southwest.

Sense of movement: N

Comments: Kirkham and Rogers (1981) indicated normal movement on these faults.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Quaternary landslide deposits mapped by Williams (1964) are offset by three of the faults included in this fault system. The faults lie primarily in Jurassic to Cretaceous bedrock. Less than 20% of the combined fault trace area extends into Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Cater (1955h) indicated small folds and faults are present in Quaternary deposits within the Paradox Valley Graben. Williams (1964) mapped Quaternary landslide deposits as being offset by three of the faults. Kirkham and Rogers (1981) postulated possible Holocene movement on these faults. Colman (1985) indicated Quaternary movement on these faults. Without more specific evidence the most recent paleoevent on this fault system is herein considered to have occurred during the Quaternary (<1.6 Ma).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on the lack of evidence for offset of Quaternary deposits, a slip rate of <0.2 mm/yr is estimated for this system.

Earthquake notes:

References Cited:

Cater, F.W., Jr., 1955h, Geology of the Naturita NW quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-65.

Cater, F.W., Jr., 1970, Geology of the salt anticline region in southwestern Colorado, with a section on stratigraphy by F.W. Cater and L.C. Craig: U.S. Geological Survey Professional Paper 637, 80 p.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q38 - Big Gypsum Valley Graben

Structure type: Simple fault

Structure number: Q38

Comments: Fault 92 in Kirkham and Rogers (1981); fault 2288 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Big Gypsum Valley Graben

Comments: The Big Gypsum Valley Anticline is a salt-cored structure with a collapsed crest that is called the Big Gypsum Valley Graben. Multiple northwest-trending faults form the Big Gypsum Valley Graben which lies on the northern edge of Island Mesa and continue southeast across the Dolores River and past Gypsum Gap. Williams (1964) referred to the graben as the Big Gypsum Valley. The salt-cored anticline was referred to as the Gypsum Valley Anticline by Cater (1970).

Synopsis:

The Big Gypsum Valley Graben was formed at the crest of a salt-cored anticline in response to flowage and dissolution of underlying Pennsylvanian evaporite rocks beneath the area (Cater, 1970). Williams (1964) mapped Quaternary alluvial deposits as being offset by these faults, and Cater (1970) mapped Quaternary landslide deposits as being offset by the faults. Cater (1955a; 1955e; 1955f) alluded to small faults and folds in Quaternary deposits which may indicate continued collapse and readjustment of the system.

Date of compilation: 9/4/97

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

State: Colorado

County: San Miguel, Montrose

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T46N,R19W-T43N,R16W

Strike: N54W

Number of traces: 14

End to end length: 32.31 km

Cumulative length: 60.53 km

Reliability of location: Good

Comments: The faults of the Big Gypsum Valley Graben were mapped at a scale of 1:24.000 by Cater (1955a; 1955e; 1955f), 1:62,500 by Cater (1970), and 1:250,000 by Williams (1964). The trace used herein is from Williams (1964).

Geologic setting:

The Big Gypsum Valley Graben lies on the crest of a salt-cored anticline. Formation of the anticline is believed to be controlled by major subsurface faults that displace bedrock beneath the evaporitic Paradox Formation. The graben is a collapse feature that formed in response to flowage and dissolution of underlying evaporitic rocks (Cater, 1970). Faults in this area are generally high-angle normal and downthrown towards the graben, although some faults may be antithetic.

Sense of movement: N

Comments: Kirkham and Rogers (1981) indicated normal movement on these faults.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Faults associated with the Big Gypsum Valley Graben coincide with the walls of Big Gypsum Valley. Minor folds are present along the southwest rim of the valley and are thought to be related to collapse of the anticline structure (Cater, 1955f; Shawe, 1970). Collapse may have occurred near the end of the Laramide or early Tertiary (Cater, 1955f) or as recently as the Pleistocene (Shawe, 1970). Cater (1955a; 1955e; 1955f) alluded to small faults and folds in Quaternary deposits which may indicate continued collapse and readjustment of the system.

Age of faulted deposits:

Williams (1964) mapped Quaternary alluvial deposits as being offset by and as concealing these faults. Cater (1970) mapped Quaternary landslide deposits as being offset by and as concealing these faults, but mapped all Quaternary alluvial deposits as concealing the faults. Cater (1955a; 1955e; 1955f) alluded to small faults and folds in Quaternary deposits but did not specifically map any such features. These faults primarily offset Pennsylvanian to Cretaceous bedrock with offset generally less than 150 m (Shawe, 1970). Only about 10% of the fault system extends into or beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Williams (1964) and Cater (1970) both mapped offset of Quaternary deposits. Shawe (1970) suggested that major collapse of the Gypsum Valley Anticline took place during the middle to late Tertiary and possibly Pleistocene. Although Quaternary deposits were not mapped as offset by Cater (1955a; 1955e; 1955f), accompanying text stated that small folds and faults are in fact present within this system. Cater postulated that the presence of these features in Quaternary deposits indicates possible present-day collapse and readjustment of the system. Kirkham and Rogers (1981) postulated possible Holocene movement on these faults. Colman (1985) indicated Quaternary movement on these faults. Without more specific evidence the most recent paleoevent on this fault system is herein considered to have occurred during the Quaternary (<1.6 Ma).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

Kirkham and Rogers (1981) suggested that the fault system is probably not capable of generating earthquakes greater than magnitude 4 or 5.

References Cited:

Cater, F.W., Jr., 1955a, Geology of the Anderson Mesa quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-77.

Cater, F.W., Jr., 1955e, Geology of the Gypsum Gap quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-59.

Cater, F.W., Jr., 1955f, Geology of the Hamm Canyon quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-69.

Cater, F.W., Jr., 1970, Geology of the salt anticline region in southwestern Colorado, with a section on stratigraphy by F.W. Cater and L.C. Craig: U.S. Geological Survey Professional Paper 637, 80 p.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Shawe, D.R., 1970, Structure of the Slick Rock District and vicinity, San Miguel and Dolores Counties, Colorado: U.S. Geological Survey Professional Paper 576-C, 18 p.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Q39 - Dolores Fault Zone

Structure type: Simple fault

Structure number: Q39

Comments: Fault 93 in Kirkham and Rogers (1981); fault 2289 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Dolores Fault Zone

Comments: This series of faults consists of multiple west-northwest-trending faults between the town of Slick Rock and the Utah/Colorado border. The faults appear to form a pair of grabens that lie between and are generally parallel to Lisbon Valley and Disappointment Valley. The grabens lie on the crest of the Dolores Anticline, which is the south extension of the Lisbon Valley Anticline in Utah. The name 'Dolores Fault zone' was initiated by Shawe and others (1959).

Synopsis:

The Dolores Fault zone forms two grabens on the crest of the Dolores Anticline, a salt-cored structure. The grabens formed in response to flowage and dissolution of underlying Pennsylvanian evaporitic rocks in the Paradox Formation (Cater, 1970). Cater (1955g) postulated that small folds and faults in Quaternary deposits within the grabens indicate present-day, small-scale collapse and readjustment of the system. Williams (1964) mapped Quaternary deposits as abutting against the fault, and Cater (1970) showed no offset of Quaternary deposits. Kirkham and Rogers (1981) suggested possible Holocene movement on this system. The most recent paleoevent on this fault zone is herein considered to have occurred during the Quaternary (<1.6 Ma) based on Cater (1955g), and Kirkham and Rogers (1981).

Date of compilation: 9/4/97

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

State: Colorado

County: San Miguel

1° x 2° Sheet: Moab

Province: Colorado Plateaus

Township and Range: T43N,R18W-T44N,R18W

Strike: N67W

Number of traces: 4

End to end length: 15.18 km

Cumulative length: 21.24 km

Reliability of location: Good

Comments: The faults were mapped at a scale of 1:24,000 by Cater (1955g), 1:62,500 by Cater (1970) and 1:250,000 by Williams (1964). The trace used herein is from Williams (1964).

Geologic setting:

Faults of the Dolores Fault zone are normal and form two en echelon grabens. Throw on the faults is generally down into the grabens. The faults lie south of Paradox Basin and Big

Gypsum Valley, both of which are collapsed salt-cored anticlines and are on trend with Lower Lisbon and Disappointment Valleys. The faults are on the crest of a the Dolores Anticline, a salt-cored structure. The Dolores Anticline has not experienced major collapse, as have the Paradox Basin and Big Gypsum Valley Anticlines, only minor readjustments (Cater, 1970). The Dolores Anticline is a broad, asymmetric fold with limbs that dip 2° SW and 9° NE (Shawe, 1970). Formation of the anticline is believed to be controlled by major subsurface basement faults that displace bedrock beneath the evaporitic Paradox Formation (Cater, 1970; Shawe, 1970). Shawe (1970) reported down-to-the-northeast, dip-slip displacement of several hundred meters on this basement fault zone. Thickness of the Paradox Formation increases by about 610 m along the axis of the anticline (Shawe and others, 1968).

Sense of movement: N

Comments: Kirkham and Rogers (1981) indicated normal movement on these faults.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Cater (1955g) alluded to small faults and folds in Quaternary deposits which may indicate continued collapse and readjustment of the system.

Age of faulted deposits:

Williams (1964) mapped Quaternary deposits as abutting against the faults of the Dolores Fault zone. Cater (1955g) mapped the Cretaceous Dakota Sandstone and Burro Canyon Formation as the youngest deposits offset by the faults, but in the accompanying text he indicated small folds and faults are present in Quaternary deposits within the grabens. Quaternary movement was suggested by Shawe (1970) who reported a grade of about 30 m/km for tilted terrace gravels between the Dolores River and Glade Mountain, whereas the average grade for untilted gravels in the area is only 7.5 m/km. The faults lie primarily within Triassic to Cretaceous; only about 5% of the fault system extends beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Although Quaternary deposits are not mapped as offset, text provided by Cater (1955g) indicated that small folds and faults are in fact present within this system. He postulated that the presence of these features in Quaternary deposits indicates possible present-day collapse and readjustment of the system. Shawe (1970) discussed the possibility of up to about 300 m of Pleistocene folding, as suggested by tilted terrace gravels, but believes significant fault movement may only be early to middle Tertiary in age. Williams (1964) mapped surficial deposits as abutting against the faults. Kirkham and Rogers (1981) suggested possible Holocene movement on these faults. The most recent paleoevent for this fault system is herein considered to have occurred during the Quaternary (<1.6 Ma) based on Cater (1955g) and Shawe (1970).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

Kirkham and Rogers (1981) suggested that the fault system is probably not capable of generating earthquakes greater than magnitude 4 or 5.

References Cited:

Cater, F.W., Jr., 1955g, Geology of the Horse Range Mesa quadrangle, Colorado: U.S. Geological Survey Quadrangle Map GQ-64.

Cater, F.W., Jr., 1970, Geology of the salt anticline region in southwestern Colorado, with a section on stratigraphy by F.W. Cater and L.C. Craig: U.S. Geological Survey Professional Paper 637, 80 p.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Shawe, D.R., 1970, Structure of the Slick Rock District and vicinity, San Miguel and Dolores Counties, Colorado: U.S. Geological Survey Professional Paper 576-C, 18 p.

Shawe, D.R., Archibold, N.L., and Simmons, G.C., 1959, Geology and uranium-vanadium deposits of the Slick Rock district, San Miguel and Dolores Counties, Colorado: Economic Geology, v. 54, no. 3, p. 395-415.

Shawe, D.R, Simmons, G.C., and Archibold, N.L., 1968, Stratigraphy of the Slick Rock District and vicinity, San Miguel and Dolores Counties, Colorado: U.S. Geological Survey Professional Paper 576-A, 108 p.

Williams, P.L., 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-360.

Structure type: Simple fault

Structure number: Q41

Comments: Fault 2291 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Red Rocks Fault

Comments: The Red Rocks Fault is a west-northwest-trending fault north of and parallel to the Cimarron Fault. The fault begins in the Black Canyon of the Gunnison National Monument at the northeast end of the Bostwick Park section of the Cimarron Fault. From north of Crystal and Morrow Point dams the fault extends southeastward and terminates near Blue Mesa where it may merge with the Blue Mesa section of the Cimarron Fault.

Synopsis:

The Red Rocks Fault is north of and subparallel to the closely linked Cimarron Fault. Both faults are part of the Laramide Red Rocks - Cimarron Fault system which originated as a reverse or tear fault, but has experienced renewed late Cenozoic movement in a normal sense. Geomorphic features such as scarps, lineaments, and linear drainages are suggestive of Quaternary movement. Late Tertiary gravels are offset by the fault but offset of Quaternary deposits is not conclusive. Lettis and others (1996) recognized several subtle scarps in late Pleistocene deposits, but the origin of these scarps is not well understood. Lettis and others (1996) reported that the scarps might be of tectonic or landslide origin. A single trench was excavated across the Red Rocks Fault by Lettis and others (1996) near Jones Summit. Trench exposure revealed that late Pleistocene to Holocene deposits (200 to 9 ka) were not deformed by the Red Rocks Fault. The latest movement on the Red Rocks Fault is herein considered to have occurred during the Quaternary based on the presence of scarps, although their origin is not well understood, and because of its close association with the Cimarron Fault, sections of which have been active during the Quaternary (Lettis and others, 1996).

Date of compilation: 1/6/98

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

State: Colorado

County: Montrose, Gunnison

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T48N,R93W-T50N,R90W

Strike: N59W

Number of traces: 1

End to end length: 38.34 km

Cumulative length: 39.11 km

Reliability of location: Good

Comments: The Red Rocks Fault was mapped at a scale of 1:31,680 by Hansen (1971) and 1:250,000 by Tweto and others (1976) and Lettis and others (1996). The fault trace used herein is primarily from Lettis and others (1996).

Q41 - Red Rocks Fault

Geologic setting:

The Red Rocks Fault is a high-angle fault. Stratigraphic offset across the fault indicates Laramide reverse movement on a possible tear fault downthrown to the southwest (Hansen, 1971). Reactivation of the fault during the late Cenozoic is down to the northeast in a normal sense (Lettis and others, 1996). The Red Rocks Fault is closely linked to the Cimarron Fault. Lettis and others (1996) described the "Red Rocks - Cimarron Fault system" as originating as a Laramide reverse or tear fault, and as experiencing late Cenozoic reactivation in a normal sense. They showed both faults as flattening at depth and merging with a lateral ramp in a blind thrust fault. The Red Rocks Fault is subparallel to the Bostwick Park and Poverty Mesa sections of the Cimarron Fault, both of which were active during the late Quaternary (Lettis and others, 1996).

Sense of movement: N

Comments: Late Cenozoic movement on the fault is normal. The fault originated as a Laramide reverse or tear fault (Lettis and others, 1996).

Dip: 75°-90°NE

Comments: Hansen (1971) showed this fault as a northeast-dipping fault steepening with depth. Lettis and others (1996) indicated the fault is northeast-dipping and flattens at depth, where it merges with a lateral ramp in a blind thrust fault.

Dip direction: NE

Geomorphic expression:

The fault lies in the linear stream valley of Jones Draw. A 300-m-high escarpment, subtle scarps, and vegetation lineaments occur along the fault (Lettis and others, 1996).

Age of faulted deposits:

Late Tertiary gravels are offset by the fault, and subtle scarps are present in probable late Pleistocene and possible Holocene colluvial deposits (Lettis and others, 1996). The fault lies primarily within Precambrian bedrock with about 15% of the fault extending into or beneath Tertiary volcanics or Quaternary deposits.

Detailed studies:

Lettis and others (1996) conducted a trenching investigation across the Red Rocks Fault in Jones Draw near Jones Summit at the northwest end of the fault. Only one trench was excavated at this site, which they labeled trench JDT1. Their study revealed that late Pleistocene and Holocene deposits were not offset by the Red Rocks Fault. The trench is labeled Q41-1 on the map that accompanies this database.

Q41-1 (JDT1): Lettis and others (1996) excavated a trench across a small, south-facing scarp near Jones Summit. The Red Rocks Fault consists of a 5-m-wide fault zone that dips steeply to the northeast in Precambrian rocks exposed in the trench. Holocene alluvial and colluvial deposits, latest Pleistocene alluvial and colluvial deposits, and scarp-derived deposits of latest Pleistocene - Holocene age were found to be undeformed by the fault. Charcoal deposits in undeformed beds were dated at 11 to 9 ka indicating that no faulting occurred during the Holocene. Alluvial fans (200 to 10 ka) were also found to be undeformed by the fault suggesting that the fault has not been active since the late Quaternary.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Quaternary deposits are not clearly offset by the Red Rocks Fault. However, geomorphic features such as scarps, lineaments, and linear drainages suggest possible

Quaternary movement (Lettis and others, 1996). Scarps occur in late Pleistocene to Holocene (?) deposits along the fault, but they may result from either tectonism or landsliding. Based on field and trenching investigations, Lettis and others (1996) concluded that the scarps were due to mass movement but did not rule out the possiblility of tectonic movement. The most recent paleoevent on the Red Rocks Fault is herein considered to have occurred during the Quaternary based on the presence of scarps and its close association with the Cimarron Fault, sections of which were active during the Quaternary (Lettis and others, 1996).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on low scarp height, lack of definitive evidence for Quaternary offset, and on estimated slip rates for the closely related Cimarron Fault, a slip rate of <0.2 mm/yr is estimated for the Red Rocks Fault.

Earthquake notes:

The Red Rocks - Cimarron Fault system may be capable of generating a magnitude 6 3/4 earthquake (Unruh and others, 1993a).

References Cited:

Hansen, W.R., 1971, Geologic map of the Black Canyon of the Gunnison River and vicinity, western Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-584.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Unruh, J.R., Noller, J.S., Lettis, W.R., Sawyer, T.L., and Bott, J.D.J., 1993a, Quaternary faults of the Central Rocky Mountains, Colorado; a new seismotectonic evaluation [abs.]: Geological Society of America Abstracts with Programs, v. 25, no. 5, p. 157.

Q42 - Unnamed Fault along the Grand Hogback Monocline Southwest of Glenwood Springs

Structure type: Simple fault

Structure number: Q42

Comments: Fault 61 in Kirkham and Rogers (1981); fault 2292 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault along the Grand Hogback Monocline Southwest of Glenwoo

Comments: This is a northeast-trending fault that occurs at the bend in the Grand Hogback Monocline southwest of Glenwood Springs and west of the Roaring Fork River. Although faults in this area were previously recognized (e.g., Murray, 1969; Tweto and others, 1978; Kirkham and Rogers, 1981), Kirkham and others (1995a) were the first to map this particular fault, and to suggest it cuts Quaternary deposits.

Synopsis:

This fault is roughly perpendicular to the Grand Hogback Monocline southwest of Glenwood Springs. Murray (1969) suggested that faults in this area are related to the "unfolding" of the monocline as salt migrates or dissolves from beneath the monocline. Late Pleistocene-Holocene alluvium and colluvium is offset by this fault (Kirkham and others, 1995a).

Date of compilation: 3/4/98

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

State: Colorado

County: Garfield

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T6S,R89W

Strike: N63E

Number of traces: 1

End to end length: 2.44 km

Cumulative length: 2.44 km

Reliability of location: Good

Comments: This fault was mapped at 1:24,000 by Kirkham and others (1995a; 1996b) and Carroll and others (1996). The fault traces used herein are from Kirkham and others (1995a; 1996b) and Carroll and others (1996).

Geologic setting:

This is a high-angle, down to the northwest normal fault. It is roughly perpendicular to the Grand Hogback Monocline. The fault appears to be associated with a number of Neogene bedding-plane faults that cut Miocene basalt (Kirkham and others, 1995a; 1996b, Carroll and others, 1996), but this is the only fault with evidence of Quaternary movement (Kirkham and others, 1995a). Murray (1969) suggested that faults in this area are related to the "unfolding" of the monocline as salt migrates or dissolves from beneath the monocline.

Q42 - Unnamed Fault along the Grand Hogback Monocline Southwest of Glenwood Springs

Sense of movement: N

Comments: Faults in this area were considered to be normal (Kirkham and others, 1995a).

Dip:

Comments:

Dip direction:

Geomorphic expression:

Miocene basalt caps and overlying gravel deposits are tilted to the east on west-dipping bedding-plane faults.

Age of faulted deposits:

Miocene basalt and late Pleistocene to Holocene alluvium and colluvium are offset by this fault (Kirkham and others, 1995a).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Kirkham and others (1995a) mapped offset of late Pleistocene to Holocene age deposits. Without better age constraints for these deposits, the most recent paleoevent is herein considered to have occurred during the late Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

A moment magnitude (Mw) 5 maximum credible earthquake was assigned to faults along the Grand Hogback Monocline by Unruh and others (1993b).

References Cited:

Carroll, C.J., Kirkham, R.M., and Stelling, P.L., 1996, Geologic map of the Center Mountain quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 96-2.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Kirkham, R.M., Streufert, R.K., and Cappa, J.A., 1995a, Geologic map of the Glenwood Springs quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 95-3.

Kirkham, R.M., Streufert, R.K., Hemborg, T.H., and Stelling, P.L., 1996b, Geologic map of the Cattle Creek quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 96-1.

Q42 - Unnamed Fault along the Grand Hogback Monocline Southwest of Glenwood Springs

Murray, F.N., 1969, Flexural slip as indicated by faulted lava flows along the Grand Hogback Monocline, Colorado: Journal of Geology, v. 77, no. 3, p. 333-339.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

Q43 - Unnamed Faults along the Grand Hogback Monocline near Fourmile Creek

Structure type: Simple fault

Structure number: Q43

Comments: Fault 2294 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults along the Grand Hogback Monocline near Fourmile Creek

Comments: This is a series of three northwest-trending faults west of Carbondale and the Roaring Fork River. The faults are bedding-plane faults along the Grand Hogback Monocline. The faults have been mapped mapped by by Soule and Stover (1985), Stover (1986) and Kirkham and others (1996b). Due to the close spatial association of the faults, only two of the faults are shown on the map that accompanies this database.

Synopsis:

Three closely spaced, parallel faults lie along the Grand Hogback Monocline west of Carbondale. The faults are marked by topographic scarps up to 3 m high and vegetation lineaments in debris-flow deposits of late Pleistocene to Holocene (?) age (Kirkham and others, 1996b; 1997b). The faults are bedding-plane faults that are downthrown to the west. Movement on the faults is attributed to unfolding or relaxation of the Grand Hogback Monocline as salt migrates and dissolves from beneath the monocline.

Date of compilation: 3/4/98

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

State: Colorado

County: Garfield

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T7S,R89W

Strike: N32W

Number of traces: 2

End to end length: 2.49 km

Cumulative length: 3.97 km

Reliability of location: Good

Comments: The faults were mapped at a scale of 1:24,000 by Kirkham and others (1996b) and Stover (1986) and 1:50,000 by Soule and Stover (1985). The fault traces used herein are from Kirkham and others (1996b).

Geologic setting:

These faults are generally high-angle, listric, normal, with downthrown to the west. Most of the faults are parallel to the Grand Hogback Monocline which is underlain by more than 2.5 km of halite and other evaporite deposits. The faults offset faults offset debris-flow deposits of Holocene (?) to Pleistocene age and are thought to be due to unfolding or relaxation of the monocline as salt migrates and dissolves from beneath the monocline (Stover, 1986; Unruh and others, 1993b; Kirkham and others, 1996b; 1997b). Murray (1969) proposed a similar origin for late Cenozoic faults along the monocline north of this locale. Increasing scarp heights in deposits of increasing age suggests the faults move recurrently (Stover, 1986; Kirkham and others, 1996b).

Sense of movement: N

Comments: These faults were shown as normal bedding-plane faults on a cross section by Kirkham and others (1996b).

Dip: ~45°W

Comments: A near-surface dip of about 45° is shown on a cross section by Kirkham and others (1996b). The faults flatten with depth as they approach the axis of the Grand Hogback Syncline.

Dip direction: W

Geomorphic expression:

Scarps up to about 3 m high in late Pleistocene to Holocene (?) deposits occur along these faults, and most are associated with prominent vegetation lineaments and linear swales (Kirkham and others, 1996b).

Age of faulted deposits:

Older debris flow deposits of late Pleistocene to Holocene (?) age are offset up to 3 m by these faults. Late Cenozoic to early Quaternary deposits are displace up to 30 m by these faults (Kirkham and others, 1996b).

Detailed studies:

No detailed studies have been conducted on this fault.

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

Comments: The youngest deposits cut by these faults are late Pleistocene to Holocene (?) in age (Kirkham and others, 1996b). The latest movement on these faults therefore likely occurred during the Holocene or post-glacial.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on 30-m-high scarps in late Tertiary to early Quaternary deposits and 3-m-high scarps in late Pleistocene to Holocene (?) deposits (Kirkham and others, 1996b), a slip rate of <0.2 mm/yr is estimated for these faults.

Earthquake notes:

References Cited:

Kirkham, R.M., Streufert, R.K., Hemborg, T.H., and Stelling, P.L., 1996b, Geologic map of the Cattle Creek quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 96-1.

Kirkham, R.M., Steufert, R.K., Scott, R.B., Lidke, D.J., Bryant, B., Perry, W.J., Jr., Kunk, M.J., Driver, N.E., and Bauch, N.J., 1997b, Active salt dissolution and resulting geologic collapse in the Glenwood Springs region of west-central Colorado [abs.]: Geological Society of America Abstracts with Programs, v. 29, no. 6, p. A-416.

Murray, F.N., 1969, Flexural slip as indicated by faulted lava flows along the Grand Hogback Monocline, Colorado: Journal of Geology, v. 77, no. 3, p. 333-339.

Soule, J.M., and Stover, B.K., 1985, Surficial geology, geomorphology, and general engineering geology of parts of the Colorado River Valley, Roaring Fork River Valley and adjacent areas, Garfield County, Colorado: Colorado Geological Survey Open-file Report 85-1.

Stover, B.K., 1986, Geologic evidence of Quaternary faulting near Carbondale, Colorado, with possible associations to the 1984 Carbondale earthquake swarm, 'in' Rogers, W.P., and Kirkham, R.M., eds., Contributions to Colorado tectonics and seismicity - A 1986 update: Colorado Geological Survey Special Publication 28, p. 295-301.

Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 154 p.

Q44 - Unnamed Faults along the Grand Hogback Monocline near Freeman Creek

Structure type: Simple fault

Structure number: Q44

Comments: Fault 2295 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults along the Grand Hogback Monocline near Freeman Creek

Comments: This is a series of about 26 northwest-trending faults west of Carbondale and the Roaring Fork River. The faults are bedding-plane faults along the Grand Hogback Monocline. The faults have been mapped by Soule and Stover (1985), Stover (1986) and Kirkham and others (1996b). Due to the close spatial association of the faults, only 17 of the faults are shown on the map that accompanies this database.

Synopsis:

More than 26 closely spaced, parallel faults lie along of the Grand Hogback Monocline west of Carbondale. The faults are marked by topographic scarps up to 30 m high in late Tertiary to early Quaternary high-level gravel deposits and by and vegetation lineaments (Kirkham and others, 1996b; 1997b). The flaults are downthrown to the west as bedding-plane faults in the monocline. Movement on the faults is attributed to unfolding or relaxation of the Grand Hogback Monocline that occurs as salt migrates and dissolves from beneath the monocline. This series of faults is herein considered to have moved during the Quaternary, although without better age constraints on the high-level gravel deposits, late Tertiary movement instead of Quaternary movement on the faults cannot be ruled out.

Date of compilation: 3/4/98

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

State: Colorado

County: Garfield

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T7S,R89W-T8S,R88W

Strike: N17W

Number of traces: 17

End to end length: 5.69 km

Cumulative length: 25.30 km

Reliability of location: Good

Comments: The faults were mapped at a scale of 1:24,000 by Kirkham and others (1996b) and Stover (1986) and 1:50,000 by Soule and Stover (1985). The fault traces used herein are from Kirkham and others (1996b).

Geologic setting:

These faults are generally high-angle, listric, normal, with downthrown to the west. Most of the faults are parallel to the Grand Hogback Monocline which is underlain by more than 2.5 km of halite and other evaporite deposits. The faults offset faults offset late Tertiary to early Quaternary deposits and are thought to be due to unfolding or relaxation of the monocline as salt migrates and dissolves from beneath the monocline (Stover, 1986; Unruh and others, 1993b; Kirkham and others, 1996b; 1997b). Murray (1969) proposed a similar origin for late Cenozoic faults along the monocline north of this locale. Increasing scarp heights in deposits of increasing age suggests the faults move recurrently (Stover, 1986; Kirkham and others, 1996b).

Sense of movement: N

Comments: These faults were shown as bedding-plane faults with normal sense of movement on a cross section by Kirkham and others (1996b).

Dip: ~45°W

Comments: A near-surface dip of about 45° is shown on a cross section by Kirkham and others (1996b). The faults flatten with depth as they approach the axis of the Grand Hogback Syncline.

Dip direction: W

Geomorphic expression:

Scarps up to about 30 m high in late Tertiary to early Quaternary deposits occur along these faults, and most are associated with prominent vegetation lineaments and linear swales (Kirkham and others, 1996b).

Age of faulted deposits:

High-level basaltic gravel deposits of late Tertiary to early Pleistocene age are offset by these faults. The gravels have been offset by as much as 30 m (Kirkham and others, 1996b).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: These faults offset deposits of late Tertiary to early Quaternary age. The most recent paleoevent on these faults is therefore considered to have occurred during the Quaternary. However, without better age constraints, the possibility of late Tertiary instead of Quaternary movement cannot be completely discounted.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on 30-m-high scarps in late Tertiary to early Quaternary deposits (Kirkham and others, 1996b), a slip rate of <0.2 mm/yr is estimated for these faults.

Earthquake notes:

References Cited:

Kirkham, R.M., Streufert, R.K., Hemborg, T.H., and Stelling, P.L., 1996b, Geologic map of the Cattle Creek quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 96-1.

Kirkham, R.M., Steufert, R.K., Scott, R.B., Lidke, D.J., Bryant, B., Perry, W.J., Jr., Kunk, M.J., Driver, N.E., and Bauch, N.J., 1997b, Active salt dissolution and resulting geologic collapse in the Glenwood Springs region of west-central Colorado [abs.]: Geological Society of America Abstracts with Programs, v. 29, no. 6, p. A-416.

Murray, F.N., 1969, Flexural slip as indicated by faulted lava flows along the Grand Hogback Monocline, Colorado: Journal of Geology, v. 77, no. 3, p. 333-339.

Soule, J.M., and Stover, B.K., 1985, Surficial geology, geomorphology, and general engineering geology of parts of the Colorado River Valley, Roaring Fork River Valley and adjacent areas, Garfield County, Colorado: Colorado Geological Survey Open-file Report 85-1.

Stover, B.K., 1986, Geologic evidence of Quaternary faulting near Carbondale, Colorado, with possible associations to the 1984 Carbondale earthquake swarm, 'in' Rogers, W.P., and Kirkham, R.M., eds., Contributions to Colorado tectonics and seismicity - A 1986 update: Colorado Geological Survey Special Publication 28, p. 295-301.

Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 154 p.

Structure type: Simple fault

Structure number: Q45

Comments: Fault 57 in Kirkham and Rogers (1981); fault 2296 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults near Burns

Comments: This fault number refers to a series of about seven variously oriented faults near the towns of Sylvan and Burns along the Colorado River valley. The faults were first recognized by Kirkham and Rogers (1981).

Synopsis:

These faults were first described by Kirkham and Rogers (1981). Vegetation and topographic lineaments are present in Quaternary pediment gravels. The faults offset pre-Bull Lake deposits and are tentatively attributed to local flowage and dissolution of evaporite deposits from beneath the area.

Date of compilation: 6/12/97

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

State: Colorado

County: Eagle

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T2S,R86W-T2S,R84W

Strike: N55W

Number of traces: 9

End to end length: 13.31 km

Cumulative length: 22.73 km

Reliability of location: Poor

Comments: These faults were originally recognized on air photos by Kirkham (1977b) but were not actually mapped until 1981 by Kirkham and Rogers at a scale of 1:500,000. Unruh and others (1993b) showed several photolineaments in this location on their 1:250,000 map, but the lineaments do not coincide with faults mapped by Kirkham and Rogers (1981). The trace used herein is from Kirkham (1977b).

Geologic setting:

Kirkham an d Rogers (1981) described these faults as normal. The faults lie northeast of the White River uplift near the Colorado River. The faults occur in bedrock and Quaternary deposits that overlie Pennsylvanian evaporite deposits. They are variously oriented and appear to be related to salt tectonism.

Sense of movement: N

Comments: Kirkham and Rogers (1981) described these faults as normal.

Dip: 75°NW

Comments: Kirkham and Rogers (1981) measured a dip of 75°NW on the northern of two northeast-trending faults in a roadcut near Blue Hill (SW 1/4 of sec. 18, T2S, R84W).

Dip direction: NW

Geomorphic expression:

Vegetation and topographic lineaments are present in pediment gravels and landslide deposts (Kirkham and Rogers, 1981).

Age of faulted deposits:

Kirkham and Rogers (1981) reported that Quaternary landslide deposits and pediment gravels (pre-Bull Lake?) are offset by faults in this area. Two faults are exposed in a road cut near Blue Hill. The northerly fault offsets pre-Bull Lake pediment gravels about 2 m. The southerly fault offsets the pediment gravels about 0.7 m (Kirkham and Rogers, 1981). The faults lie primarily in Cretaceous Mancos Shale and Dakota Sandstone.

Detailed studies:

No detailed studies have been conducted on these faults.

Timing of most recent paleoevent: (3) Quaternary-middle and late (<750ka)

Comments: Kirkham and Rogers (1981) described pre-Bull Lake deposits (>130 ka) as offset by the fault. Colman (1985) assigned these faults to the middle to early Pleistocene.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on offset of 0.7 to 2.0 m in pre-Bull Lake pediment gravels (Kirkham and Roger, 1981), a slip rate of <0.2 mm/yr is estimated for these faults.

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., 1977b, unpublished file information based on interpretation of aerial photography: Colorado Geological Survey file information.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 154 p.

Q46 - Greenhorn Mountain Fault

Structure type: Simple fault

Structure number: Q46

Comments: Fault 58 in Kirkham and Rogers (1981); fault 2297 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Greenhorn Mountain Fault

Comments: The Greenhorn Mountain Fault is defined by a series of seven northwest-trending faults north of Eagle extending from the Colorado River north of Big Red Hill on the northwest, to I-70 between Eagle and Wolcott on the southeast. Unruh and others (1993b) refered to this fault series as the Greenhorn Mountain Fault.

Synopsis:

Tweto and others (1978) showed this fault as a single down to the northeast fault. Unruh and others (1993b) showed a total of seven faults down to the northeast and southwest forming a northwest-trending graben. The fault zone is marked by an escarpment and scarps (Kirkham and Rogers, 1981), and closed depressions, saddles and springs (Unruh and others, 1993b). The faults offset Quaternary landslide deposits according to Kirkham and Rogers (1981). Unruh and others (1993b) concluded that the faults are related to evaporite flowage and dissolution.

Date of compilation: 6/12/97

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

State: Colorado

County: Eagle

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T3S,R85W-T4S,R84W

Strike: N49W

Number of traces: 7

End to end length: 21.35 km

Cumulative length: 29.14 km

Reliability of location: Good

Comments: Tweto and others (1978) and Unruh and others (1993b) mapped this series of faults at a scale of 1:250,000. Kirkham and Rogers (1981) mapped these faults at a scale of 1:500,000. The trace used herein is from Unruh and others (1993b).

Geologic setting:

This series of faults forms a northwest-trending graben on the northeastern flank of Greenhorn Mountain, east of the White River Uplift. Eiby Creek lies within this graben but bends south and flows out of the graben at the south end. The area is underlain by Pennsylvanian evaporite deposits.

Q46 - Greenhorn Mountain Fault

Sense of movement: N

Comments: Normal movement is indicated on these faults by Kirkham and Rogers (1981) and Unruh and others (1993b).

Dip:

Comments: The main fault trace is described as a northeast-dipping normal fault (Unruh and others, 1993b).

Dip direction: NE

Geomorphic expression:

The southwest margin of the graben is marked by a 25-m-high northeast-facing escarpment (Kirkham and Rogers, 1981). Scarps are present along the fault traces of the graben margins and are typically 3 m high or less. Other features include closed depressions, saddles, and springs (Unruh and others, 1993b).

Age of faulted deposits:

Tweto and others (1978) showed Holocene and Pleistocene landslide deposits as faulted against Mesozoic and Paleozoic rocks. Kirkham and Rogers (1981) reported Quaternary landslide deposits as being offset by the fault. Unruh and others (1993b) reported the presence of scarps and geomorphic features indicative of Quaternary faulting, but suggested these features developed in response to flowage and dissolution of evaporite deposits from beneath the area.

Detailed studies:

No detailed studies have been conducted on these faults.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Tweto (1978) showed this fault system as pre-Neogene but Tweto and others (1978) showed Quaternary landslide deposit as being offset by the faults. Kirkham and Rogers (1981) reported Quaternary movement related to salt flowage and dissolution. Colman (1985) and Unruh and others (1993b) also reported faulting due to salt tectonism.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, 1978, Northern rift guide 1, Denver-Alamosa, Colorado, 'in' Hawley, J.W., ed., Guidebook to the Rio Grande Rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 13-27.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 154 p.

Q47 - Unnamed Faults of Red Hill

Structure type: Simple fault

Structure number: Q47

Comments: Fault 60 in Kirkham and Rogers (1981); fault 2298 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults of Red Hill

Comments: This series of faults is comprised of about 26 faults on Red Hill southwest of Dotsero and south of I-70. Many of the faults form east-west-trending grabens. Only two or three faults were previously mapped by Kirkham and Rogers (1981) and Colman (1985). More detailed mapping by Streufert and others (1997a; 1997b) indicated there are numerous small faults in this area.

Synopsis:

These faults extend across Red Hill southwest of Dotsero. Several graben structures and fault traces are clearly visible on air photos. The largest of the grabens has as much as 20 m of topographic relief (Unruh and others, 1993b). Quaternary movement on these faults is evidenced by offset of Quaternary landslide deposits (Kirkham and Rogers, 1981). Faulting is attributed to salt migration and dissolution rather than to regional tectonics (Kirkham and Rogers, 1981; Unruh and others, 1993b).

Date of compilation: 6/12/97

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

State: Colorado

County: Eagle

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T5S,R86W

Strike: N16W

Number of traces: 26

End to end length: 6.12 km

Cumulative length: 34.60 km

Reliability of location: Good

Comments: The faults were mapped at 1:24,000 by Streufert and others (1997a; 1997b). The trace used herein is from Streufert and others (1997a; 1997b).

Geologic setting:

These faults are typically high-angle, normal, graben-forming faults. The area is underlain by thick deposits of the Pennsylvanian Eagle Valley Evaporite which consist primarily of gypsum, dolomite, and possible halite at depth. The highly variable orientation of the faults suggests that fault activity is related to salt tectonics rather than regional stress regimes. The faults are believed to have formed in response to piping or collapse of the overburden due to flowage and dissolution of evaporite deposits from beneath the area (Kirkham and Rogers, 1981; Unruh and others, 1993b).

Sense of movement: N

Comments: A cross section through Red Hill by Streufert and others (1997b) showed these faults as high-angle normal faults.

Dip:

Comments:

Dip direction:

Geomorphic expression:

A northeast-trending topographic depression at the crest of Red Hill defines a graben with up to 20 m of relief. Other grabens are also visible on Red Hill and closed depression are common in the grabens. Bedrock fault scarps are present in Paleozoic sediments (Unruh and others, 1993b).

Age of faulted deposits:

Quaternary landslide deposits are offset across several of the faults (Kirkham and Rogers, 1981). The fault traces extend primarily through Pennsylvanian and Permian deposits with less than 10% of the fault traces in Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on these fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Deformation during the Quaternary is evidenced by offset of Quaternary landslide deposits (Kirkham and Rogers, 1981). Orientation of faults in the area is not consistant with contemporary stress fields, and offset is probably not linked to a single tectonic event (Unruh and others, 1993b). Rather, movement on the faults is believed to be associated with collapse of overburden in response to the on-going process of salt flowage and dissolution (Kirkham and Rogers, 1981; Unruh and others, 1993b).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Unruh and others (1993b) indicated 20 m of relief across the largest graben on Red Hill, but did not indicate what portion of that offset is Quaternary in age. A slip rate of <0.2 mm/yr is estimated for these faults based on slip rates calculated for other similarly formed faults in this area.

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Streufert, R.K., Kirkham, R.M., Schroeder, T.J., II, and Widmann, B.L., 1997a, Geologic map of the Dotsero quadrangle, Eagle and Garfield Counties, Colorado: Colorado Geological Survey Open-file Report 97-2.

Streufert, R.K., Kirkham, R.M., Widmann, B.L., and Schroeder, T.J., II, 1997b, Geologic map of the Cottonwood Pass quadrangle, Eagle and Garfield Counties, Colorado: Colorado Geological Survey Open-file Report 97-4.

Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 154 p.

Structure type: Simple fault

Structure number: Q48

Comments:

Structure name: Basalt Mountain Fault

Comments: The Basalt Mountain Fault is a curvilinear fault that extends from Cottonwood Creek southward along the west flank of Basalt Mountain to near Sopris Creek. Welder (1954) referred to this fault as the West Basalt Mountain Fault. Unruh and others (1993b), Streufert and others (1997b; 1998) and Kirkham and others (1998) simply called the entire structure the Basalt Mountain Fault, which is the terminology adopted herein. Possible Quaternary movement has only been recognized on the southern end of the fault, which extends from the town of Basalt to near Sopris Creek.

Synopsis:

The Basalt Mountain Fault is a major down-to-the-east Laramide reverse fault that was reactivated during the late Cenozoic in a normal sense probably as a result of salt tectonism (Unruh and others, 1993b; Kirkham and others, 1998; Streufert and others, 1998). The Basalt Mountain Fault defines the eastern margin of the Carbondale collapse center, a large Neogene structural depression due to flowage and dissolution of underlying Pennsylvanian evaporites (Kirkham and Widmann, 1997; Kirkham and others, 1998). Movement on the fault is related to the regional collapse associated with evaporite tectonism. Evidence of Quaternary movement was reported only for the south end of the Basalt Mountain Fault (Unruh and others, 1993b), which extends from near the town of Basalt to Sopris Creek parallel to the Roaring Fork River Valley. Only the southern end of the fault is included in this database. Unruh and others (1993b) reported that Pleistocene terraces are faulted and tilted along the south end of the fault. Streufert and others (1998) interpreted these deformed deposits as Tertiary sediments with cut terraces of Quaternary age developed on them. The fault is herein assigned to the Quaternary because Streufert and others (1998) did not specifically discount Quaternary movement on the fault.

Date of compilation: 1/12/98

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

State: Colorado

County: Eagle, Pitkin, Grand

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T8S,R86W

Strike: N56W

Number of traces: 1

End to end length: 6.97 km

Cumulative length: 7.05 km

Q48 - Basalt Mountain Fault

Reliability of location: Good

Comments: The south end of the Basalt Mountain Fault was mapped at a scale of 1:24,000 by Streufert and others (1998), 1:31,680 by Welder (1954), and at 1:250,000 by Tweto and others (1978) and Unruh and others (1993b). The trace used herein is from Streufert and others (1998) and Unruh and others (1993b).

Geologic setting:

During the Laramide the Basalt Mountain Fault behaved as a down-to-the-east reverse or thrust fault (Unruh and others, 1993b; Kirkham and Widmann, 1997). During the Neogene the Basalt Mountain Fault has acted as the eastern margin of the Carbondale collapse center, a large Neogene structural depression due to flowage and dissolution of underlying Pennsylvanian evaporitic rocks. Movement during the Neogene has been down to the west. Unruh and others (1993b) reported folded and faulted Pleistocene terraces along the southern end of the fault, but Streufert and others (1998) interpeted these deformed deposits as Tertiary sediments with cut terraces developed on them.

Sense of movement: N

Comments: Although Laramide movement on the fault has been interpreted as reverse by Streufert and others (1997b; 1998) and as thrust or tear by Unruh and others (1993b), late Cenozoic tilting along the fault is normal (Kirkham and others, 1998; Streufert and others, 1998).

Dip:

Comments: The dip and dip direction on the fault plane have not been definitively determined. The large amount of stratigraphic throw (about 1300 m in pre-Miocene bedrock) favors a low-angle fault model. However, the straight map trace of the fault suggests a high-angle fault (Unruh and others, 1993b).

Dip direction:

Geomorphic expression:

Scarps in Pleistocene terraces and tilted Pleistocene terraces were reported on the southern end of the Basalt Mountain Fault by Unruh and others (1993b). Streufert and others (1998) interpreted these surfaces as terraces cut into Tertiary gravel deposits during the Quaternary.

Age of faulted deposits:

Unruh and others (1993b) reported that Pleistocene terraces on the southern section of the fault are tilted and faulted, and they documented late Tertiary to early Quaternary offset of about 70 m. Streufert and others (1998) interpreted these deformed surfaces as Pleistocene cut terraces developed on Tertiary gravels.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Unruh and others (1993b) indicated Pleistocene terraces are offset and tilted along the southern end of the fault. Streufert and others (1998) interpreted these deformed surfaces as cut terraces developed during the Pleistocene on Tertiary sediments.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Unruh and others (1993b) calculated a dip-slip rate of 0.02 to 0.04 mm/yr for the south end of the Basalt Mountain Fault

Earthquake notes:

A moment magnitude (Mw) 6 1/4 maximum credible earthquake was assigned to the southern end of the Basalt Mountain Fault by Unruh and others (1993b).

References Cited:

Kirkham, R.M., and Widmann, B.L., and Streufert, R.K., 1998, Geologic map of the Leon quadrangle, Eagle and Garfield County, Colorado: Colorado Geological Survey Open-file Report 98-3.

Streufert, R.K., Kirkham, R.M., Widmann, B.L., and Schroeder, T.J., II, 1997b, Geologic map of the Cottonwood Pass quadrangle, Eagle and Garfield Counties, Colorado: Colorado Geological Survey Open-file Report 97-4.

Streufert, R.K., Widmann, B.L., and Kirkham, R.M., 1998, Geologic map of the Basalt quadrangle, Eagle, Garfield, and Pitkin Counties, Colorado: Colorado Geological Survey Open-file Report 98-1.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 154 p.

Welder, G.E., 1954, Geology of the Basalt area, Eagle and Pitkin Counties: Boulder, Colorado, University of Colorado, M.S. thesis, 72 p.

Q49 - Unnamed Faults in Williams Fork Valley

Structure type: Simple fault

Structure number: Q49

Comments: Fault 55 in Kirkham and Rogers (1981); fault 2300 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults in Williams Fork Valley

Comments: This is a series of about 10 faults that lie in the Neogene Williams Fork Valley Graben. The graben lies southeast of Kremmling between the Williams Fork Range on the west and the Vasquez Mountains on the east. Six faults trend northeast, two trend east-west, and two trend northwest. The graben was formed in the hanging wall of the Laramide Williams Fork thrust sheet (Unruh and others, 1993b).

Synopsis:

These faults occur on the floor of a Neogene graben which sits in the hanging wall of the Laramide Williams Fork thrust sheet. The Miocene Troublesome Formation is offset by the graben-bounding faults and Quaternary deposits are offset by this fault series on the floor of the graben. Topographic breaks up to 75 m high offset the Troublesome Formation and possibly pre-Bull Lake gravels (Kirkham and Rogers, 1981).

Date of compilation: 6/12/97

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

State: Colorado

County: Grand

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T2S,R78W-T1S,R79W

Strike: N19E

Number of traces: 10

End to end length: 18.42 km

Cumulative length: 37.20 km

Reliability of location: Good

Comments: These faults were mapped at 1:62,500 by Tweto and Reed (1973a) and 1:250,000 by Tweto and others (1978). The trace used herein is from Tweto and others (1978).

Geologic setting:

These faults are predominately high-angle normal faults that are down to the northwest, south, and northeast. The faults lie on the floor of a Neogene graben formed in the hanging wall of the Laramide Williams Fork Thrust. Orientation of the faults is roughly perpendicular to the northwest-trending graben.

Sense of movement: N

Comments: Kirkham and Rogers (1981) suggested these faults are probably normal.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Several of the faults are marked by prominent topographic breaks, some up to 75 m high. Elevation changes in gravels of corresponding ages, and lineaments are also noticeable (Kirkham and Rogers, 1981).

Age of faulted deposits:

Tweto and Reed (1973a) and Tweto and others (1978) showed offset of pre-Bull Lake deposits. Kirkham and Rogers (1981) also recognized offset in pre-Bull Lake deposits and further state that there is no offset of Bull Lake deposits. The faults bring pre-Bull Lake deposits into contact with the Miocene Troublesome Formation along all of the fault traces.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (3) Quaternary-middle and late (<750ka)

Comments: Pre-Bull Lake (older than 130 ka) deposits are offset by these faults. Bull Lake deposits however are not offset by the fault thus constraining the last movement of the fault to the middle and late Quaternary, prior to 130 ka (Kirkham and Rogers, 1981). Colman (1985) also indicated the most recent paleoevent on these faults occurred during the middle to late Pleistocene.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on a 75-m-high scarp that offsets the Miocene Troublesome Formation and pre-Bull Lake gravels (Kirkham and Rogers, 1981), as slip rate of <0.2 mm/yr is estimated for these faults.

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, and Reed, J.C., Jr., 1973a, Reconnaissance geologic map of the Ute Peak 15-minute quadrangle, Grand and Summit Counties, Colorado: U.S. Geological Survey Open-file Report, 73-288.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 154 p.

Q50 - Williams Fork Mountains Fault

Structure type: Simple fault

Structure number: Q50

Comments: Fault 53 in Kirkham and Rogers (1981); fault 186 in Witkind (1976); fault 2301 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Williams Fork Mountains Fault

Comments: Unruh and others (1993b) referred to this fault as the Williams Fork Mountains Fault. It includes a series of three northwest-trending faults on the east flank of the Williams Fork Mountains and the west margin of the Neogene Williams Fork Valley Graben southeast of Kremmling. The faults are parallel to and northeast of the Laramide Williams Range Thrust and occur in the hanging wall of the thrust.

Synopsis:

This fault series forms the western margin of the Neogene Williams Fork Valley Graben. It is marked by an east-facing topographic break and other lineations. Tweto (1973b) and Tweto and Reed (1973) showed the Miocene Troublesome Formation as being offset by the faults, but more detailed studies revealed offset in Quaternary deposits (e.g. Witkind, 1976; Unruh, 1993b). Unruh and others (1993b) reported evidence for two episodes of faulting during Pinedale to post-Pinedale time and a deformation rate of 0.3 to 1.3 mm/yr.

Date of compilation: 6/12/97

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

State: Colorado

County: Grand

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T1S,R80W-T3S,R77W

Strike: N40W

Number of traces: 4

End to end length: 37.68 km

Cumulative length: 49.74 km

Reliability of location: Good

Comments: These faults were mapped at a scale of 1:62,500 by Tweto (1973b) and Tweto and Reed (1973a) and 1:250,000 by Tweto and others (1978) and Unruh and others (1993b). The trace used herein is from Tweto and others (1978).

Geologic setting:

This fault series forms the western margin of the Neogene Williams Fork Valley Graben (Kirkham and Rogers, 1981). The faults are high-angle normal and down to the northeast. The faults are parallel to the southwest-verging Laramide Williams Range Thrust to the west and developed during Neogene extension in the hanging wall of the thrust (Unruh and others, 1993b).

Sense of movement: N

Comments: Normal movement on these faults was reported by Witkind (1976), Kirkham and Rogers (1981) and Unruh and others (1993b).

Dip:

Comments:

Dip direction:

Geomorphic expression:

The Williams Fork Mountains Fault forms the western margin of the Williams Fork Valley Graben. It is marked by an east-facing topographic break and by vegetation and topographic linears. A slight bevel in fan deposits across the scarp suggests at least two eposides of recent movement (Unruh and others, 1993b).

Age of faulted deposits:

Tweto (1973b), Tweto and Reed (1973a), and Tweto and others (1978) showed the Miocene Troublesome Formation as faulted against Precambrian bedrock. However, Pinedale fan deposits (10-40 ka) are offset about 13 m across the fault according to Unruh and others (1993b). The fault trace lies almost entirely within late Tertiary and Precambrian rocks with only about 3% of the fault extending into Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

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

Comments: Howard and others (1978) indicated the most recent paleoevent on this fault occurred during the Quaternary. Unruh and others (1993b) studied a northeast-facing scarp in Pinedale age alluvial fan deposits with down-to-the-east discplacement of about 13 m. A bevel on the scarp in the fan deposits was interpreted as indicating two episodes of movement since deposition of the fan deposits, or since the last 10-40 ka.

Recurrence interval: ND

Comments:

Slip rate: (C) 0.2-1 mm/yr

Comments: A deformation rate of 0.3 to 1.3 mm/yr was reported by Unruh and others (1993b) based on two episodes of faulting which produced a total of about 13 m of vertical offset in Pinedale age (10-40 ka) fan deposits.

Earthquake notes:

A moment magnitude (Mw) 6 3/4 maximum credible earthquake was assigned to this fault by Unruh and others (1993b).

References Cited:

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, 1973b, Reconnaissance geologic map of the Mount Powell 15-minute quadrangle, Grand, Summit, and Eagle Counties, Colorado: U.S. Geological Survey Open-file Report 73-286.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

Tweto, Ogden, and Reed, J.C., Jr., 1973a, Reconnaissance geologic map of the Ute Peak 15-minute quadrangle, Grand and Summit Counties, Colorado: U.S. Geological Survey Open-file Report, 73-288.

Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 154 p.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q51 - Frontal Fault

Structure type: Simple fault

Structure number: Q51

Comments: Fault 50 in Kirkham and Rogers (1981); fault 181 in Witkind (1976); fault 2302 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Frontal Fault

Comments: The Frontal Fault is a northwest-trending fault on the east flank of the Gore and Tenmile Ranges. On its northern end the fault branches from the Gore Fault southwest of Sheephorn Mountain and extends south to Hoosier pass. The fault was originally referred to as the Blue River Fault, but is now generally called the Frontal Fault after Tweto and others (1970).

Synopsis:

The Frontal Fault is a range-front fault that forms the east margin of the Gore and Tenmile Ranges. The fault was originally called the Blue River Fault but more recently is known as the Frontal Fault. Tweto and others (1970) reported geomorphic features along the fault trace that they interpreted as evidence for Quaternary movement, but West (1977; 1978) argued that the features could be attributed to normal alpine mass movement and other erosional processes. Unruh and others (1993b) studied two sites along the fault and concluded the fault has probably experienced multiple episodes of late Quaternary movement. The most recent paleoevent on the Frontal Fault is herein considered to have occurred during the late Quaternary.

Date of compilation: 6/5/97

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

State: Colorado

County: Summit, Eagle, Park

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T2S,R81W-T6S,R78W

Strike: N24W

Number of traces: 8

End to end length: 74.99 km

Cumulative length: 105.70 km

Reliability of location: Good

Comments: The Frontal Fault was mapped at a scale of 1:12,000 by West (1977), 1:48,000 by Tweto and others (1970), 1:62,000 by Tweto (1973a; 1973b), and 1:250,000 by Tweto and others (1978). The trace used herein is from Tweto and others (1978).

Geologic setting:

The Frontal Fault is a high-angle fault delineated by left-stepping, en echelon, down-to-the-northeast faults. Movement on the fault is predominately normal but in some locations may be reverse. It is a range-front fault that forms the east margin of the Gore and Tenmile Ranges. The Frontal Fault is also part of the Precambrian Ilse-Gore Fault system (Kirkham and Rogers, 1981).

Sense of movement: NR

Comments: Movement on the fault is predominately normal, but in some locations reverse (Behre, 1953).

Dip: 78°W, 83°E

Comments: Behre (1953) records two measurements for the Frontal Fault although the exact location of the field measurements is unknown. He measured a normal section of the fault as dipping 78°W, and a reverse section of the fault as dipping 83°E.

Dip direction: W,E

Geomorphic expression:

The Frontal Fault is marked by a major bedrock scarp up to 610 m high near Boulder Creek. Several geomorphic features suggest Quaternary movement on the fault. These features include scarps up to 18 m high in glacial moraine deposits, ridge-top springs, gouge boils up to 12 m high, landslides, aligned drainages, and other topographic and vegetation lineaments (Tweto and others, 1970; West, 1977). Unruh and others (1993b) described nickpoints in drainages and a 5- to 7-m-high, northeast-facing scarp along the fault trace.

Age of faulted deposits:

Tweto and others (1970) reported glacial moraine deposits as being offset by the fault and suggested historic movement on the fault based on a 1920 earthslump. West (1977) argued that Miocene-Pliocene deposits are offset by the fault but that offset in Quaternary deposits is a result of normal alpine fluvial and colluvial processes rather than tectonic processes. Unruh and others (1993b) conducted studies at two sites on the fault. They described as much as 7 m of offset in late Pleistocene fluvial deposits of Pinedale age. They concluded that Holocene sediments are in depositional contact with the fault and are therefore not faulted.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Tweto and others (1970) indicated faulting in middle to early glacial deposits but also suggested historic movement on the fault based on a 1920 earth slump that created scarps and a ridge top stream north of Boulder Creek. West (1977; 1978) argued that all of the geomorphic features that Tweto and others (1970) attributed to young faulting are the result of normal alpine fluvial and colluvial processes and are not tectonic in origin. He suggested the latest movement on the fault occurred during the Miocene or Pliocene. Tweto (1979a) indicated movement on the fault as recently as the Quaternary. Kirkham and Rogers (1981) suggested that the latest movement on the fault occurred prior to the Bull Lake glaciation, possibly during the early Quaternary. Howard and others (1978) and Colman (1985) indicated the most recent paleoevent on this fault occurred during the Quaternary. An investigation at two sites along the fault by Unruh and others (1993b) revealed that Pinedale glacial deposits are offset by the fault indicating the fault has moved during the Quaternary. The most recent paleoevent of this fault is interpreted to have occurred during the late Quaternary based on Unruh and others (1993b).

Recurrence interval: ND

Comments:

Slip rate: unknown; (C) 0.2-1 mm/yr

Comments: Tweto and others (1970) reported an 18-m-high scarp in young glacial deposits and recent landslide deposits, but did not indicate how much of the scarp is in glacial deposits versus bedrock. Unruh and others (1993b) reported 5 to 7 m of offset in Pinedale deposits (13 to 35 ka), which indicates a slip rate of 0.14 to 0.54 mm/yr.

Earthquake notes:

A moment magnitude (Mw) 7 maximum credible earthquake was assigned to this fault by Unruh and others (1993b).

References Cited:

Behre, C.H., 1953, Geology and ore deposits of the west slope of the Mosquito Range, Colorado: U.S. Geological Survey Professional Paper 235, 176 p.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, 1973a, Reconnaissance geologic map of the Dillon 15-minute quadrangle, Summit, Eagle, and Grand Counties, Colorado: U.S. Geological Survey Open-file Report.

Tweto, Ogden, 1973b, Reconnaissance geologic map of the Mount Powell 15-minute quadrangle, Grand, Summit, and Eagle Counties, Colorado: U.S. Geological Survey Open-file Report 73-286.

Tweto, Ogden, 1979a, The Rio Grande Rift system in Colorado, 'in' Riecker, R.E., ed., Rio Grande Rift: Tectonics and magmatism: American Geophysical Union, Washington, D.C., p. 33-56.

Tweto, Ogden, Bryant, Bruce, Williams, F.E., 1970, Mineral resources of the Gore Range-Eagles Nest primitive area and vicinity, Summit and Eagle Counties, Colorado: U.S. Geological Survey Bulletin 1319-C, 127 p.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 154 p.

West, M.W., 1977, A preliminary evaluation of the Quaternary geology, reported surface faulting, and seismicity along the east flank of the Gore Range, Summit County, Colorado: Golden, Colorado, Colorado School of Mines, M.S. Thesis T-1828, 195 p.

West, M.W., 1978, Quaternary geology and reported surface faulting along east flank of the Gore Range, Summit County, Colorado: Colorado School of Mines Quarterly, v. 73, no. 2, 66 p.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q52 - Mosquito Fault

Structure type: Simple fault

Structure number: Q52

Comments: Fault 56 in Kirkham and Rogers (1981); fault 182 in Witkind (1976); fault 2303 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Mosquito Fault

Comments: The north-trending Mosquito Fault forms the west flank of the Tenmile and Mosquito Ranges and represents the southern extension of the Gore Fault. The northern end of the fault is near Silverthorne. It extends south between Climax and Leadville, and then bends to the southwest where it truncates against faults which form the northeast margin of the upper Arakansas Valley. Unruh and others (1993b) included the Mosquito Fault in what they referred to as the Northeastern Boundary Fault systm which forms the northeastern margin of the upper Arkansas Valley basin.

Synopsis:

The Mosquito Fault is a range-front fault on the west flank of the Tenmile and Mosquito Ranges. Tweto and Sims (1963) suggested a possible Precambrian origin for the fault with major movement occuring during the Laramide orogeny. Neogene activity is evident by the offset of the Miocene-Pliocene Dry Union Formation (Tweto and Case, 1972; Tweto and Reed, 1973b; Tweto, 1974a). Fault activity may have continued into the Quaternary with offset of possible late Pleistocene or glacial deposits (Kirkham and Rogers, 1981).

Date of compilation: 6/12/97

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

State: Colorado

County: Summit, Chaffee, Lake

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T11S,R80W-T5S,R78W

Strike: N9E

Number of traces: 8

End to end length: 51.54 km

Cumulative length: 72.65 km

Reliability of location: Good

Comments: The Mosquito Fault was mapped at a scale of 1:62,500 by Tweto (1973a; 1974a; 1974b) and Tweto and Reed (1973b) and 1:250,000 by Tweto and others (1978). The trace used herein is from Tweto and others (1978).

Geologic setting:

The Mosquito Fault is a high-angle normal fault that is down to the west and northwest. It is a range-front fault that forms the west margin of the Tenmile and Mosquito Ranges. The fault extends north from the upper Arkansas Valley and is linked to the Rio Grande Rift (Tweto, 1979a).

Sense of movement: NS

Comments: Wallace and others (1968) indicated 458 m of left-lateral slip and 2,745 m of normal displacement.

Dip: 70°W

Comments: According to Wallace and others (1968) the fault dips 70°W near the town of Climax. The exact location of the measurment was not reported.

Dip direction: W

Geomorphic expression:

The Mosquito Fault is a range-front fault with several distinctive scarps up to 12 m high in morainal and landslide deposits (Kirkham and Rogers, 1981).

Age of faulted deposits:

Tweto and Case (1972), Tweto and Reed (1973b) and Tweto (1974a) showed the Miocene-Pliocene Dry Union Formation as being offset by the fault. Kirkham and Rogers (1981) indicated offset of morainal and landslide deposits of Wisconsinan age, but state that Holocene deposits are not offset by the fault. The fault primarily displaces Precambrian bedrock against Tertiary intrusive and sedimentary deposits and Pennsylvanian-Permian bedrock. Only about 10% of the fault lies in or beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Tweto (1973a; 1974a; 1974b) and Tweto and Reed (1973b) did not show offset of Quaternary deposits. Witkind (1976) designated the fault as late Quaternary based on oral communication with Ogden Tweto. Kirkham and Rogers (1981) indicated offset of Wisconsinan age (10-130 ka) deposits and stated that Holocene deposits are not offset by the fault. Colman (1985) assigned the fault to the late Pleistocene. Latest movement on the fault is herein considered to have occurred during the late Pleistocene.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: This slip rate is estimated from evidence cited in Kirkham and Rogers (1981) of fault scarps up to 12 m high in morainal and landslide deposits of Wisconsinan age (10-130 ka).

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, 1973a, Reconnaissance geologic map of the Dillon 15-minute quadrangle, Summit, Eagle, and Grand Counties, Colorado: U.S. Geological Survey Open-file Report.

Tweto, Ogden, 1974a, Geologic map of the Mount Lincoln 15-minute quadrangle, Eagle, Lake, Park, and Summit Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-556.

Tweto, Ogden, 1974b, Reconnaissance geologic map of the Fairplay West, Mount Sherman, South Peak, and Jones Hill 7 1/2 minute quadrangles, Park, Lake, and Chaffee Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-555.

Tweto, Ogden, 1979a, The Rio Grande Rift system in Colorado, 'in' Riecker, R.E., ed., Rio Grande Rift: Tectonics and magmatism: American Geophysical Union, Washington, D.C., p. 33-56.

Tweto, Ogden, and Case, J.E., 1972, Gravity and magnetic features as related to geology in the Leadville 30-minute quadrangle, Colorado: U.S. Geological Survey Professional Paper 726-C, 31 p.

Tweto, Ogden, and Reed, J.C., Jr., 1973b, Reconnaissance geologic map of the Mount Elbert 15-minute quadrangle, Lake, Chaffee, and Pitkin Counties, Colorado: U.S. Geological Survey Open-file Report, 73-5279.

Tweto, Ogden, and Sims, P.K., 1963, Precambrian ancestry of the Colorado mineral belt: Geological Society of America Bulletin, v. 74, p. 991-1014.

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Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by Wm. Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, 154 p.

Wallace, S.R., Muncaster, N.K., Johnson, D.C., Mackenzie, W.B., Bookstrom, A.A., and Surface, V.E., 1968, Multiple intrusion and mineralization at Climax, Colorado, 'in' Ridge, J.D., ed., Ore deposits of the United Sates, 1933-1967, (Graton-Sales volume): American Institute of Mining, Metallurgical and Petroleum Engineers, v. 1, p. 605-640.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q53 - Unnamed Fault South of Leadville

Structure type: Simple fault

Structure number: Q53

Comments: Fault 163 in Kirkham and Rogers (1981); fault 183 in Witkind (1976); fault 2305 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault South of Leadville

Comments: This unnamed fault is part of the upper Arkansas Valley Graben system near Leadville between the Sawatch Fault and the Mosquito Fault.

Synopsis:

This unnamed fault lies in the northern end of the upper Arkansas Valley Graben which is a major Neogene structure that is the northernmost topographically prominent feature of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. Tweto and Reed (1973b) mapped this fault as an inferred fault that offsets the Miocene Dry Union Formation and younger unconsolidated Quaternary deposits. Late Quaternary movement was reported by Witkind (1976) based on personal communication with Ogden Tweto. However, no detailed studies have been conducted on faults in this area. Thus, Quaternary movement on this fault is not definitive. The most recent paleoevent on this fault is herein considered to have occurred during the Quaternary (<1.6 Ma).

Date of compilation: 6/19/97

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

State: Colorado

County: Lake

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T10S,R81W-T9S,R80W

Strike: N49E

Number of traces: 1

End to end length: 12.84 km

Cumulative length: 13.28 km

Reliability of location: Poor

Comments: This fault was mapped at at a scale of 1:24,000 by Tweto and Reed (1973b) and Tweto (1974c) and 1:250,000 by Tweto and others (1978). The trace used herein is from Tweto and Reed (1973b).

Geologic setting:

This fault lies in the northern end of the upper Arkansas Valley Graben which is a major Neogene structure that is the northernmost topographically prominent feature of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. The fault is high-angle and downthrown to the west and northwest.

Sense of movement: N

Comments: Witkind (1976) indicated normal movement on this fault.

Dip:

Comments:

Dip direction: NW

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Tweto and Reed (1973b) mapped this fault as an inferred fault that offsets the Miocene Dry Union Formation and younger unconsolidated Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Tweto and Reed (1973b) suggested Quaternary deposits are offset by this fault. Witkind (1976) reported probable late Quaternary movement on this fault based on oral communication with Ogden Tweto. However, no detailed studies have been conducted on faults in this area and Quaternary movement on this fault is not definitive. The most recent movement on the fault is herien tentatively considered to have occurred during the Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, 1974c, Geologic map and section of the Holy Cross [15-minute] quadrangle, Eagle, Lake, Pitkin and Summit Counties, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-830.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

Tweto, Ogden, and Reed, J.C., Jr., 1973b, Reconnaissance geologic map of the Mount Elbert 15-minute quadrangle, Lake, Chaffee, and Pitkin Counties, Colorado: U.S. Geological Survey Open-file Report, 73-5279.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Simple fault

Structure number: Q54

Comments: Fault 2306 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults Northwest of Leadville

Comments: This structure includes several generally northeast- to northwest-trending faults west and north of Leadville. The faults are part of the Arkansas Valley Graben system.

Synopsis:

These faults lie between the Mosquito Fault and the northern section of the Sawatch Fault west and north of Leadville. Tweto (1974c) described the faults as inferred concealed faults of the upper Arkansas Valley Graben system. The upper Arkansas Valley Graben is a major Neogene structure that is the northernmost topographically prominent feature of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. Tweto (1974c) stated "from subsurface data and from a few exposures south of [the] quadrangle faults are known to displace [the] bedrock surface, strata of the concealed upper Tertiary Dry Union Formation, and some of the older Pleistocene units such as pre-Bull Lake glacial drift (Qdpb) and Malta Gravel (Qm)". However, Quaternary movement on each of these faults has not been definitively demonstrated. Although lacking conclusive evidence, the most recent movement on these faults is herein considered to have occurred during the Quaternary (<1.6 Ma).

Date of compilation: 6/26/97

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

State: Colorado

County: Lake

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T9S,R80W

Strike: N31E

Number of traces: 13

End to end length: 5.24 km

Cumulative length: 9.13 km

Reliability of location: Poor

Comments: The faults were mapped at a scale of 1:24,000 by Tweto (1974c), 1:125,000 by Tweto and Case (1972), and 1:250,000 by Tweto and others (1978). Fault traces were interpreted by Tweto (1974c) from subsurface data and nearby surface exposures and were considered approximate or conjectural. Tweto and Case (1972) mapped these faults as inferred faults in Cenozoic deposits. The traces used herein is from Tweto (1974c).

Geologic setting:

These faults were described as inferred concealed faults of the Arkansas Valley Graben system (Tweto, 1974c). The faults lie in an area of complex faulting between the Mosquito

Fault and the northern section of the Sawatch Fault and are part of the upper Arkansas Valley Graben, a Neogene west-tilted structure that forms the northernmost topographically prominent expression of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline.

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Tweto (1974c) described the faults as inferred concealed faults of the Arkansas Valley Graben system. Tweto (1974c) stated "from subsurface data and from a few exposures south of [the] quadrangle faults are known to displace [the] bedrock surface, strata of the concealed upper Tertiary Dry Union Formation, and some of the older Pleistocene units such as pre-Bull Lake glacial drift (Qdpb) and Malta Gravel (Qm)". However, Quaternary movement on each of these faults has not been definitively demonstrated.

Detailed studies:

No detailed studies have been conducted on these faults.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Tweto (1974c) suggested the Miocene Dry Union Formation and perhaps pre-Bull Lake Quaternary deposits were offset by these faults, based on subsurface data and a few exposures south of the quadrangle. Without more definitive evidence for Quaternary movement, the last paleoevent on these faults is herein considered to have occurred during the Quaternary, but may actually have occurred prior to the Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Tweto, Ogden, 1974c, Geologic map and section of the Holy Cross [15-minute] quadrangle, Eagle, Lake, Pitkin and Summit Counties, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-830.

Tweto, Ogden, and Case, J.E., 1972, Gravity and magnetic features as related to geology in the Leadville 30-minute quadrangle, Colorado: U.S. Geological Survey Professional Paper 726-C, 31 p.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

Structure type: Simple fault

Structure number: Q55

Comments: A few of these faults were previously mapped as fault 160 by Kirkham and Rogers (1981); fault 2307 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Faults near Twin Lakes Reservoir

Comments: This series of unnamed faults lies in the upper Arkansas Valley south of Leadville. The faults are perpendicular to the south end of the northern section of the Sawatch Fault and the southern end of the Mosquito Fault.

Synopsis:

These faults lie in the northern end of the upper Arkansas Valley Graben which is a major Neogene structure that is the northernmost topographically prominent feature of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. Two of the faults bound Twin Lakes Reservoir on the north and south sides, four faults bound the Clear Creek Reservoir, and several of the other faults form closed depressions. Tweto and Case (1972) suggested faulting in late Cenozoic deposits based on geologic mapping, drill hole data, and gravity and magnetic data which revealed a northeast-trending magnetic low in the vicinity of Twin Lakes Reservoir. Tweto and Reed (1973b) mapped these faults as inferred faults in Miocene Dry Union Formation and younger unconsolidated Quaternary deposits. No detailed studies have been conducted in this area and Quaternary movement on these faults is not definitive. The most recent paleoevent on these faults is herein tentatively considered to have occurred during the Quaternary (<1.6 Ma).

Date of compilation: 6/19/97

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

State: Colorado

County: Lake

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T11S,R80W

Strike: N9E

Number of traces: 13

End to end length: 13.95 km

Cumulative length: 55.46 km

Reliability of location: Good

Comments: The faults were mapped at 1:62,000 by Tweto and Reed (1973b), at 1:125,000 by Tweto and Case (1972), and at 1:250,000 by Tweto and others (1978). The trace used herein is from Tweto and Reed (1973b).

Geologic setting:

The faults lie on the north margin of the Precambrian high that separates the northern and southern sections of the Sawatch Fault. Twin Lakes and Clear Creek Reservoirs lie in basins bound by several of these faults. The faults are part of the upper Arkansas Valley Graben, a

Neogene west-tilted structure that forms the northernmost topographically prominent expression of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. Gravity and magnetic data revealed a northeast-trending magnetic low in the vicinity of Twin Lakes Reservoir (Tweto and Case, 1972).

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Test holes drilled in the area by the U.S. Bureau of Reclamation indicated late Cenozoic deposits (including the Miocene Dry Union Formation) are deeply faulted against Precambrian rocks on the south side of Twin Lakes Reservoir (Tweto and Case, 1972). Tweto and Reed (1973b) inferred offset of the Miocene Dry Union Formation and younger unconsolidated Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on these faults.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Based on geologic mapping, drill hole data, and magnetic features, Tweto and Case (1972) indicated probable faulting in late Cenozoic deposits. Tweto and Reed (1973b) mapped these faults as inferred faults in Miocene Dry Union Formation and younger unconsolidated Quaternary deposits. Without more definitive evidence for Quaternary movement, the last paleoevent on these faults is herein considered to have occurred during the Quaternary, but may actually have occurred prior to the Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Tweto, Ogden, and Case, J.E., 1972, Gravity and magnetic features as related to geology in the Leadville 30-minute quadrangle, Colorado: U.S. Geological Survey Professional Paper 726-C, 31 p.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

Tweto, Ogden, and Reed, J.C., Jr., 1973b, Reconnaissance geologic map of the Mount Elbert 15-minute quadrangle, Lake, Chaffee, and Pitkin Counties, Colorado: U.S. Geological Survey Open-file Report 73-5279.

Q57 - Northeastern Boundary Fault System

Structure type: Simple fault

Structure number: Q57

Comments: Fault 161 in Kirkham and Rogers (1981); fault 2309 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Northeastern Boundary Fault System

Comments: This series of eight northwest-trending faults forms the northeast margin of the upper Arkansas Valley Graben and is the southern extension of the Mosquito Fault (Unruh and others, 1993b) between Leadville and Buena Vista. The northernmost fault is called the Iron Fault and the fault exending from the south end of the Iron Fault is the Dome Fault (Behre, 1953). The Iron and Dome Faults were collectively known as the Union Fault by Tweto and Case (1972). The fault that splays to the southeast from the Iron Fault was referred to as the Mike Fault by Behre (1953) and Tweto (1974b) but was called the Weston Fault by Tweto and Case (1972), Chronic (1974), and Tweto (1974b). These faults, as well as the Mosquito Fault, are collectively referred to as the Northeastern Boundary Fault systm by Unruh and others (1993b) because the faults form the northeastern margin of the upper Arkansas Valley.

Synopsis:

The Northeastern Boundary Fault systm forms the northeastern margin of the upper Arkansas Valley Graben between Leadville and Buena Vista. The graben is a major Neogene structure that is the northernmost topographically prominent feature of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. Several fault traces are marked by west-facing scarps in Quaternary landslide deposits. Pre-Bull Lake glacial drift and Kansan (?) alluvium is mapped as offset by the fault. The fault system was previously considered to be a late Cenozoic feature (e.g., Tweto, 1978; Kirkham and Rogers, 1981; Colman, 1985) despite Quaternary offset shown on maps by Scott (1975b) and Tweto and others (1978). Subsequent reports by Unruh and others (1992), Unruh and others (1993b) and Lettis and others (1996) indicated late Pleistocene fault activity within this system. The most recent paleoevent on the Northeastern Boundary Fault systm is herein considered to have occurred during the middle and late Quaternary.

Date of compilation: 6/17/98

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

State: Colorado

County: Lake, Park, Chaffee

1° x 2° Sheet: Montrose, Leadville

Province: Southern Rocky Mountains

Township and Range: T9S,R80W-T14S,R78W

Strike: N18W

Number of traces: 6

End to end length: 47.50 km

Cumulative length: 145.91 km

Reliability of location: Good

Comments: The fault system was mapped at a scale of 1:62,500 by Tweto and Reed (1973b), Tweto (1974b), and Scott (1975b), at 1:125,000 by Tweto and Case (1972), and at 1:250,000 by Tweto and others (1976; 1978) Unruh and others (1992), Unruh and others (1993b), and Lettis and others (1996). The trace used herein is from Tweto and others (1976; 1978) and Lettis and others (1996).

Geologic setting:

The Northeastern Boundary Fault systm forms the northeastern margin of the upper Arkansas Valley Graben, a west-tilted Neogene structure that is the northernmost topographically prominent feature of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. Faults in this system are typically high-angle normal and down to the west, with step-down displacement toward the upper Arkansas Valley.

Sense of movement: N,R

Comments: Most of the faults are normal faults (e.g., Behre, 1953; Tweto and Case, 1972, Kirkham and Rogers, 1981; Unruh and others, 1992). The Mike Fault (the northernmost fault) has reverse movement (Behre, 1953; Tweto and Case, 1972).

Dip: 65°-80°W

Comments: Most of the fault planes dip to the west. The Dome and Iron Faults dip 67°W and 68°W according to Behre (1953). The Mike Fault is the only fault of this system to dip to the east at 80° (Behre, 1953).

Dip direction: W,E

Geomorphic expression:

This fault system is marked by west-facing scarps and lineaments in Quaternary landslide deposits. The scarps occur at the base of a west-facing escarpment in the Miocene-Pliocene Dry Union Formation (Unruh and others, 1993b).

Age of faulted deposits:

The Miocene-Pliocene Dry Union Formation is offset by this fault system. Tweto and others (1978) mapped offset of pre-Bull Lake glacial drift along the westernmost faults, and Scott (1975) mapped offset of Kansan (?) alluvium. Scarps are developed in late Pleistocene landslide deposits but Bull Lake and Holocene deposits are not deformed across the fault (Unruh and others, 1992; Unruh and others, 1993b; Lettis and others, 1996). The western faults lie primarily in Precambrian to Pennsylvanian bedrock with Quaternary deposits mapped along less than 5% of the fault trace. The eastern faults drop Precambrian and Tertiary deposits down into the upper Arkansas Valley Graben.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (3) Quaternary-middle and late (<750ka)

Comments: Tweto (1978) mapped this system of faults as Neogene in age. Kirkham and Rogers (1981) indicated late Cenozoic movement on this fault system based on recognized offset of the Miocene-Pliocene Dry Union Formation. Likewise, Colman (1985) did not report Quaternary movement on this system. However, Scott (1975) and Tweto and others (1978) both mapped offset of Quaternary deposits on the westernmost faults. Based on the presence of linear scarps in late Pleistocene deposits, Unruh and others (1992), Unruh and others (1993b), and Lettis and others (1996) suggested late Quaternary movement within the fault system. Unruh and others (1992), Unruh and others (1993b), and Lettis and others (1996) were careful to add that the scarps could be related to landsliding, although they favored a tectonic origin for the scarps. The most recent movement on this fault system is herein classified as occurring during the middle and late Quaternary based on offset of Kansan and pre-Bull Lake deposits.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

A moment magnitude (Mw) 7 maximum credible earthquake was assigned to the Northeastern Boundary Fault systm by Unruh and others (1993b) and Lettis and others (1996).

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Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Scott, G.R., 1975b, Reconnaissance geologic map of the Buena Vista quadrangle, Chaffee and Park Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-657.

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Tweto, Ogden, and Reed, J.C., Jr., 1973b, Reconnaissance geologic map of the Mount Elbert 15-minute quadrangle, Lake, Chaffee, and Pitkin Counties, Colorado: U.S. Geological Survey Open-file Report, 73-5279

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Unruh, J.R., Sawyer, T.L, and Lettis, W.R., 1992, Seismotectonic evaluation of Green Mountain Dam, Shadow Mountain Dam, Grandby Dam, and Willow Creek Dam, Colorado-Big Thompson Project: unpublished preliminary report prepared by William Lettis & Associates for U.S. Bureau of Reclamation, Denver, Colorado, 78 p.

Unruh, J.R., Wong, I.G., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1993b, Seismotectonic evaluation, Rifle Gap Dam, Silt Project, Ruedi Dam, Fryingpan-Arkansas Project, northwestern Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 154 p.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q58 - Unnamed Fault West of Buena Vista

Structure type: Simple fault

Structure number: Q58

Comments: Fault 2310 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault West of Buena Vista

Comments: This unnamed fault is perpendicular to the north end of southern section of the Sawatch Fault. The fault is north of and parallel to Cottonwood Creek and is west of Buena Vista.

Synopsis:

This fault is perpendicular to the southern section of the Sawatch Fault which forms the western margin of the upper Arkansas Valley Graben, a Neogene west-tilted structure that forms the northernmost topographically prominent expression of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. Tweto and others (1976) mapped pre-Bull Lake gravel deposits as abutting against the fault.

Date of compilation: 6/10/98

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

State: Colorado

County: Chaffee

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range:

Strike: N85E

Number of traces: 1

End to end length: 2.73 km

Cumulative length: 2.74 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Tweto and others (1976).

Geologic setting:

The Sawatch Fault is a high-angle, down-to-the-east normal fault. It forms the eastern margin of the Collegiate Peaks and lies on the west margin of the upper Arkansas River Valley Graben, a Neogene west-tilted structure that forms the northernmost topographically prominent expression of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. This unnamed fault is perpendicular to the Sawatch Fault and is down to the south.

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Tweto and others (1976) mapped pre-Bull Lake gravel deposits as offset by the fault. The western two-thirds of the fault lies in Precambrian bedrock and the eastern one-third is in pre-Bull Lake gravel deposits.

Detailed studies:

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Tweto and others (1976) mapped Quaternary pre-Bull Lake deposits as offset by the fault. Without better age constraints the most recent movement on the fault is herein considered to have occurred during the Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Q59 - Unnamed Fault South of Shavano Peak

Structure type: Simple fault

Structure number: Q59

Comments: Fault 2311 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault South of Shavano Peak

Comments: This unnamed fault extends from the south end of southern section of Sawatch Fault. It is nearly perpendicular to the Sawatch Fault at this location just north of the Arkansas River on the flank of Taylor Mountain.

Synopsis:

The fault lies at the south end of the wouthern section of the Sawatch Fault on the flank of Taylor Mountain. The Sawatch Fault forms the western margin of the upper Arkansas Valley Graben, a Neogene west-tilted structure that forms the northernmost topographically prominent expression of the Rio Grande Rift. Tweto and others (1976) mapped pre-Bull Lake glacial drift as abutting against the fault, and mapped Bull Lake and younger glacial deposits as concealing the fault. Without better age constraints, and stronger evidence for actual Quaternary offset, the fault is herein only tentatively considered to have moved during the Quaternary.

Date of compilation: 6/10/98

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

State: Colorado

County: Chaffee

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range:

Strike: N15W

Number of traces: 1

End to end length: 5.83 km

Cumulative length: 6.39 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:250,000 by Tweto and others (1976).

Geologic setting:

The Sawatch Fault is a high-angle, down-to-the-east normal fault. It forms the eastern margin of the Collegiate Peaks and lies on the west margin of the upper Arkansas Valley Graben, a Neogene west-tilted structure that forms the northernmost topographically prominent expression of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. This unnamed fault is generally perpendicular to the south end of the Sawatch Fault and is down to the east.

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Tweto and others (1976) mapped pre-Bull Lake glacial drift as abutting against the fault. Bull Lake and younger deposits conceal the fault. The fault lies primarily in Precambrian bedrock with about 30% of the fault extending into Quaterary deposits.

Detailed studies:

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Tweto and others (1976) mapped Quaternary pre-Bull Lake deposits as abutting the fault. Without better age constraints, and stronger evidence for actual Quaternary offset, the fault is tentatively herein considered to have moved during the Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Q60 - Unnamed Fault of Missouri Park

Structure type: Simple fault

Structure number: Q60

Comments: Fault 158 in Kirkham and Rogers (1981); fault 146 in Witkind (1976); fault 2312 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Unnamed Fault of Missouri Park

Comments: This unnamed northwest-trending fault extends through Missouri Park to Poncha Springs in the south end of the upper Arkansas Valley.

Synopsis:

This unnamed, northwest-trending fault lies in the southern end of the upper Arkansas Valley near Poncha Springs. Pinedale outwash deposits are offset by the fault, but Holocene deposits cover the fault.

Date of compilation: 9/30/97

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

State: Colorado

County: Chaffee

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T50N,R8E-T49N,R8E

Strike: N49W

Number of traces: 1

End to end length: 5.85 km

Cumulative length: 5.92 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:62,500 by Scott and others (1975) and 1:125,000 by Colman and others (1985). The trace used herein is from Colman and others (1985).

Geologic setting:

This fault lies in an area of complex faulting in the southern end of the upper Arkansas Valley. It is a normal fault that is down to the southwest.

Sense of movement: N

Comments: Witkind (1976) and Kirkham and Rogers (1981) reported normal movement on this fault.

Dip:

Comments:

Dip direction:

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Pinedale outwash deposits (11-40 ka) are the youngest deposits offset by this fault according to Colman and others (1985). Bull Lake deposits are also offset by the fault but Upper Holocene alluvium is not offset by the fault (Scott and others, 1975).

Detailed studies:

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Scott and others (1975) and Colman and others (1985) indicated offset of Pinedale outwash deposits. Colman and others (1985) reported these faulted deposits as being 11 to 40 ka. More recent Holocene deposits are not offset, suggesting that the fault has not been active since the late Pleistocene. Kirkham and Rogers (1981), Colman (1985) and Lettis and others (1996) also reported Quaternary activity movement for this fault.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Colman, S.M., McCalpin, James, Ostenaa, D.A., and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande Rift, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1594.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Scott, G.R., Van Alstine, R.E., and Sharp, W.N., 1975, Geologic map of the Poncha Springs quadrangle, Chaffee County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-658.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q61 - Western Boundary Fault

Structure type: Simple fault

Structure number: Q61

Comments: Fault 119 in Kirkham and Rogers (1981); fault 2313 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Western Boundary Fault

Comments: The Western Boundary Fault is a curvilinear north-south oriented fault that begins north of Starvation Creek and ends near Kerber Creek midway between Brewer Creek and Little Kerber Creek. The fault lies on the east flank of Sheep and Flagstaff Mountains in the southern Sawatch Range and on the west side of the San Luis Valley near the Bonanza Caldera.

Synopsis:

The Western Boundary Fault forms the western rim of the Bonanza Caldera. The fault originated as a reverse fault in the early to middle Oligocene with the collapse of the Bonanza Caldera, but has also experienced post-Oligocene movement associated with continued collapse and perhaps activity associated with the Rio Grande Rift. The fault is marked by a prominent fault scarp, cold springs, fault gouge, and anomalous drainages and topography. Oligocene to Miocene volcanics are clearly offset by the fault, while offset of Pleistocene alluvium is less definitive. The most recent movement on this fault is herein considered to have occurred during the late Quaternary.

Date of compilation: 9/29/97

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

State: Colorado

County: Saguache, Chaffee

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T48N,R7E-T46N.R,8E

Strike: N16W

Number of traces: 1

End to end length: 20.08 km

Cumulative length: 23.10 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:20,000 by Marrs (1973), 1:62,500 by Knepper (1974b), and 1:250,000 by Tweto and others (1976). The trace used herein is from Tweto and others (1976).

Geologic setting:

The Bonanza Caldera is located along the western margin of the north end of San Luis Valley. The Western Boundary Fault is a high-angle normal, listric fault that is down to the northeast and east. The fault lies within a pattern of concentric faults and defines the western rim of the Bonanza Caldera. The fault probably originated during the early to middle

Oligocene as a reverse fault in response to doming of the Bonanza Caldera due to a pressure increase in the magma chamber below. Normal movement on the fault is related to collapse of the magma chamber and subsequent local readjustment (Marrs, 1973).

Sense of movement: N

Comments: The fault originated as a reverse fault in the early to middle Oligocene but has experienced subsequent normal reactivation associated with the collapse of the Bonanza Caldera (Marrs, 1973).

Dip:

Comments: Marrs (1973) descibed the Western Boundary Fault as a high-angle, concentric fault that dips northeast and east towards the Bonanza Caldera.

Dip direction: NE

Geomorphic expression:

The Western Boundary Fault is defined by a prominent cliff that appears to be a fault-line scarp that is marked by bouldery fault gouge. Cold water springs are present along the fault trace. Stream beds that cross the fault trace have an anomalous character, topography on the downthrown side of the fault is hummocky, and drainage patterns are not well developed (Marrs, 1973).

Age of faulted deposits:

Oligocene volcanic flows associated with the Bonanza Caldera are offset by the fault (Marrs, 1973; Knepper, 1974b). Knepper (1974b) mapped Quaternary deposits as concealing the fault. Tweto and others (1976) mapped offset of mid-Tertiary intrusives of Oligocene to Miocene age. Lettis and others (1996) indicated that the fault offsets early to middle Pleistocene and possibly late Pleistocene alluvium. The fault lies almost entirely in Tertiary volcanics with Precambrian bedrock exposed only at the north end of the fault on the upthrown side.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Movement on the fault is clearly documented by offset of Oligocene to Miocene volcanics. More recent movement on the fault is less definitive. Marrs (1973) suggested youthful fault movement based on stream beds, topography and drainage patterns. He observed evidence for increased stream energy and steepened profiles in stream beds that cross the fault trace, which seemed to indicate recent flooding. However, he found no evidence for flooding in other drainages and no historical documentation of flooding in the area. He concluded that the apparent flood indicaters could be related instead to youthful faulting. Further, topography on the downthrown side of the fault is hummocky with poorly defined drainage patterns. Marrs (1973) ackowledged that there is no definitive evidence for youthful faulting but suggested that these anomalies may in fact be indicators for Quaternary fault activity. Kirkham and Rogers (1981) classified this fault as a possible Quaternary fault. Colman (1985) indicated that this fault offsets early to middle Pleistocene alluvium. Lettis and others (1996) concluded the fault is potentially active based on offset of Quaternary alluvial fans and geomorphic evidence indicative of late Pleistocene faulting. The fault is herein considered to have last moved during the late Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

A moment magnitude (Mw) 6 3/4 maximum credible earthquake was assigned to this fault by Lettis and others (1996).

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Knepper, D.H., Jr., 1974b, Tectonic analysis of the Rio Grande Rift zone, central Colorado: Golden, Colorado, Colorado School of Mines, Ph.D. Thesis T-1593, 237 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Marrs, R.W., 1973, Application of remote-sensing techniques to the geology of the Bonanza volcanic center: Golden, Colorado, Colorado School of Mines, Ph.D. Thesis T-1531, 281 p.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Q62 - Lucky Boy Fault

Structure type: Simple fault

Structure number: Q62

Comments: Fault 120 in Kirkham and Rogers (1981); fault 2314 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Lucky Boy Fault

Comments: The Lucky Boy Fault is a northwest-trending fault that splays from the Western Boundary Fault near Flagstaff Mountain and continues southeast into Little Kerber Creek on the west side of San Luis Valley.

Synopsis:

The Lucky Boy Fault is a branch fault of the Western Boundary Fault which forms the western rim of the Bonanza Caldera. The Lucky Boy Fault originated as a reverse fault in the early to middle Oligocene with the collapse of the Bonanza Caldera, but has experienced post-Oligocene movement associated with continued collapse and perhaps activity associated with the Rio Grande Rift. Quaternary terrace gravels are reportedly slightly offset across the fault (Marrs, 1973). The most recent movement on this fault is herein considered to have occurred during the late Quaternary.

Date of compilation: 9/29/97

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

State: Colorado

County: Saguache

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T47N,R7R-T46N.R8E

Strike: N29W

Number of traces: 1

End to end length: 11.06 km

Cumulative length: 11.66 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:20,000 by Marrs (1973), 1:62,500 by Knepper (1974b), and 1:250,000 by Tweto and others (1976). The trace used herein is from Tweto and others (1976).

Geologic setting:

The Bonanza Caldera is located along the western margin of the northern end of San Luis Valley. The Lucky Boy Fault is a high-angle normal, listric fault that is down to the northeast. The fault is a branch fault of the Western Boundary Fault which defines the western rim of the Bonanza Caldera. The Lucky Boy Fault probably originated during the early to middle Oligocene as a reverse fault in response to doming of the Bonanza Caldera due to a pressure increase in the magma chamber below. Normal movement on the fault is related to collapse of the magma chamber and subsequent local readjustment (Marrs, 1973).

Q62 - Lucky Boy Fault

Sense of movement: N

Comments: The fault originated as a reverse fault in the early to middle Oligocene but has experienced subsequent normal reactivation associated with the collapse of the Bonanza Caldera (Marrs, 1973).

Dip:

Comments: Marrs (1973) descibed the Lucky Boy Fault as a high-angle, concentric fault that dips northeast towards the Bonanza Caldera.

Dip direction: NE

Geomorphic expression:

A subtle, fault-controlled topographic change across the drainage was recognized on color aerial photographs by Marrs (1973). Lettis and others (1996) recognized subdued geomorphic indicators of late Pleistocene faulting in this area but did not describe these indicators.

Age of faulted deposits:

Oligocene volcanic flows associated with the Bonanza Caldera and Quaternary terrace gravels are offset by the fault according to Marrs (1973). Knepper (1974b), however, did not show Quaternary offset along the fault trace. Tweto and others (1976) mapped Oligocene to Miocene intrusives as being offset by the fault. Lettis and others (1996) indicated offset of early to middle Pleistocene alluvium. The fault lies almost entirely in Tertiary volcanics.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Marrs (1973) reported Quaternary movement on the fault based on offset of Quaternary terrace gravels. Tweto (1978) mapped the Lucky Boy Fault as a pre-Neogene fault. Kirkham and Rogers (1981) classified this fault as a possible Quaternary fault. Colman (1985) and Lettis and others (1996) indicated the fault was active during the late Pleistocene. Latest movement on the fault is herein considered to have occurred during the late Quaternary (<130 ka).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on the subdued nature of geomorphic features indicative of possible youthful faulting in this area, a slip rate of <0.2 mm/yr is estimated for this system.

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Knepper, D.H., Jr., 1974b, Tectonic analysis of the Rio Grande Rift zone, central Colorado: Golden, Colorado, Colorado School of Mines, Ph.D. Thesis T-1593, 237 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Marrs, R.W., 1973, Application of remote-sensing techniques to the geology of the Bonanza volcanic center: Golden, Colorado, Colorado School of Mines, Ph.D. Thesis T-1531, 281 p.

Tweto, Ogden, 1978, Northern rift guide 1, Denver-Alamosa, Colorado, 'in' Hawley, J.W., ed., Guidebook to the Rio Grande Rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 13-27.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Structure type: Simple fault

Structure number: Q63

Comments: Fault 100 in Kirkham and Rogers (1981); fault 2315 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Faults near Monte Vista

Comments: This is a series of about 10 generally northwest-trending faults south of Highway 160 between Del Norte and Monte Vista. The fault name was assigned during this compilation.

Synopsis:

The faults near Monte Vista include a number of northwest- or north-trending faults in the foothills west of Monte Vista on the west side of San Luis Valley. The faults are downthrown both to the southwest and southeast (Steven and others, 1974; Lipman, 1976) and appear to be minor faults developed along the hinge zone along the western margin of the Rio Grande Rift. The faults offset Pleistocene and Pliocene fan deposits (Lipman, 1976). Two of the faults were investigated by Kirkham (1992) and McCalpin (1992), who concluded the latest movement was during the Quaternary but was pre-Holocene.

Date of compilation: 7/10/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Rio Grande

1° x 2° Sheet: Durango

Province: Southern Rocky Mountains

Township and Range: T38N,R7E-T39N,R6E

Strike: N34W

Number of traces: 11

End to end length: 16.24 km

Cumulative length: 46.19 km

Reliability of location: Good

Comments: The trace of these faults is mainly from Lipman (1976; scale 1:48,000), and modified locally based on Kirkham (1992) and McCalpin (1992).

Geologic setting:

The faults near Monte Vista include several northwest- and north-trending, minor normal faults in the foothills west of Monte Vista (Lipman, 1976). The faults lie along the east-tilted hinge zone on the west side of the Rio Grande Rift. The faults offset undifferentiated Pleistocene and Pliocene fan deposits (Lipman, 1976) but apparently have not moved during the Holocene (Kirkham, 1992; McCalpin, 1992).

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

Discontinuous, somewhat subtle scarps occur in surficial deposits along some of the faults (Kirkham, 1992; McCalpin, 1992).

Age of faulted deposits:

Pleistocene and Pliocene fan deposits are cut by these faults (Lipman, 1976; Kirkham, 1992; McCalpin, 1992).

Detailed studies:

McCalpin (1992) measured profiles on two of the faults near Monte Vista. Scarp profiles suggested the last rupture was during the Quaternary but was pre-Holocene.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: All of the faults included in this group displace Pleistocene and Pliocene fan deposits (Lipman, 1976). Two of the faults were studied by Kirkham (1992) and McCalpin (1992), who concluded they were Quaternary faults,but had not moved during the Holocene.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Kirkham, R.M., 1992, Preliminary geologic assessment of a tract of land in sections 19 and 30, T39N, R7E for use as the new landfill site for Rio Grande County: unpublished report prepared by Colorado Geological Survey for Rio Grande County Commissioners, 18 p.

Lipman, P.W., 1976, Geologic map of the Del Norte area, eastern San Juan Mountains, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-952.

McCalpin, J.P., 1992, Assessment of faulting at the proposed new landfill site for Rio Grande County, Colorado: unpublished report by GEO-HAZ Consultants for the Rio Grande County Commissioners, 13 p.

Steven, T.A., Lipman, P.W., Hail, W.J., Jr., Barker, Fred, and Luedke, R.G., 1974, Geologic map of the Durango quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-764.

Q64 - West-Side Chase Gulch Fault

Structure type: Simple fault

Structure number: Q64

Comments: Fault 178 in Kirkham and Rogers (1981); fault 2316 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: West-Side Chase Gulch Fault

Comments: The West-Side Fault is a northwest-trending fault on the west side of Spinney Mountain, which along with the East-Side Fault, is associated with the Laramide Chase Gulch Fault system. The fault extends north from the S. Platte River, northwest of Eleven Mile Canyon Reservoir to the southwest flank of Spinney Mountain. The term Chase Gulch--West-Side Fault was used by Shaffer (1980). In the following descriptions the fault is referred to simply as the West-Side Fault.

Synopsis:

The West-Side Fault lies on the west side of Spinney Mountain in the Laramide South Park basin. Due to its close proximity to Spinney Mountain dam, the fault was studied in detail by Shaffer (1980) who excavated eleven trenches. The fault trace is marked by a low scarp visible in low sun-angle photography. Trenching investigations revealed Pinedale pediment gravels offset by about 2.4 m. Latest movement on the fault is believed to have occurred between 13 to 30 ka. Shaffer (1980) theorized that fault movement occurred sympathetic to movement on the East-Side Fault and was related to the Laramide Elkhorn thrust fault at depth.

Date of compilation: 11/25/97

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

State: Colorado

County: Park

1° x 2° Sheet: Pueblo

Province: Southern Rocky Mountains

Township and Range: T12S,R74W

Strike: N26W

Number of traces: 1

End to end length: 2.65 km

Cumulative length: 2.65 km

Reliability of location: Good

Comments: The fault was mapped in detail by Shaffer (1980) at scale of 1:12,000. It was also mapped at a scale of 1:250,000 by Scott and others (1978). The trace used herein is from Shaffer (1980).

Geologic setting:

The West-Side Fault lies on the west flank of Spinney Mountain, which is an erosional remnant of the hanging wall of the Elkhorn thrust fault, and may merge with it at depth (Shaffer, 1980). The West-Side Fault is referred to as a reverse fault by Shaffer (1980) but measured dip angles of less than 45° (Shaffer, 1980) suggest it is a thrust fault. Movement is down to southwest. The fault lies within the Laramide South Park basin which is bounded by the Mosquito Range on the west, the Front Range on the north and east, and the Thirtynine Mile volcanic field on the south.

Sense of movement: T

Comments: Shaffer (1980) reported reverse movement on the West-Side Fault. However, they measured dip angles of 6° to 43° which indicates the fault is probably better described as a thrust fault.

Dip: 6°-43°NE

Comments: Shaffer (1980) reported average dips of 6° and 21° for the north and south sections of the West-Side Fault. The middle section of the fault is steeper with an average dip of 32° to 43°

Dip direction: E

Geomorphic expression:

The West-Side Fault is marked by a west-facing scarp on the west side of Spinney Mountain. Scarp heights in Bull Lake and early Pinedale deposits typically range from 1.2 to 1.8 m (Shaffer, 1980).

Age of faulted deposits:

Pinedale pediment gravels are offset by about 2.4 m across the West-Side Fault (Shaffer, 1980). The fault lies almost entirely in Pinedale deposits.

Detailed studies:

Shaffer (1980) conducted a detailed site investigation of the fault due to its proximity to the Spinney Mountain dam. Eleven trenches were excavated but the trenches which he labeled T-402, T-403, T-404 and T-405 were the only ones that were described indivudually in his report. These faults are herein labeled Q64-1 through Q64-4, respectively. Other methods of investigation included low sun-angle photo analysis, geologic mapping, radiocarbon age dating drilling, electrical resistivity surveys, and siesmic refraction surveys.

Q64-1: The average dip of the fault in this trench was 21°E and the average vertical offset was 7 m. One alluvial sand deposit observed in this trench was offset by about 1.2 m.

Q64-2: The average dip of the fault in this trench was 32°E and the average vertical offset was 10.7 m. Drag folding and rotation of cobbles was observed in alluvial gravels within the fault zone.

Q64-3: The average dip of the fault in this trench was 43°E and the average vertical offset was 15.2 m. Two slip planes were observed in this trench. About 6.1 m of offset was recognized across the upper slip plane.

Q64-4: The average dip of the fault in this trench was 6°E and the average vertical offset was 4.3 m.

Data from these trenches as well as other trenches not specifically described by Shaffer (1980) revealed fault offset within the past 35,000 years on the order of about 2.5 m. It was concluded that the fault was originally a secondary plane of the Elkhorn Thrust and now branches at depth from the East-Side Fault plane. Movement on the fault is believed to have been sympathetic to movement on the East-Side Fault Shaffer (1980).

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Shaffer (1980; 1981) and Shaffer and Williamson (1986) concluded that the fault has not been active since the end of the Pinedale glaciation about 13,000 years ago, with latest movement on the fault occurring between 13 to 30 ka (Shaffer, 1980).

Recurrence interval: ND

Comments:

Slip rate: (D) <0.2 mm/yr

Comments: Shaffer (1980) calculated a slip rate of <0.14mm/yr.

Earthquake notes:

Four earthquakes, the largest of which was about an M 3.2, have been felt within 50 km of Spinney Mountain since 1960 (Shaffer, 1980).

References Cited:

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Scott, G.R., Taylor, R.B., Epis, R.C., and Wobus, R.A., 1978, Geologic map of the Pueblo 1° x 2° quadrangle, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1022.

Shaffer, M.E., 1980, Seismic hazard evaluation, Spinney Mountain project, Park County, Colorado: unpublished report prepared by Converse Ward Davis Dixon, Inc., Report 78-5129, for R.W. Beck and Associates, 77 p.

Shaffer, M.E., 1981, Earthquake Hazard studies for Spinney Mountain dam, Park County, Colorado, 'in' Junge, W.R., ed., Colorado tectonics, seismicity and earthquake hazards: Proceedings and field trip guide: Colorado Geological Survey Special Publication 19, p. 26.

Shaffer, M.E., and Williamson, J.V., 1986, Seismic evaluation of Spinney Mountain Dam, 'in' Rogers, W.P., and Kirkham, R.M., eds., Contributions to Colorado tectonics and seismicity - A 1986 update: Colorado Geological Survey Special Publication 28, p. 104-121.

Structure type: Simple fault

Structure number: Q65

Comments: Fault 177 in Kirkham and Rogers (1981); fault 2317 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: East-Side Chase Gulch Fault

Comments: This is a northwest-trending fault in South Park that is parallel to, but west of Chase Gulch. The fault begins west of Schoolmarm Mountain, continues south past Spinney Mountain and onto the southwest side of Eleven Mile Canyon Reservoir. It ends at the southeast end of the Puma Hills in the Front Range. The East-Side Fault and associated West-Side Fault are closely linked to the Laramide Chase Gulch Fault system. The term Chase Gulch--East-Side Fault was used by Shaffer (1980). Unruh and others (1994) refered to this fault as the Chase Gulch Fault. In the following descriptions the fault is referred to simply as the East-Side Fault.

Synopsis:

The East-Side fault lies between Schoolmarm Mountain and the Puma Hills on the west side of Eleven Mile Canyon Reservoir. Due to its close proximity to Spinney Mountain dam, the fault was studied in detail by Shaffer (1980), who excavated eleven trenches. The fault trace is marked by a low scarp visible in low sun-angle photography. Trenching investigations revealed Pinedale pediment gravels offset by the fault. Latest movement on the fault is believed to have occurred between 13 to 30 ka, as early Pinedale deposits are offset by about 2.4 m. The East-Side Fault is a segment of an older fault system called the Chase Gulch Fault, which most likely connects with the Laramide Elkhorn Thrust at depth (Shaffer, 1980).

Date of compilation: 11/17/97

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

State: Colorado

County: Park

1° x 2° Sheet: Denver, Pueblo

Province: Southern Rocky Mountains

Township and Range: T11S,R74W-T13S,R73W

Strike: N23W

Number of traces: 1

End to end length: 30.68 km

Cumulative length: 31.98 km

Reliability of location: Good

Comments: The fault was mapped in detail by Shaffer (1980) at scale of 1:12,000. It was also mapped at a scale of 1:250,000 by Scott and others (1978) and Bryant and others (1981). The trace used herein is from Scott and others (1978) and Bryant and others (1981).

Q65 - East-Side Chase Gulch Fault

Geologic setting:

The fault is high-angle normal, down to the northeast. The fault is linked to the Laramide Chase Gulch Fault system and steepens at depth before merging with the Laramide Elkhorn Thrust (Shaffer, 1980; Shaffer and Williamson, 1986). The fault lies within the Laramide South Park basin which is bounded by the Mosquito Range on the west, the Front Range on the north and east, and the Thirtynine Mile volcanic field on the south.

Sense of movement: N

Comments: Shaffer (1980) reported normal movement on this fault.

Dip: 50°-90°NE

Comments: The minimum dip near the surface is 50°, the fault steepens to nearly vertical at depth (Shaffer, 1980).

Dip direction: NE

Geomorphic expression:

The fault trace is marked by lineaments and scarps (Unruh and others, 1994). Scarp heights in Bull Lake and early Pinedale deposits typically range from 1.2 to 1.8 m, but one scarp 1 1/2 miles east of the Spinney Mountain dam has about 9.1 m of vertical releif.

Age of faulted deposits:

Pinedale pediment gravels are offset by as much as 2.4 m, and Bull Lake terrace gravels are offset by about 9.1 m (Shaffer, 1980; Shaffer and Williamson, 1986). Less detailed maps by Scott and others (1978) and Bryant and others (1981) did not show offset of Quaternary deposits.

Detailed studies:

Shaffer (1980) conducted a detailed site investigation of the East-Side Fault due to its proximity to the Spinney Mountain dam. Eleven trenches were excavated in this area, but the trenches which he labeled T-407, T-408 and T-409 were the only ones that were described indivuduually in his report. These faults are herein labeled Q65-1 through Q65-3, respectively. Other methods of investigation included low sun-angle photo analysis, geologic mapping, radiocarbon dating, drilling, electrical resistivity surveys, and seismic refraction surveys.

Q65-1 (T-407): In this trench the fault contact between Precambrian bedrock and alluvium dips 48°E. The upper segments of slip planes are rolled over to 25° to 30°W.

Q65-2 (T-408): The upper segments of slip planes in this trench are rolled over to 25° to 30°W. Bull Lake terrace gravels are offset by 9.1 m. A faulted carbonate-cemented zone in the Bull Lake deposits was estimated to be 28 ka ± 1.5 ka.

Q65-3 (T-408A): Bull Lake terrace gravels are offset by 9.1 m in this trench.

Data from these trenches as well as other trenches not specifically described by Shaffer (1980) revealed fault offset within the past 35,000 years on the order of about 2.5 m. Shaffer (1980) concluded that "the controlling tectonic structure was the East-Side Fault, whose surface rupture was...estimated to occur along a 16-km trace roughly coincident with a segment of the old Chase Gulch Fault."

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Shaffer (1980; 1981) and Shaffer and Williamson (1986) concluded that the fault has not been active since the end of the Pinedale glaciation about 13,000 years ago, with latest movement on the fault occurring between 13 to 30 ka. Kirkham and Rogers (1981) and Colman (1985) also reported late Quaternary movement on the East-Side Fault.

Recurrence interval: ND

Comments:

Slip rate: (D) <0.2 mm/yr

Comments: Shaffer (1980) calculated a slip rate of <0.14mm/yr for the East-Side Fault.

Earthquake notes:

Four earthquakes, the largest of which was about an M 3.2, have been felt within 50 km of Spinney Mountain since 1960 (Shaffer, 1980). Assuming a 16-km surface rupture length a Richter Magnitude of 6.2 was correlated to the fault (Shaffer, 1981; Williamson and Shaffer, 1982). Unruh and others (1994) assigned a moment magnitude (Mw) 6 3/4 maximum credible earthquake to this fault.

References Cited:

Bryant, Bruce, McGrew, L.W., and Wobus, R.A., 1981, Geologic map of the Denver 1°x 2°quadrangle, north-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1163.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Scott, G.R., Taylor, R.B., Epis, R.C., and Wobus, R.A., 1978, Geologic map of the Pueblo 1° x 2° quadrangle, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1022.

Shaffer, M.E., 1980, Seismic hazard evaluation, Spinney Mountain project, Park County, Colorado: unpublished report prepared by Converse Ward Davis Dixon, Inc., Report 78-5129, for R.W. Beck and Associates, 77 p.

Shaffer, M.E., 1981, Earthquake Hazard studies for Spinney Mountain dam, Park County, Colorado, 'in' Junge, W.R., ed., Colorado tectonics, seismicity and earthquake hazards: Proceedings and field trip fuide: Colorado Geological Survey Special Publication 19, p. 26.

Shaffer, M.E., and Williamson, J.V., 1986, Seismic evaluation of Spinney Mountain Dam, 'in' Rogers, W.P., and Kirkham, R.M., eds., Contributions to Colorado tectonics and seismicity - A 1986 update: Colorado Geological Survey Special Publication 28, p. 104-121.

Unruh, J.R., Wong, I.G., Hitchcock, C.S., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1994, Seismotectonic evaluation, Pueblo Dam, Fryingpan-Arkansas Project, south-central Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Federal Services for U.S. Bureau of Reclamation, Denver, Colorado, 134 p.

Williamson, J.V., and Shaffer, M.E., 1982, Seismic analysis of Spinney Mountain Dam: Proceedings of the 14th Congress of the International Commission on large dams, Rio de Janeiro, Brazil, p. 643-660.

Q66 - Eleven Mile Fault

Structure type: Simple fault

Structure number: Q66

Comments: Fault 176 in Kirkham and Rogers (1981); fault 2318 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Eleven Mile Fault

Comments: The Eleven Mile Fault is a northwest-trending fault that is oblique to the East-Side Chase Gulch Fault south of Eleven Mile Canyon Reservoir.

Synopsis:

The Eleven Mile Fault branches from the East-Side Chase Gulch Fault near Eleven Mile Canyon Reservoir. The East-Side Chase Gulch Fault is linked to an older Laramide thrust at depth. The association with the East-Side Chase Gulch Fault suggests that the Eleven Mile Fault may also be related in some way to the Laramide thrust. The fault is marked by a low scarp and ponded groundwater. Slocum Alluvium and Bull Lake deposits are each offset by about 1.6 m across the fault. Shaffer (1980) suggested the latest movement on the fault was during the Pinedale glaciation (13 to 30 ka).

Date of compilation: 11/25/97

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

State: Colorado

County: Park

1° x 2° Sheet: Pueblo

Province: Southern Rocky Mountains

Township and Range: T13S,R73W

Strike: N10W

Number of traces: 1

End to end length: 4.65 km

Cumulative length: 4.65 km

Reliability of location: Good

Comments: The fault is mapped at a scale of 1:62,500 by Wobus and Epis (1974) and 1:250,000 by Scott and others (1978). The trace used herein is from Scott and others (1978).

Geologic setting:

The fault branches from the East-Side Chase Gulch Fault, which is believed to be linked to the Chase Gulch Fault system that merges at depth with the Laramide Elkhorn Thrust (Shaffer, 1980). The relationship between the Eleven Mile Fault, the East-Side Chase Gulch Fault and Laramide Elkhorn Thrust is not clear. The fault lies within the Laramide South Park basin which is bounded by the Mosquito Range on the west, the Front Range on the north and east, and the Thirtynine Mile volcanic field on the south. The Eleven Mile Fault is down to the east which is consistent with throw on the East-Side Chase Gulch Fault.

Q66 - Eleven Mile Fault

Sense of movement: N

Comments: Kirkham and Rogers (1981) reported normal movement for this fault.

Dip:

Comments:

Dip direction:

Geomorphic expression:

The Eleven Mile Fault is recognized by a low scarp visible in low-sun-angle photos. Groundwater is ponded behind the trace of the fault at Union Creek and Balm of Gilead Creek (Shaffer, 1980).

Age of faulted deposits:

Bull Lake alluvial deposits are offset by about 1.8 m across the fault. The older Slocum Alluvium is offset by about the same amount (Shaffer, 1980). Along most of the fault trace, Precambrian bedrock on the east is juxtaposed against the Oligocene Thirtynine Mile Andesite on the west. Quaternary deposits are offset only at the north end of the fault.

Detailed studies:

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Slocum Alluvium and Bull Lake deposits are offset across the Eleven Mile Fault according to Wobus and Epis (1974), Scott and others (1978), and Shaffer (1980). Shaffer (1980) suggested that the last significant movement on the fault occurred during the Pinedale glaciation (13 to 30 ka).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Shaffer (1980) calculated a slip rate of <0.14mm/yr for the East-Side Gulch Fault. Scarps and stratigraphic offset on the Eleven Mile Fault are less than on the East-Side Chase Gulch Fault, suggesting a lower slip rate for the Eleven Mile Fault. A slip rate of <0.2 mm/yr is therefore estimated for the Eleven Mile Fault.

Earthquake notes:

Four earthquakes, the largest of which was about an M 3.2, have been felt within 50 km of Spinney Mountain since 1960 (Shaffer, 1980). Microgeophysics (1991) located about 6 local events with magnitudes greater than 2.0 between February 1983 and December 1991.

References cited:

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Scott, G.R., Taylor, R.B., Epis, R.C., and Wobus, R.A., 1978, Geologic map of the Pueblo 1° x 2° quadrangle, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1022.

Shaffer, M.E., 1980, Seismic hazard evaluation, Spinney Mountain project, Park County, Colorado: unpublished report prepared by Converse Ward Davis Dixon, Inc., Report 78-5129, for R.W. Beck and Associates, 77 p.

Wobus, R.A., and Epis, R.C., 1974, Reconnaissance geologic map of the Florissant 15-minute quadrangle, Park and Teller Counties, Colorado: U.S. Geological Survey Open-file Report 74-95.

Q67 - Villa Grove Fault Zone

Structure type: Simple fault

Structure number: Q67

Comments: Fault 118 in Kirkham and Rogers (1981); fault 132 in Witkind (1976); fault 2319 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Villa Grove Fault Zone

Comments: The Villa Grove Fault zone is comprised of a series of northwest-trending faults and fault scarps southeast of the town of Villa Grove.

Synopsis:

The Villa Grove Fault zone is a northwest-trending series of faults that cut obliquely across the northern end of San Luis Valley from near Valley View hot springs to Villa Grove (Scott and others, 1978; McCalpin, 1981a; 1982; Kirkham and Rogers, 1981). The fault zone consists of about 40 scarps on the east side of San Luis Creek that are generally down to the southwest (McCalpin, 1981a; 1982), and six scarps west of San Luis Creek that are down to the east or northeast (Scott and others, 1978). The scarps offset pre-Bull Lake, Bull Lake, and Pinedale alluvium up to 14 m, and appear to be related to deep-seated basement structures (Stoughton, 1977; Huntley, 1976a; 1976b; McCalpin, 1981a). McCalpin (1981a; 1982) measured several profiles and excavated one trench across scarps in the Villa Grove Fault zone. Colman and others (1985) also described profiles across the fault zone.

Date of compilation: 7/10/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Saguache

1° x 2° Sheet: Pueblo

Province: Southern Rocky Mountains

Township and Range: T45N,R10E-T47N,R9E

Strike: N42W

Number of traces: 28

End to end length: 18.95 km

Cumulative length: 39.46 km

Reliability of location: Good

Comments: Fault traces east of San Luis Creek are modified from McCalpin (1982; scale 1:125,000). Fault traces west of San Luis Creek are from Scott and others (1978; scale 1:250,000). McCalpin (1981a) mapped part of the Villa Grove Fault zone at scales of 1:50,000 and 1:15,840. Colman (1985) mapped these faults at 1:1,000,000.

Geologic setting:

The Villa Grove Fault zone is a northwest-trending series of faults that cut obliquely across the Rio Grande Rift in the northern end of San Luis Valley from near Valley View hot springs to Villa Grove. Most of the fault scarps are down to the southwest on the east side of San Luis Creek (McCalpin, 1981a; 1982), and down to the east or northeast on the west side of

San Luis Creek (Scott and others, 1978). Colman and others (1985) do not show the fault scarps on the west side of the creek. The scarps displace pre-Bull Lake, Bull Lake, and Pinedale alluvium as much as 14 m, and appear to be related to basement structures (Stoughton, 1977; Huntley, 1976a; 1976b; McCalpin, 1981a).

Sense of movement: N

Comments: Witkind (1976), Kirkham and Rogers (1981), and McCalpin (1981a; 1982) indicated normal movement on these faults.

Dip:

Comments: Most faults dip southwest, but a few may dip to the northeast (McCalpin, 1981a; 1982).

Dip direction: SW, NE

Geomorphic expression:

The fault is expressed as a series of low scarps in various aged alluvial deposits (McCalpin, 1981a; 1982). Most scarps face southwest, but several small, northeast-facing antithetic scarps are present, forming small horst ang graben features (McCalpin, 1981a).

Age of faulted deposits:

Pre-Bull Lake, Bull Lake, and Pinedale alluvium are cut by the Villa Grove Fault zone, but Holocene alluvium along San Luis Creek is not offset (McCalpin, 1981a; 1982; Scott and others, 1978).

Detailed studies:

McCalpin (1981a; 1982) measured several profiles across scarps associated with the Villa Grove Fault zone and excavated a single trench across one scarp. Colman and others (1985) report on 64 profiles measured across the fault zone.

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

Comments: Timing is based upon offset of middle to late Pinedale fans (about 13 ka) and scarp morphology (McCalpin, 1981a; 1982).

Recurrence interval: 60-100 ka

Comments: McCalpin (1982) suggested the recurrence interval for ruptures on the Villa Grove Fault zone ranged from about 60 to 100 ka.

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Colman, S.M., McCalpin, James, Ostenaa, D.A., and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande Rift, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1594.

Huntley, David, 1976a, Groundwater recharge to the aquifers of the northern San Luis Valley, Colorado: Golden, Colorado, Colorado School of Mines, Ph.D. dissertation T-1864, 298 p.

Huntley, David, 1976b, Ground water recharge to aquifers of northern San Luis Valley, Colorado--a remote sensing investigation: Colorado School of Mines Remote Sensing Report, v. 76-3, 247 p.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

McCalpin, James, 1981a, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Golden, Colorado, Colorado School of Mines, Ph. D. dissertation, 287 p.

McCalpin, J.P., 1982, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Colorado School of Mines Quarterly, v. 77, no. 3, 97 p.

Scott, G.R., Taylor, R.B., Epis, R.C., and Wobus, R.A., 1978, Geologic map of the Pueblo 1° x 2° quadrangle, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1022.

Stoughton, Dean, 1977, Interpretation of seismic reflection data from the San Luis Valley, south-central Colorado: Golden, Colorado, Colorado School of Mines, M.S. thesis T-1960, 100 p.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q68 - Mineral Hot Springs Fault

Structure type: Simple fault

Structure number: Q68

Comments: This fault is the same as the northern end of fault 184 in Kirkham and Rogers (1981); fault 2 in Colman (1985); fault 2320 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Mineral Hot Springs Fault

Comments: The Mineral Hot Springs Fault is a north-northwest-trending fault in the northern end of San Luis Valley. This structure name was assigned during this compilation.

Synopsis:

The Mineral Hot Springs Fault is a north-northwest-trending, down-to-the-east fault along the western margin of the San Luis Valley at the point where the valley abruptly narrows in width. Colman and others (1985) and Kirkham and Rogers (1981) suggested the fault displaces Quaternary deposits based on the presence of a possible fault scarp along the fault trend. The Mineral Hot Springs Fault may be related to the concealed fault on the east side of the buried, mid-valley horst block beneath San Luis Valley that was described by Tweto (1978; 1979a). Burroughs (1981) and Brister and Gries (1994) interpreted the structure on the east side of the buried horst as a faulted fold.

Date of compilation: 7/10/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Saguache, Alamosa

1° x 2° Sheet: Pueblo

Province: Southern Rocky Mountains

Township and Range: T39N,R12E-T46N,R9E

Strike: N23W

Number of traces: 1

End to end length: 7.82 km

Cumulative length: 7.83 km

Reliability of location: Good

Comments: This fault trace is from Colman and others (1985; scale 1:125,000).

Geologic setting:

The Mineral Hot Springs Fault lies along the western margin of the Rio Grande Rift at the northern end of San Luis Valley where the valley narrows abruptly as it approaches Poncha Pass. This high-angle, north-trending fault is downthrown to the east.

Sense of movement: N

Comments: Kirkham and Rogers (1981) described this fault as a normal fault. Colman and others (1985) mapped the northern section as a normal fault downthrown to the east. Unruh and others (1994) indicated normal movement on this fault based on gravity data.

Dip:

Comments:

Dip direction: E

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Colman and others (1985) mapped the fault as offsetting upper to middle Pleistocene Bull Lake deposits and upper Pleistocene Pinedale deposits. Kirkham and Rogers (1981) reported this fault offsets Wisconsin age deposits. James McCalpin (1997, personal commun.) suspects the scarp mapped by Colman and others (1985) and Kirkham and Rogers (1981) is a non-tectonic erosional feature.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments:

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa Basin (northern San Luis Basin), Rio Grande Rift, south-central Colorado, 'in' Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift: Structure, stratigraphy and tectonic setting: Geological Society of America Special Publication 291, p. 39-58.

Burroughs, R.L., 1981, A summary of the geology of the San Luis Basin, Colorado-New Mexico, with emphasis on the geothermal potential for the Monte Vista Graben: Colorado Geological Survey Special Publication 17, 30 p.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Colman, S.M., McCalpin, James, Ostenaa, D.A., and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande Rift, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1594.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, 1978, Northern rift guide 1, Denver-Alamosa, Colorado, 'in' Hawley, J.W., ed., Guidebook to the Rio Grande Rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 13-27.

Tweto, Ogden, 1979a, The Rio Grande Rift system in Colorado, 'in' Riecker, R.E., ed., Rio Grande Rift: Tectonics and magmatism: American Geophysical Union, Washington, D.C., p. 33-56.

Unruh, J.R., Wong, I.G., Hitchcock, C.S., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1994, Seismotectonic evaluation, Pueblo Dam, Fryingpan-Arkansas Project, south-central Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Federal Services for U.S. Bureau of Reclamation, Denver, Colorado, 134 p.

Q70 - Faults of the Northern Basaltic Hills

Structure type: Simple fault

Structure number: Q70

Comments: Fault 112 in Kirkham and Rogers (1981); fault 2322 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Faults of the Northern Basaltic Hills

Comments: The name of this group of faults was assigned during this compilation.

Synopsis:

The faults of the northern Basaltic Hills include several generally northwest-trending faults, only nine of which are shown on the 1:250,000-scale map that accompanies this compilation due to the close spatial proximity of the faults (Colton, 1976; Kirkham, 1977b). This group of faults lies in the northern Basaltic Hills about 6 to 16 km south and southeast of the town of Blanca. The faults offset basalt flows of the Pliocene Servilleta Formation that cap the Basaltic Hills. Kirkham and Rogers (1981) indicated the faults displace deposits of Wisconsinan age, while Colman (1985) suggested the most recent movement is middle to early Pleistocene. Colman and others (1985) report a Quaternary age for these faults. The faults of the northern Basaltic Hills may also be related to non-tectonic slope failure processes along the northeast margin of the Basaltic Hills. Without further detailed study the faults of the norhtern Basaltic Hills are herein tentatively considered to have moved during the Quaternary.

Date of compilation: 5/4/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geologial Survey

State: Colorado

County: Costilla

1° x 2° Sheet: Trinidad

Province: Southern Rocky Mountains

Township and Range: Costilla County

Strike: N31W

Number of traces: 10

End to end length: 12.64 km

Cumulative length: 24.63 km

Reliability of location: Good

Comments: The faults have in part been mapped by Colton (1976; scale 1:250,000), Kirkham and Rogers (1981; scale 1:500,000), Colman (1985; scale 1:1,000,000) and Colman and others (1985; scale 1:125,000). The traces used for this compilation were simplified from unpublished mapping by Kirkham (1977b; scale 1:24,000).

Geologic setting:

The faults of the northern Basaltic Hills lie along the eastern margin of San Luis Basin between Blanca and San Luis. Most of the faults trend northwest and are downthrown to the northeast.

Sense of movement: N

Comments:

Dip:

Comments: Most of the faults in this group dip to the northeast but dip angles are not known.

Dip direction: NE

Geomorphic expression:

Several faults within this group are associated with linear or arcuate topographic escarpments up to about 35 m high.

Age of faulted deposits:

The Pliocene Servilleta Formation is displaced by these faults (Kirkham, 1977b; Colman and others, 1985). Kirkham and Rogers (1981) reported that Quaternary Wisconsin-age deposits are offset by the faults, and Colman and others (1985) indicated pre-Bull Lake deposits are cut by some of these faults.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: The timing of the most recent paleoevent is unknown. The Pliocene Servilleta Formation is offset by these faults. Kirkham and Rogers (1981) reported that Wisconsinan deposits are offset by the faults, and Colman and others (1985) suggested some of the faults cut pre-Bull Lake deposits. Colman (1985) indicated the latest documented movement was during the middle or early Pleistocene or Pleistocene undifferentiated. Because of these discrepancies, the most recent paleoevent on this fault series is herein classified as Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Colman, S.M., McCalpin, James, Ostenaa, D.A., and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande Rift, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1594.

Colton, R.B., 1976, Map showing landslide deposits and late Tertiary and Quaternary faulting in the Fort Garland-San Luis area, Colorado-New Mexico: U.S. Geological Survey Open-file Report 76-185.

Kirkham, R.M., 1977b, unpublished file information based on interpretation of aerial photography: Colorado Geological Survey file information.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Structure type: Simple fault

Structure number: Q72

Comments: Fault 108 in Kirkham and Rogers (1981); fault 189 in Witkind (1976); fault 2015 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Mesita Fault

Comments: The north-trending Mesita Fault was mapped by Colton (1976) and Thompson and Machette (1989) in southern Colorado, and by Machette and Personius (1984) in northern New Mexico. The fault name was first used by Kirkham and Rogers (1981) and is derived from Mesita Hill, a prominent Pliocene (?) cinder cone offset by the fault in southern Colorado. The fault extnds from the eastern flank of Ute Mountain in New Mexico to about 5 km north of Mesita cone in southern Colorado. The southern end of the fault is about 4 km east of Ute Mountain, and the fault crosses the New Mexico-Colorado border about 7 km north-northeast of Ute Mountain. Several small faults that lie west of the main trace of the Mesita Fault in Colorado have been mapped by Thompson and Machette (1989) and are included in this description of the Mesita Fault.

Synopsis:

The Mesita Fault is a north-striking normal fault within the southern San Luis basin; the fault lies 7 to 14 km west of the Sangre de Cristo Fault and has the same down-to-the-west sense of displacement. In southern Colorado, the fault forms prominent topographic scarps of less than 1.5 m on latest Pleistocene alluvium, 2 to 3 m on late Pleistocene alluvium, 2 to 8 m on middle Pleistocene alluvium, and 8 to10 m on Pliocene (?) basalt. In New Mexico, the fault is marked by 2- to 5-m-high scarps in middle to late (?) Pleistocene alluvium.

Date of compilation: 11/14/97

Compiler and affiliation: Keith I. Kelson, William Lettis and Associates, Inc.
Stephen F. Personius, U.S. Geological Survey
Robert M. Kirkham, Colorado Geological Survey

State: Colorado, New Mexico

County: Costilla, Taos

1° x 2° Sheet: Trinidad, Raton

Province: Southern Rocky Mountains

Township and Range: Costilla County

Strike: N5E

Number of traces: 8

End to end length: 19.44 km

Cumulative length: 25.44 km

Reliability of location: Good

Comments: The fault trace in Colorado is from the 1:50,000-scale map by Thompson and Machette (1989). In New Mexico the fault trace is from the 1:250,000-scale map by Machette and Personius (1984). The Mesita Fault has also been mapped at a scale of 1:250,000 by Colton (1976), 1:500,000 by Witkind (1976), 1:5,000,000 by Howard and others

(1978), 1:500,000 by Kirkham and Rogers (1981), 1:1,000,000 by Colman (1985), and 1:125,000 by Colman and others (1985).

Geologic setting:

The west-down Mesita Fault lies within the southern San Luis Basin and is parallel to the rift-margin Sangre de Cristo Fault to the east.

Sense of movement: N

Comments:

Dip: 60°W

Comments: No deep structural data have been published for the Mesita Fault, so down-dip fault geometry is unknown. Deep seismic reflection data and two-dimensional modeling of gravity data suggest that the most likely dip of the Sangre de Cristo Fault is 60° (Kluth and Schaftenaar, 1994). Based on the presence of similarly west-dipping faults in seismic reflection data given by Kluth and Schaftenaar (1994) and Brister and Gries (1994), a 60° dip is reasonable for the Mesita Fault.

Dip direction: W

Geomorphic expression:

The Mesita Fault has prominent geomorphic expression along most of its mapped length. The fault displaces the Pliocene (?) Mesita cone in southern Colorado, and crosses Pleistocene alluvium on the flaoor of the San Luis basin in Colorado and northern New Mexico. Thompson and Machette (1989) indicate that a dip reversal occurs across the fault in geomorphic surfaces developed on middle Pleistocene alluvium.

Age of faulted deposits:

In Colorado, total displacements across the Mesita Fault are 15 to 30 m in Pliocene Servilleta Basalt (Burroughs, 1978), 8 to 13 m in Pliocene (?) Andesite of Mesita Hill (Kirkham and Rogers, 1981; Thompson and Machette, 1989), 2 to 8 m in middle Pleistocene (200 to 600 ka) alluvium, 2 to 3 m in uppermost middle Pleistocene (125 to150 ka) alluvium, and about 1.5 m in late Pleistocene (15 to 25 ka) alluvium (Thompson and Machettte, 1989). In New Mexico, the fault is marked by 2- to 5-m-high scarps on middle to late (?) Pleistocene alluvium (Machette and Personius, 1984; Personius and Machette, 1984). Holocene-aged (<10 ka) alluvial deposits bury the fault at Costilla Creek in southern Colorado (Thompson and Machette, 1989).

Detailed studies:

There have been no detailed paleoseismic investigations along the Mesita Fault although Machette and Personius (1984), Personius and Machette (1984), and Thompson and Machette (1989) measured fault scarp profiles and estimated ages of offset deposits along the fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: The most recent event post-dates middle to late (?) Pleistocene alluvium in New Mexico (Machette and Personius, 1984; Personius and Machette, 1984), and late Pleistocene (15 to 25 ka) alluvium in southern Colorado (Thompson and Machette, 1989). The fault is buried by Holocene (<10 ka) alluvium in Colorado (Thompson and Machette, 1989).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Personius and Machette (1984) noted that the Mesita Fault displaces late Pleistocene alluvium approximately 2 to 5 m, but that the alluvium probably is older than about 25 ka. Assuming an age range of 25 to130 ka for the late Pleistocene alluvium and a displacement of 2 to 5 m, a slip rate of 0.01 to 0.20 mm/yr can be estimated for the fault in New Mexico. In southern Colorado, offsets of about 1.5 m in latest Pleistocene (15 to 25 ka) deposits and 8 m in middle Pleistocene (200 to 600 ka) deposits (Thompson and Machette, 1989) yield estimated slip rates of 0.01 to 0.10 mm/yr.

Earthquake notes:

References Cited:

Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa Basin (northern San Luis Basin), Rio Grande Rift, south-central Colorado, 'in' Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift: Structure, stratigraphy and tectonic setting: Geological Society of America Special Publication 291, p. 39-58.

Burroughs, R.L., 1978, Northern rift guide 2--Alamosa to Antonito, Colorado, 'in' Hawley, J.W., ed., Guidebook to the Rio Grande Rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 33-36.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Colman, S.M., McCalpin, James, Ostenaa, D.A., and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande Rift, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1594.

Colton, R.B., 1976, Map showing landslide deposits and late Tertiary and Quaternary faulting in the Fort Garland-San Luis area, Colorado-New Mexico: U.S. Geological Survey Open-file Report 76-185.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Kluth, C.F., and Schaftenaar, C.H., 1994, Depth and geometry of the northern Rio Grande Rift in the San Luis Basin, south-central Colorado, 'in' Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift - Structure, stratigraphy and tectonic setting: Geological Society of America Special Paper 291, p. 27-37.

Machette, M.N., and Personius, S.F., 1984, Quaternary and Pliocene faults in the eastern part of the Aztec quadrangle and the western part of the Raton quadrangle, northern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-B.

Personius, S.F., and Machette, M.N., 1984, Quaternary and Pliocene faulting in the Taos Plateau region, northern New Mexico, 'in' Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande Rift Northern New Mexico: New Mexico Geological Society, Guidebook, 35th Field Conference, October 11-13, 1984, p. 83-90.

Thompson, R.A., and Machette, M.N., 1989, Geologic map of the San Luis Hills area, Conejos and Costilla Counties, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1906.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q73 - Faults near Garcia

Structure type: Simple fault

Structure number: Q73

Comments: Fault 2323 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Faults near Garcia

Comments: This name was assigned during the compilation of this database.

Synopsis:

The faults near Garcia include three short, north-south-trending faults mapped by Thompson and Machette (1989) that offset late and middle Pleistocene alluvium near Costilla Creek. These faults lie between the Mesita Fault and the San Pedro Mesa section of the Southern Sangre de Cristo Fault.

Date of compilation: 4/30/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Costilla

1° x 2° Sheet: Trinidad

Province: Southern Rocky Mountains

Township and Range:

Strike: N5W

Number of traces: 2

End to end length: 3.43 km

Cumulative length: 5.89 km

Reliability of location: Good

Comments: The faults near Garcia were mapped by Thompson and Machette (1989) at a scale of 1:50,000.

Geologic setting:

The faults near Garcia lie within the San Luis basin part of the Rio Grande Rift. They include three small displacement, short length faults that lie between the Mesita Fault and the San Pedro Mesa section of the Southern Sangre de Cristo Fault. The two north- and northwest-trending faults south of Costilla Creek are downthrown to the west and merge about 2.8 km south of the Costilla Creek. A single, down-to-the-east, north-northeast-trending fault extends northward from near Costilla Creek.

Sense of movement: N

Comments: Sense of movement is inferred from Thompson and Machette (1989).

Dip:

Comments: The two faults south of Costilla Creek probably dip west and the one north of the creek probably dips east, based on mapping by Thompson and Machette (1989).

Dip direction: W,E

Geomorphic expression:

Although geomorphic indicators of youthful faulting have not been reported in the literature, subtle scarps and topographic linears can be seen fairly clearly on aerial photographs (B.Widmann).

Age of faulted deposits:

Thompson and Machette (1989) indicated the two faults south of Costilla Creek displace late middle Pleistocene alluvium (125 to 150 ka) and late Pleistocene alluvium (15 to 25 ka), and they end the faults at the contact with early (?) Holocene floodplain alluvium. The fault north of Costilla Creek offsets late middle Pleistocene alluvium and is terminated where it encounters the contact with late Pleistocene alluvium (15 to 25 ka) and early (?) Holocene flood-plain alluvium.

Detailed studies:

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Thompson and Machette (1989) mapped the faults as offsetting late middle and late Pleistocene deposits and as terminating against or being covered by early (?) Holocene and late Pleistocene deposits.

Recurrence interval: ND

Slip rate: unknown; (D) <0.2 mm/yr

Earthquake notes:

References cited:

Thompson, R.A., and Machette, M.N., 1989, Geologic map of the San Luis Hills area, Conejos and Costilla Counties, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1906.

Structure type: Simple fault

Structure number: Q76

Comments: The graben near Golden was previously included as part of the Golden Fault (fault #166) by Kirkham and Rogers (1981). It is also fault 2326 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Graben near Golden

Comments: The graben near Golden lies about 1.2 km northwest of downtown Golden. It is about 210 m east of the mapped trace of the Golden Fault (Kirkham and Rogers, 1981). The graben includes several small Quaternary faults, but due to their very close spatial proximity they are shown as a single fault on the map that accompanies this database. Dames & Moore (1981) mapped the graben in detail.

Synopsis:

The graben near Golden is a localized structure along the east side of the Front Range near Golden, Colorado. The graben does not have any geomorphic expression. It was first described by Scott (1970) based on an exposure in a clay exploration trench. The graben was trenched by Kirkham (1977a) and Kirkham and Rogers (1981) who inferred it was related to the Golden Fault, and by Dames & Moore (1981) who concluded it was not a tectonic feature and was very short in length. The graben has ruptured twice since deposition of Verdos Alluvium and prior to development of a Sangamon(?) or perhaps younger soil.

Date of compilation: 4/24/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Jefferson

1° x 2° Sheet: Denver

Province: Great Plains

Township and Range: T3S, R70W

Strike: N9W

Number of traces: 1

End to end length: 0.60 km

Cumulative length: 0.60 km

Reliability of location: Good

Comments: The fault trace is from Van Horn (1972; scale 1:24,000). The graben is also shown by Scott (1970) and Kirkham (1977a; scale about 1:32,700), and by Kirkham and Rogers (1981; scale about 1:29,500).

Geologic setting:

The graben near Golden is a localized structure along the east flank of the Front Range near Golden, Colorado. The graben lies about 210 m east of the trace of the Golden Fault mapped by Van Horn (1972), and is within the structural hinge zone that bounds the east flank of the Front Range. The graben is a bedding-plane slip structure. Verdos Alluvium is offset up to 5.5 m by the graben but there is no overall displacement of these gravel deposits across the ends of the graben (Kirkham, 1977a). The 620 ka Lava Creek B ash is also cut by the graben. Relationships between the graben and the Golden Fault are poorly understood. Kirkham (1977a) and Kirkham and Rogers (1981) associated the graben with the Golden Fault. Subsequent investigations by Dames & Moore (1981) concluded the graben was non-tectonic in origin.

Sense of movement: N,R

Comments: Individual faults within the graben are primarily normal, but reverse movement occurred on one fault. Interestingly, there is no overall net displacement of the Verdos Alluvium across the graben.

Dip: 70°-83°SW

Comments: Trenching investigations by Kirkham and Rogers (1981) revealed that the faults bounding the graben dip 83° to the southwest. Dames & Moore (1981) reported dips of 70° to 75° on the east-bounding fault of the graben in trenches excavated during their investigation.

Dip direction: SW

Geomorphic expression:

Geomophic features indicative of late Cenozoic faulting are absent in this area.

Age of faulted deposits:

Kansan or Yarmouth Verdos Alluvium, the 0.62 Ma Lava Creek B ash, and a middle Pleistocene colluvial deposit are displaced by the graben (Kirkham, 1977a; Kirkham and Rogers, 1981; Dames & Moore, 1981). The volcanic ash was originally described by Kirkham (1977a) and Kirkham and Rogers (1981) as being 0.6 to 0.7 Ma. Subsequent work by Izett and Wilcox (1982) correlated the ash with the Lava Creek B ash, which is generally considered to be 0.62 Ma.

Detailed studies:

Two trenches were excavated across the graben by Kirkham (1977a) and Kirkham and Rogers (1981). Dames & Moore (1981) excavated several trenches in this vicinity, including three initial exploratory trenches and eight more comprehensive trenches. Locations of these trenches are not depicted individually on the map accompanying this database because of the close spacing of the trenches and the small scale of the map. Rather, all of the trenches are represented by a single trench labeled Q76-1. The east-bounding fault was exposed in several trenches. It consisted of a shear zone in bedrock (Cretaceous Laramie Formation) and a zone of shingled or rotated gravel clasts with the outwash gravel. The Verdos Alluvium is offset up to 5.5 m across the east-bounding fault. The west-bounding fault was encountered in only a few trenches and was well-exposed only in the Colorado Geological Survey trench, where it consisted of a series of parallel, west-dipping reverse faults. Work by Dames & Moore (1981) suggested the graben is of limited lateral extent and of non-tectonic origin. Evidence of the graben was recently removed by earthwork activities associated with the construction of the Highway 92 by-pass around Golden.

Timing of most recent paleoevent: (3) Quaternary-middle and late (<750ka)

Comments: The most recent paleoevent occurred after deposition of the 620 ka Lava Creek ash and a middle Pleistocene colluvial deposit, and prior to development of a soil considered to be Sangamon in age by Kirkham (1977a) and Kirkham and Rogers (1981). Dames &

Moore (1981) reported that no discernable offset has occurred on the graben for at least 35,000 to 40,000 years.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Dames & Moore, 1981, Geologic and seismologic investigations for Rocky Flats Plant: unpublished report prepared for U.S. Department of Energy.

Izett, G.A., and Wilcox, R.E., 1982, Map showing localities and inferred distributions of the Huckleberry Ridge, Mesa Falls, and Lava Creek ash beds (Pearlette family ash bed) of Pliocene and Pleistocene age in the western United States and southern Canada: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1325.

Kirkham, R.M., 1977a, Quaternary movements on the Golden Fault, Colorado: Geology, v. 5, p. 689-692.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Scott, G.R., 1970, Quaternary faulting and potential earthquakes in east-central Colorado, 'in' Geological Survey research 1970, chapter C: U.S. Geological Survey Professional Paper 700-C, p. C11-C18.

Van Horn, Richard, 1972, Surficial and bedrock geologic map of the Golden quadrangle, Jefferson County, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-761-A.

Q77 - Ute Pass Fault Zone

Structure type: Simple fault

Structure number: Q77

Comments: Fault 144 in Kirkham and Rogers (1981); fault 142 in Witkind (1976); fault 2327 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Ute Pass Fault Zone

Comments: The Ute Pass Fault zone is defined by a series of about five generally northwest-trending faults west of Colorado Springs. The main fault is parallel to the southwest flank of the Rampart Range and Fountain Creek. The fault series begins east of Deckers near Devil's Head in the Rampart Range and terminates in a series of splay faults at the southern end of the east flank of the Front Range near Gray Back Peak.

Synopsis:

The Ute Pass Fault zone defines the west and southwest margin of the Rampart Range. Tonal and vegetation lineaments and bedrock scarps are discontinuous along the southern trace of the fault but are lacking along the northern trace. Late Cenozoic movement on the fault is strongly supported along the length of the fault (e.g., Taylor, 1975; Scott and others, 1978; Kirkham and Rogers, 1981; Dickson, 1986). Quaternary deposits do not appear to be offset across the north end of the fault (Bryant and others, 1981; Dickson and others, 1986). Scarps developed in Quaternary (Yarmouth to Illinoian age) rockfall deposits are cited as evidence for recent fault activity on the south end of the fault by Scott and Wobus (1973) and Kirkham and Rogers (1981). Unruh and others (1994) did not recognize any evidence to support mid-Pleistocene to Holocene displacement. However, they did not address the scarps in rockfall deposits as previously presented by Scott and Wobus (1973) and Kirkham and Rogers (1981). The fault most recent paleoevent on this fault is herein tentatively classified as having occurred during the middle to late Quaternary.

Date of compilation: 11/6/97

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

State: Colorado

County: El Paso, Teller, Douglas

1° x 2° Sheet: Pueblo, Denver

Province: Southern Rocky Mountains, Great Plains

Township and Range: T16S,R67W-T9S,R69W

Strike: N28W

Number of traces: 8

End to end length: 71.40 km

Cumulative length: 126.88 km

Reliability of location: Good

Comments: Faults in this system were mapped by Wobus and Scott (1977) at a scale of 1:24,000, by Scott and Wobus (1973) at a scale of 1:62,500, and by Bryant and others (1981) and Scott and others (1978) at a scale of 1:250,000. The trace used herein is from Scott and others (1978) and Bryant and others (1981).

Geologic setting:

The Ute Pass Fault zone lies along the western margin of the Rampart Range from near Devils Head to Gray Back Peak and bounds the east side of the Pikes Peak massif west of Colorado Springs. Throw on the fault varies along its length. At the north end the fault plane is nearly vertical. The middle part of the fault near Woodland Park is defined by steeply dipping fault planes that are graben-forming. The south end of the fault is characterized by west-dipping reverse faults that dip as little as 30° (Epis and others, 1976a). Throw can be generalized as down to west in the north, and down to the east in the south.

Sense of movement: NR

Comments: Witkind (1976) and Bryant and others (1981) showed the fault system as high-angle normal. Harms (1959) and Epis and others (1976a) mapped the middle section of the fault as moderate-angle reverse.

Dip: 20°-50°NE,SW

Comments: The fault dips southwest at the north end and northeast at the south end (Epis and others, 1976a). Dip angles are considered to be between 20°-50° (Harms, 1959; Epis and others, 1976a).

Dip direction: NE,SW

Geomorphic expression:

The fault system is marked by subtle, discontinuous, anomalous lineaments, visible on aerial photos, that extend through rockfall deposits at the south end of the fault (Kirkham and Rogers, 1981). A prominent scarp is present in Verdos Alluvium at the south end of the fault (Scott and Wobus, 1973). Unruh and others (1994) reported discontinuous tonal and vegetation lineaments, as well as an east-facing bedrock scarp and a southwest-facing scarp on the south end of the fault.

Age of faulted deposits:

The fault lies primarily in Precambrian bedrock. Scott and Wobus (1973) and Wobus and Scott (1977) mapped the fault as concealed by Quaternary deposits. Pliocene and Miocene gravel deposits were mapped by Scott and others (1978) as offset by the fault. Pleistocene fan alluvium abuts against the fault according to Bryant and others (1981). The best evidence for Quaternary fault activity is limited to the south end of the fault system near Cheyenne Mountain where development of a prominent scarp in Verdos Alluvium and scarps extending through Pleistocene rockfall deposits indicate youthful fault activity (Kirkham and Rogers, 1981). Unruh and others (1994) however, found no evidence of offset in late Pleistocene to Holocene deposits along the south end of the fault. Pleistocene to Holocene deposits are not disturbed across the north end of the fault (Dickson and others, 1986; Geotechnical Advisory Committee, 1986).

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (3) Quaternary-middle and late (<750ka)

Comments: Neogene fault activity is apparent based on offset of Pliocene and Miocene gravels (Scott and Wobus, 1973), and 300 m of throw on the fault since the Eocene was recorded by Epis and Chapin (1975). Evidence for Quaternary movement is not observed north of Woodland Park (Dickson and others, 1986). Although evidence for Quaternary movement on the fault is not definitive, geomorphic features on the south end of the fault near Cheyenne Mountain suggest the possiblity of two ruptures during the Quaternary. Scarps and lineations in rockfall deposits are believed to represent the second of the two ruptures, while the rockfalls themselves are interpretted as resulting from an earthquake during the Yarmouth interglacial period (Scott and Wobus, 1973). Howard and others (1978) showed this as a fault with late Quaternary movement. Kirkham and Rogers (1981) stated that the Slocum Alluvium is not offset across the fault, thus constraining the timing of the second period of activity to between the Yarmouth interglacial period and the Illinoisan glacial period. Unruh and others (1994) found no evidence of offset in late Pleistocene to Holocene deposits along the south end of the fault and concluded that scarp features are fault-line scarps or the result of diferential erosion. Evidence against Quaternary movement provided by Unruh and others (1994) does not address all of the arguments for Quaternary movement presented by Scott and Wobus (1973), Kirkham and Rogers (1981), and Dickson and others (1986) and is considered insufficient to warrant discounting the fault system as a Quaternary fault.

Recurrence interval: ND

Comments:

Slip rate: (D) <0.2 mm/yr

Comments: Despite the possibility of two events during the Yarmouth to Illinoian, a long-term slip rate of <0.2 mm/yr is estimated for this fault based on the small size of the scarps and the fact that the fault apparently has not ruptured since the initial deposition of the Slocum Alluvium (about 130 ka). Jack Benjamin and Associates and Geomatrix Consultants (1996) calculated a long-term average slip rate of 0.01 mm/yr for the Ute Pass Fault zone.

Earthquake notes:

Young fault movement may be related to earthquake activity near Colorado Springs during the Yarmouth to Illinoian (Scott and Wobus, 1973; Kirkham and Rogers, 1981). Jack Benjamin and Associates and Geomatrix Consultants (1996) assigned a 0.4 probability of a 6.5 to 7.0 magnitude earthquake occurring on this fault.

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Q78 - Rampart Range Fault

Structure type: Simple fault

Structure number: Q78

Comments: Fault 145 in Kirkham and Rogers (1981); fault 143 in Witkind (1976); fault 2328 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Rampart Range Fault

Comments: The north-trending Rampart Range Fault forms the eastern margin of the Rampart Range north of Colorado Springs. The fault begins near Larkspur and continues south towards Colorado Springs, ending near Highway 24.

Synopsis:

The Rampart Range Fault trends north-south along the Front Range north of Colorado Springs. It is a range-front fault that experienced reverse movement during the Laramide, but normal movement during the late Cenozoic. The fault is marked by topographic breaks and vegetation lineaments. Approximately 8 m of down-to-the-west Quaternary displacement was reported by Scott (1970). Trenching by Dickson (1986) demonstrated the fault offset the Kansas or Yarmouth Douglass Mesa gravel 29.3 m sometime between 600 and 30 to 50 ka.

Date of compilation: 11/06/1997

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

State: Colorado

County: El Paso, Douglas

1° x 2° Sheet: Pueblo, Denver

Province: Great Plains

Township and Range: T14S,R67W-T9S,R68W

Strike: N9W

Number of traces: 4

End to end length: 45.73 km

Cumulative length: 51.75 km

Reliability of location: Good

Comments: Wobus and Scott (1977) mapped the south part of the fault at a scale of 1:24,000. The fault was also mapped at a scale of 1:62,500 by Scott and Wobus (1973), 1:100,000 by Trimble and Machette (1979a; 1979b), 1:250,000 by Scott and others (1978) and Bryant and others (1981), 1:1,000,000 by Colman (1985) and 1:5,000,000 by Howard and others (1978). The trace used herein is from Trimble and Machette (1979a; 1979b).

Geologic setting:

The Front Range is defined by a 500- to 1,000-m-high, east-facing escarpment that is both a tectonic and erosional feature. Estimations of Neogene offset across the Front Range are as little as 30 m and as much as 2,200 m. Scott (1970), Epis and Chapin (1975), and Trimble (1980) suggested much of the topographic relief across the escarpment is related to Neogene fault activity. Jacob and Albertus (1985), Leonard and Langford (1994), and Steven and others (1997) indicated that Neogene fault activity only acounts for a minor amount of topographic relief across the escarpment. Steven and others (1997) noted anomalies in paleo- and modern, range-front stream flow directions which they interpretted to indicate tilting of the Front Range off the northeast flank of the Rio Grande Rift during the Miocene, and regional uplift during the early Pliocene and possibly early Quaternary. Jacob and Albertus (1985) and Chapin and Kelley (1997) argued that the Front Range escarpment is primarily a product of differential erosion.

The Rampart Range Fault forms the east flank of the Rampart Range which is part of the Colorado Front Range. It is a west-dipping, high-angle, range-front, Laramide reverse fault with renewed late Cenozoic normal displacement (Dickson, 1986). Scott (1970) reported down-to-the-east movement in early Tertiary time, and down-to-the-west movement in Quaternary time. Overall stratigraphic offset indicates down-to-the-east reverse movement, while offset in Quaternary deposits indicates down-to-the-west, normal displacement.

Sense of movement: N

Comments: Late Cenozoic normal movement was reported by Witkind (1976), Dickson (1986), and Unruh and others (1994). Scott (1970) indicated reverse movement in early Tertiary time and normal movement in Quaternary time.

Dip: 50°W

Comments: A dip of 50°W was measured from a cross section by Harms (1959). Dickson (1986) and Dickson and others (1986) reported fault dips of 45°-80°W in trenches excavated near the U.S. Air Force Academy.

Dip direction: W

Geomorphic expression:

Discontinuous topographic breaks and vegetation lineaments mark the trace of this fault (Scott, 1970; Unruh and others, 1994). A well developed fault-line scarp is visable along much of the fault trace (Kirkham and Rogers, 1981).

Age of faulted deposits:

The majority of the fault extends through Precambrian and early Tertiary rocks. Scott (1970) described about 8 m of offset in the Douglass Mesa Gravel, which is considered to be Kansan or Yarmouth in age. Epis and Chapin (1975) suggested 450 m of Neogene offset, as evidenced by offset of the Oligocene Wall Mountain Tuff. Taylor (1975) suggested 370 m of Neogene offset across the fault. Trimble (1980) described as much as 700 m of offset on this fault based on stratigrahic offset of the late Eocene surface and the Wall Mountain tuff. Jacob and Allbertus (1985) indicated less than 230 m of Neogene offset across this fault. Trenching investigations by Dickson (1986) demonstrated that Quaternary dip-slip displacement in the Douglass Mesa Gravel amounts to nearly 30 m, and that there has not been any movement on the Rampart Range Fault during the past 30 to 50 ka. Leonard and Langford (1994) suggested only 90 to 95 m ± 60 m of of post-Eocene displacement across the Front Range based on contouring of paleo-surfaces and the base of the Wall Mountain tuff and Castle Rock conglomerate on either side of the range front faults.

Detailed studies:

Dickson (1986) excavated and logged two trenches, which he labeled AF-1 and AF-2, on the section of the fault that extends through the southwest corner of the Air Force Academy property south of the Colorado Springs filtration plant. These trenches are labeled as Q68-1 and Q68-2 on the map that accompanies this database. Trenching investigations indicated that the last displacement on this fault occurred between 600 ka and 30 to 50 ka.

Q68-1 (AF-1): This 152-m-long trench revealed slip surfaces dipping 45° to 80°W in the Douglass Mesa Gravel. The gravel was offset 29.3 m in a dip-slip mammer.

Q68-2 (AF-2): This 23-m-long trench exposed slip surfaces in the Douglass Mesa Gravel that are overlain by an unfaulted paleosol estimated to be 30 to 50 ka.

Timing of most recent paleoevent: (3) Quaternary-middle and late (<750ka)

Comments: Scott (1970) described offset Kansan or Yarmouth deposits. Trenching investigations by Dickson (1986) indicated the latest movement on the fault was between 600 ka and 30-50 ka. Airphoto analysis and aerial reconnaissance by Unruh and others (1994) revealed no evidence for Holocene fault activity.

Recurrence interval: ND

Comments:

Slip rate: (D) <0.2 mm/yr

Comments: Based on offset of 8 m (Scott, 1970) and a paleoevent ocurring between 600 and 30 ka (Dickson, 1986), a slip rate of <0.2 mm/yr is estimated for this fault. Jack Benjamin and Associates and Geomatrix Consultants (1994) calculated slip rates of 0.01 to 0.07 mm/yr based on dip-slip values of 8.8 to 43 m as determined from trenching investigations by Dickson (1986).

Earthquake notes:

Late Cenozoic fault activity may be related to earthquake activity near Colorado Springs (Kirkham and Rogers, 1981). Jack Benjamin and Associates and Geomatrix Consultants (1996) assigned a 0.6 probability for a magnitude 7 earthquake. In April 1991, Microgeophysics (1991) located a swarm sequence with magnitudes 2.6 to 2.8 on the south end of this fault system.

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Structure type: Simple fault

Structure number: Q79

Comments: Fault 127 in Kirkham and Rogers (1981); fault 140 in Witkind (1976); fault 2329 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Goodpasture Fault

Comments: The Goodpasture Fault is a northwest-trending fault east of Hogback Mountain in the Wet Mountains between the North St. Charles River and the Spring Branch of the St. Charles River. The fault is south of the town of Goodpasture and was named by Unruh and others (1994).

Synopsis:

The Goodpasture Fault was named by Unruh and others (1994). A fairly prominent escarpment and vegetation lineation defines the fault trace (Kirkham, 1977b). Scott and others (1978) mapped the Verdos and Slocum Alluviums as abutting against the fault. Kirkham and Rogers (1981) classified this fault as a Quaternary fault based on the mapping of Scott and others (1978). Colman (1985) listed the most recent fault movement as occurring during middle to early Pleistocene. More recent investigation by Unruh and others (1994) discounted late Quaternary activity based on field and air photo interpretation, but did not entirely rule out early to middle Quaternary movement on the fault.

Date of compilation: 10/3/97

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

State: Colorado

County: Pueblo

1° x 2° Sheet: Pueblo

Province: Southern Rocky Mountains

Township and Range: T23S,R67W

Strike: N32W

Number of traces: 1

End to end length: 4.92 km

Cumulative length: 4.92 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:24,000 by Scott and Taylor (1973) and 1:250,000 by Scott and others (1978). The trace used herein is from Scott and others (1978).

Geologic setting:

The Goodpasture Fault is a high-angle normal fault that is down to the northeast. Neogene and younger movement (normal) is opposite to reverse Precambrian movement (Scott and Taylor, 1973). The fault may be associated with other faults that bound the east flank of the Wet Mountains.

Sense of movement: N

Comments: Scott and Taylor (1973) and Witkind (1976) indicated normal movement on this fault.

Dip:

Comments: Witkind (1976) indicated normal movement on a northeast-dipping plane.

Dip direction: NE

Geomorphic expression:

A fairly prominent escarpment and vegetation lineation defines the fault trace (Kirkham, 1977b). The fault is marked by an east-facing scarp about 2 m high in Cretaceous bedrock that is overlain by a layer of colluvium <2 m thick. Geomorphic features in Quaternary deposits indicative of youthful faulting were not observed in aerial reconnaissance by Unruh and others (1994).

Age of faulted deposits:

Scott and Taylor (1973) mapped the Verdos and Slocum Alluviums as abutting against and concealing the fault. Scott and others (1978) mapped the same gravels as abutting against the Goodpasture Fault. The Slocum Alluvium (the younger of the two) is considered to be Sangamon or Illinoian in age (about 130 ka). Unruh and others (1994) concluded that the fault has not moved during the late Quaternary. The fault trace lies almost entirely within Cretaceous bedrock with only two small fingers of Quaternary deposits offset by the fault.

Detailed studies:

No detailed studies have been conducted on this fault.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Scott and Taylor (1973) mapped the Slocum and Verdos Alluvium as concealing and abutting against the fault. They indicated west-Side-down movement on the fault based on truncation of these deposits against the fault. Witkind (1976) and Kirkham and Rogers (1981) listed this fault as a Quaternary fault. Colman (1985) indicated the most recent activity on the fault occurred during the middle to early Pleistocene. Unruh and others (1994) discounted late Quaternary movement on the fault suggesting that the gravels previously mapped as Slocum and Verdos Alluvium by Scott and Taylor (1973) represented instead the Stroup loam soil. Field mapping by Unruh and others (1994) revealed no west-Side-down late Quaternary movement on the fault, and geomorphic indicators of late Pleistocene faulting were not observed in aerial reconnaissance. While Unruh and others (1994) have shown that there is little evidence for late Pleistocene movement, early Pleistocene movement cannot be ruled out since they were unable to examine exposures cited by Scott and Taylor (1973) as indicating youthful faulting. Without further study the most recent paleoevent on this fault is tentatively considered to have occurred during the Quaternary (<1.6Ma).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

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Q80 - Cheraw Fault

Structure type: Simple fault

Structure number: Q80

Comments: Fault 173 in Kirkham and Rogers (1981); fault 156 in Witkind (1976); fault 2330 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Cheraw Fault

Comments: The Cheraw Fault was first recognized during regional mapping in the late 1960's and 1970's (Sharps, 1976) but was not formally named until Kirkham and Rogers (1981) associated it with the small town of Cheraw, Colorado, which is located about 10 km south of the scarp.

Synopsis:

The Cheraw Fault was originally mapped by Sharps (1976) as part of a regional mapping program (1:250,000 scale). Scott (1970) first suggested that the fault might be a potential source of earthquakes, but despite Scott's suggestion, no detailed studies of the fault were conducted during the next two decades. In 1994 M.N. Machette, A.J. Crone, and collegues (Crone and others, 1997) trenched the scarp and documented a record of late Quaternary surface ruptures on the fault and confirmed the fault as a potential source of future strong earthquakes. This documentation establishes the Cheraw Fault as only the second confirmed (after the Meers Fault, Oklahoma) late Quaternary fault in the stable continental region of the west-central U.S.

Date of compilation: 10/31/97

Compiler and affiliation: Anthony J. Crone, U.S. Geological Survey

State: Colorado

County: Crowley, Kiowa, Otero

1° x 2° Sheet: Lamar

Province: High Plains

Township and Range: T22S,R55W-T18S,R52W

Strike: N44E

Number of traces: 1

End to end length: 44.31 km

Cumulative length: 45.44 km

Reliability of location: Good

Comments: The fault was previously mapped at 1:250,000 by Sharp (1976) and Scott and others (1978). The trace herein is from 1:24,000-scale mapping, transferred to a 1:250,000 base and digitized (Crone and others, 1997; figure 2). Along much of its trace, the fault is conspicuous because of its down-to-the-northwest sense of throw that opposes the southeasterly regional slope. This sense of motion results in overland flow forming local ponds against the scarp and enhancing vegetation adjacent to the scarp (the region has a semi-arid climate, and vegetation is sparse). The increase in the density of vegetation along the scarp makes it a distinctive feature that is relatively easy to map on aerial photographs. For this reason, the reliability of the fault's location is considered to be good.

Geologic setting:

The Cheraw Fault is located on the High Plains of southeastern Colorado, about 100 km east of Pueblo, and about 140 km east of the range front of the Rocky Mountains (Crone and others, 1997). Structurally, the fault is located above the west-northwesterly sloping basement surface between the north-trending Las Animas arch to the east and the Denver basin to the northwest (Curtis, 1988); accordingly, the fault lies on the western side of the arch and along the southeastern margin of the basin. The down-to-the-northwest sense of motion that occurred during late Quaternary faulting events has the same vertical sense as the cumulative tectonic relief on the Precambrian crystalline rocks.

The Las Animas arch is a prominent, but relatively low-relief, 300-km-long, positive structural element in southeastern Colorado. The crest of the arch is approximately 20 to 40 km east of the fault. Minor uplift probably occurred along the arch in late Paleozoic time, but most of the present structural relief formed in Laramide time when the gentle westward slope on the western side of the arch developed as a result of downwarping of the Denver basin (Curtis, 1988). As the basin subsided, Cretaceous rocks were tilted westward from their original eastward-sloping depositional gradient.

There is little evidence that throw on the fault has substantially offset the bedrock (only tens of meters is demonstrable), thus the fault does not appear to have a long history of recurrent movement. For example, the cumulative throw on the fault is less than the thickness of the Smoky Hill Shale Member (150 to 215 m thick), because neither the Fort Hays Limestone Member nor the Pierre Shale (all upper Cretaceous), which are stratigraphically below and above the Smoky Hill Shale Member, respectively, are exposed along the fault.

As part of his regional mapping, Sharps (1976) drew a structure-contour map on the top of the lower Cretaceous Dakota Sandstone. The subsurface control for the structure contours is sparse, and the elevation control suggests that the contours could contain a significant amount of uncertainty. Nevertheless, a direct interpretation of the contours indicates an estimated 6 to 8 m of down-to-the-northwest throw on the fault, which is comparable with the amount of throw on early Quaternary alluvial deposits. The Cheraw Fault disrupts the gradual westward gradient of Cretaceous rock that rises up onto the arch; immediately east of the fault, these rocks have a gradient of about 5 m/km, and west of the fault they have a gradient of about 8 m/km. Even if the cumulative offset of Cretaceous rocks is four or five times greater than the estimated 6 to 8 m, the average Neogene slip rate on the fault is very low, and the fault could not have a long history of movement at rates comparable to the latest Pleistocene rate.

Sense of movement: N

Comments: The sense of motion on the fault is not well known, but is inferred to be down-to-the-northwest motion on a normal fault based on the attitude of the faults exposed in the trench across the scarp (Crone and others, 1997).

Dip: 66°NW

Comments: Dip measurment is based on the average dip of the main fault as mapped by Crone and others (1997) in the trench across the fault. This 3 to 4 m high trench provided the only known exposure of the fault.

Dip direction: NW

Geomorphic expression:

In his regional mapping, Sharps (1976) showed the fault as approximately located where it crosses the upper Cretaceous Smoky Hill Shale Member of the Niobrara Formation, and showed it as inferred or concealed where it crosses lower Pleistocene Rocky Flats Alluvium and middle (?) Pleistocene Verdos Alluvium. Kirkham and Rogers (1981) reported that vegetation changes, linear ponds, breccia, and perhaps tectonically blocked stream channels were associated with the weathered but distinct scarp. Unruh and others (1994) recognized low topographic scarps 3 to 4 m high, vegetation lineaments, sinkholes, and ponded sediments. Locally, the fault forms a rounded but distinct scarp on lower Pleistocene Rocky Flats Alluvium; this scarp vertically offsets the alluvium about 7 to 8 meters (Crone and Machette, 1995b).

At the trench site of Crone and others (1997), the scarp is 3.6 m high and has a maximum slope angle of 11°. Based on fault-scarp morphology studies in the nearby Basin and Range Province of the western U.S., a fault scarp of this size having this morphology would be inferred to be considerabley older than the Holocene age indicated by the trenching studies. However, comparing the scarp on the Cheraw Fault with Basin and Range fault scarps is complicated by the fact that the Cheraw scarp is the product of multiple surface-faulting events, whereas Basin and Range scarp-morphology studies tend to focus on single rupture events. In addition, eolian deposition and ponded alluvium has partially buried the hanging wall of the Cheraw scarp fault, both of which contribute to the scarp's subdued morphology. The net result is that, morphologically, the scarp appears to be an older feature than was documented by the trenching study.

Age of faulted deposits:

Lower Pleistocene (Rocky Flats Alluvium), middle (?) Pleistocene Verdos Alluvium, locally unnamed latest Pleistocene loess and alluvium, and Holocene colluvium.

Detailed studies:

The only detailed paleoseismic study of the fault conducted to date is that reported by Crone and others (1997). In that study, they excavated a 110-m-long trench across a 3.6-m-high scarp and reported evidence of two latest Pleistocene faulting events and an early Holocene event. This trench is labeled Q80-1 on the map that accompanies this database. The timing of these events was constrained by one radiocarbon age on charcoal fragments, four radiocarbon ages on soil organic concentrates, and nine thermoluminescence (TL) age estimates. The trench exposed Cretaceous Smoky Hill Shale bedrock in the footwall of the fault, but only exposed a mixture of scarp-derived colluvium and paludal deposits on the hanging wall side. Within the colluvial sequence, there is clear evidence of multiple (3) events, including faulted organic-rich soil A horizons.

The timing of the latest Pleistocene events, which are listed in the following section, raises the possibility that the surface-faulting events have occurred in a pattern of temporal clustering. The latest Pleistocene deposits at the trench site described by Crone and others (1997) were deposited in a low-gradient paleo-stream channel that was cut into Cretaceous shale. The length of time required to erode this wide channel down through older Pleistocene alluvial deposits and into the bedrock is thought to be on the order of 100,000 years or longer. The cumulative vertical offset on the Pleistocene erosional surface cut on the Cretaceous shale is 3.2 to 4.1 m, which represents the total offset from the three post-latest Quaternary (<25 ka) events. In contrast, lower Pleistocene Rocky Flats Alluvium, which has an estimated age of about 1.2 Ma, is only offset about 7 to 8 m by the fault. Thus, the frequency of surface-faulting earthquakes that occurred in latest Quaternary time (about 25 ka), could not have been sustained throughout all of the Pleistocene because, if this frequency had been sustained, the scarp on the Rocky Flats Alluvium would be more than 100 m high.

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

Comments: The age of the most recent event is relatively well constrained by radiocarbon and TL age estimates (Crone and others, 1997), although these estimates only provide maximum limit on the timing of events. Detrital charcoal fragments deposited within a faulted A-horizon (soil) have a calibrated AMS radiocarbon age of 8.4 ka. Based on the proximity of these charcoal fragments to the paleo-ground surface, Crone and others (1997) argued that the most recent event has an age of about 8 ka (early Holocene). Earlier, less detailed investigations by Unruh and others (1994) suggested latest movement was early to middle Pleistocene.

Recurrence interval: Average of 8 ka in latest Quaternary time (<25 ka)

Comments: Crone and others (1997) estimated that surface-rupturing events on the fault occurred at about 8 ka, 12 ka, and 20 to 25 ka based on their trenching study. They also speculated that events older than about 25 ka must have occurred before about 100 ka because of the time needed to incise, widen, and backfill the paleo-stream channel that is now filled with latest Pleistocene deposits. Based on this temporal pattern, they speculated that the fault's long-term behavior is characterized by temporal clustering of earthquakes, in which relatively short time intervals of activity (e.g., 15 to 20 ka) are separated by long intervals of quiescence (e.g., 100 ka). If correct, this pattern of temporal clustering makes it difficult to assign a realistic recurrence interval for the fault. The 8 ka average recurrence interval suggested is based solely on the estimated timing of the latest Pleistocene and Holocene events documented in the trenching study. This recurrence interval may only apply to periods of time when the fault is in an active phase; during a quiescent phase, surface-faulting earthquakes may not occur for hundreds of thousands of years. Unruh and others (1994) estimated a recurrence interval of 10 to 50 ka.

Slip rate: unknown; (D) <0.2 mm/yr

Comments: The latest Pleistocene to Holocene slip rate on the Cheraw Fault is much less than 1 mm/yr. Unruh and others (1994) calculated a slip rate of 0.01 to 0.001 mm/yr. A rigorous calculation of latest Pleistocene to Holocene slip rates yields values of 0.23 to 0.09 mm/yr based on the data of Crone and others (1997). During the time interval between 20 to 25 ka and 8 ka, two surface-faulting events occurred. The cumulative vertical offset of these two events ranges between 1.6 m and 2.7 m. A maximum latest Pleistocene slip rate would be based on the shortest time interval between these events (20 ka to 8 ka) and the maximum vertical offset in that time interval (2.7 m); this yields a slip rate of 0.225 mm/yr. Similarly, a minimum latest Pleistocene slip rate would be calculated by taking the longest time interval between events (25 ka and 8 ka) and the minimum vertical offset during that time interval (1.6 m); this yields a slip rate of 0.094 mm/yr. These slip-rate values apply to periods of time when the fault is in an active phase.

More simplistic calculations (but not rigorously correct) of latest Pleistocene-Holocene slip rates are between 0.14 to 0.18 mm/yr. These rough slip rates are determined by dividing the amount of offset (3.6 m) on the oldest faulted deposits by the age of the deposits (20 to 25 ka); these resulting slip rates are similar to the more rigorous values described above.

The long-term slip rate on the Cheraw Fault would be extremely low if one were to include the effect of quiescent phases of activity. The best estimate of a long-term slip rate is less than or equal to 0.007 mm/yr based on a cumulative offset of about 8 m on the 1.2 Ma Rocky Flats Alluvium. However, because of the apparent temporal clustering of events, one might question whether using a single slip-rate value is an appropriate way to characterize the rate of movement on this fault.

Earthquake notes:

Jack Benjamin and Associates and Geomatrix Consultants (1996) assigned a 0.4 probability of a magnitude 7 earthquake occurring on this fault.

References Cited:

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Unruh, J.R., Wong, I.G., Hitchcock, C.S., Bott, J.D.J., Silva, W.J., and Lettis, W.R., 1994, Seismotectonic evaluation, Pueblo Dam, Fryingpan-Arkansas Project, south-central Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Federal Services for U.S. Bureau of Reclamation, Denver, Colorado, 134 p.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

SECTIONED QUATERNARY FAULTS

A *sectioned fault* is a fault that appears to consist of two or more sections that have ruptured independently, but each section has not been carefully evaluated in detail to accurately characterize the rupture history of each section.

Structure type: Sectioned fault

Structure number: Q40 a-d

Comments: Fault 94 in Kirkham and Rogers (1981) coincides with the Blue Mesa section of the Cimarron Fault (94d); faults 2290a-d in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Cimarron Fault

Comments: The Cimarron Fault is a northeast-trending fault between Montrose and Blue Mesa Reservoir. Much of the fault is parallel to Highway 50 and the Gunnison River. The fault begins at the south end of the Black Canyon of the Gunnison National Monument and continues southeast past Iron Hill where it terminates south of Huntsman Mesa. The fault was described as segmented by Lettis and others (1996), but studies were not extensive enough on each section of the fault to warrant designation as a segmented fault for this database. Instead, the fault is divided into five sections which include from west to east: the Bostwick Park section, the Ellison Gulch section, the Poverty Mesa section, the Blue Mesa section, and the Powderhorn section. Only the first four sections have evidence for Quaternary movement and are included in this database. The fifth section, the Powderhorn section, is considered a late Cenozoic fault and is not discussed in this database. Names for these sections are based on segment names used by Lettis and others (1996).

Synopsis:

The following is summarized from Lettis and others (1996). The Cimarron Fault is made up of five fault sections. The Bostwick Park section is marked by a series of fault scarps or fault-line scarps and offsets middle to late Pleistocene deposits. The Ellison Gulch section is defined by a 1- to 2-m-high scarp that offsets late Pleistocene to Holocene fan deposits. This scarp was tentatively interpreted as a possible landslide feature but may also reflect secondary deformation along the southern end of the Bostwick Park section. A 300-m-high escarpment and smaller scarps offset middle to late Pleistocene deposits on the Poverty Mesa section. Trenching studies at two sites along the Poverty Mesa section supported a tectonic origin at one site but a landslide origin at the second site. The Blue Mesa section is represented by a 1-km-wide graben with low relief that offsets Oligocene-Pliocene volcanic tuff, and may also have experienced Quaternary movement. Paleoseismic trench investigations were conducted on the Poverty Mesa and Blue Mesa sections.

Date of compilation: 11/17/97

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

State: Colorado

County: Gunnison, Montrose, Saguache

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T47N,R3W-T48N,R4W

Strike: N58W

Number of traces: 6

End to end length: 57.26 km

Cumulative length: 78.80 km

Geologic setting:

Faults included in the Cimarron Fault system are generally high-angle normal. Parts of the fault are northeast- dipping Laramide reverse or tear faults that have been reactivated during the late Cenozoic in a normal sense (Hansen, 1971; Lettis and others, 1996). Lettis and others (1996) suggested the Cimarron Fault may merge with the Red Rocks Fault at a depth of 5 to 9 km and then flatten to merge with a blind thrust or detachment at a depth of 8 to 10 km. Hansen (1971) documented 5.5 km of left lateral Larmide displacement across the fault.

Number of sections: 4

The Cimarron Fault was described as segmented by Lettis and others (1996), but studies were not extensive enough on each section of the fault to warrant designation as a segmented fault in this database. The Cimarron Fault is herein divided into four sections that show evidence for Quaternary movement. They include include from west to east, the Bostwick Park section, the Ellison Gulch section, the Poverty Mesa section, and the Blue Mesa section. A fifth section, the Powderhorn section, has moved during the late Tertiary but lacks evidence of Quaternary movement. Therefore, it is not discussd herein.

Structure number: Q40 a-d

Section name: Overview

Reliability of location: Good

Comments: The Cimarron Fault was mapped at a scale of 1:24,000 and 1:250,000 by Lettis and others (1996) and 1:250,000 by Tweto and others (1976). The Blue Mesa and Poverty Mesa sections of the Cimarron Fault was also mapped at a scale of 1:31,680 by Hansen (1971). The trace used herein is from Lettis and others (1996).

Sense of movement: N

Comments: Overall movement on the faults indicates reverse faulting, but offset of late Cenozoic deposits suggests reactivation in a normal sense (Hansen, 1971; Wong and Humphrey, 1986; Lettis and others, 1996).

Dip: ~70°NE

Comments: A cross section by Hansen (1971) showed a dip of about 70° for the Poverty Mesa section.

Dip direction: NE

Geomorphic expression:

The following is summarized from Lettis and others (1996). The Bostwick Park section is marked by a series of fault scarps or fault-line scarps; the Ellison Gulch section is defined by a 1- to 2-m-high scarp; a 300-m-high escarpment and smaller scarps are present on the Poverty Mesa section; the Blue Mesa section is represented by a 1-km-wide graben with low relief.

Age of faulted deposits:

Middle to late Pleistocene deposits are offset in the Bostwick Park and Poverty Mesa sections. Late Pleistocene to Holocene deposits are offset on the Ellison Gulch section. Late Pleistocene sediments are tilted by the Blue Mesa section (Lettis and others, 1996).

Detailed studies:

Trenching investigations were conducted by Lettis and others (1996) on the two sections of the Cimarron Fault. Four trenches were excavated on the Poverty Mesa section, and three trenches were excavated on the Blue Mesa section. See individual fault reports for summaries of these trenching investigations.

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

Comments: Movement along the Cimarron Fault ranges from Oligocene-Pliocene to Holocene and post glacial (Lettis and others, 1996).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: There are no published slip rates for the Cimarron Fault.

Earthquake notes:

The Cimarron Fault may be capable of generating a magnitude 6 3/4 earthquake (Unruh and others, 1993a).

References Cited:

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Hansen, W.R., 1971, Geologic map of the Black Canyon of the Gunnison River and vicinity, western Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-584.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

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Q40a - Cimarron Fault: Bostwick Park Section

Structure type: Sectioned fault

Structure number: Q40 a

Comments: Fault 2290a in the U.S. Geological Survey Quaternary fault and fold database

Structure name: Cimarron Fault

Comments: The Cimarron Fault is a northeast-trending fault between Montrose and Blue Mesa Reservoir. Much of the fault is parallel to Highway 50 and the Gunnison River. The fault begins at the south end of the Black Canyon of the Gunnison National Monument and continues southeast past Iron Hill where it terminates south of Huntsman Mesa. This description addresses only the Bostwick Park section of the fault which extends about 12 km from the mouth of Red Rock Canyon to Bostwick Park.

Synopsis:

Lettis and others (1996) referred to this section of the Cimarron Fault as the Bostwick Park section. This section is marked by a series of fault scarps or fault-line scarps that offset middle to late Pleistocene deposits.

Date of compilation: 11/17/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T49N,R93W-T50N,R93W

Strike: N45W

Number of traces: 1

End to end length: 11.19 km

Cumulative length: 12.01 km

Geologic setting:

The Cimarron Fault was described by Lettis and others (1996) as a high-angle reverse fault with late Tertiary to possibly Holocene normal movement. This section of the fault is down to the northeast. Throw on the fault is consistent with local topography, and a tributary to the Gunnison River generally flows along the fault trace. Lettis and others (1996) suggested this section of the Cimarron Fault may merge with the Red Rocks Fault at a depth of 5 to 9 km and then flatten to merge with a blind thrust or detachment at a depth of 8 to 10 km. Bostwick Park is underlain by about 50 m of Quaternary deposits that include the Lava Creek B ash, which is dated at 620 ka (Hansen, 1971; cited in Lettis and others, 1996).

Number of sections: 4

The Cimarron Fault was described as segmented by Lettis and others (1996), but studies were not extensive enough on each section of the fault to warrant designation as a segmented fault in this database. The Cimarron Fault is herein divided into four sections that show evidence for Quaternary movement. They include include from west to east, the

Bostwick Park section, the Ellison Gulch section, the Poverty Mesa section, and the Blue Mesa section. A fifth section, the Powderhorn section, has moved during the late Tertiary but lacks evidence of Quaternary movement. Therefore, it is not discussed herein.

Structure number: Q40a

Section name: Bostwick Park Section

Lettis and others (1996) referred to this section as the Bostwick Park segment of the Cimarron Fault. As discussed previously, fault segments described by Lettis and others (1996) are herein referred to as sections.

Reliability of location: Good

Comments: This Cimarron Fault was mapped at a scale of 1:24,000 and 1:250,000 by Lettis and others (1996), and 1:250,000 by Tweto and others (1976). The trace used herein is from Lettis and others (1996).

Sense of movement: N

Comments: Lettis and others (1996) suggested this section is a northeast-dipping, normal fault.

Dip:

Comments:

Dip direction: NE

Geomorphic expression:

The Bostwick Park section of the Cimarron Fault is marked by a series of discontinuous northeast-facing fault scarps or fault-line scarps (Lettis and others, 1996).

Age of faulted deposits:

Quaternary alluvial fans are truncated by the Bostwick section of the Cimarron Fault. A 3- to 5-m-thick soil with a stage II+ calcic horizon is developed on the alluvial fans. The soil is estimated to be middle to late Pleistocene (100-150 ka) in age. Latest Pleistocene and Holocene deposits are not offset across the fault (Lettis and others, 1996). The fault lies primarily in Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this section.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Lettis and others (1996) reported that middle to late Pleistocene deposits (100-150 ka) are cut by the fault, but not latest Pleistocene and Holocene fans.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Scarps or fault-line scarps are present in middle to late Pleistocene deposits, but the height of the scarps is not documented (Lettis and others, 1996). Based on slip rates calculated for other sections on the Cimarron Fault, a slip rate of <0.2 mm/yr is estimated for this section.

Earthquake notes:

The Cimarron Fault may be capable of generating a magnitude 6 3/4 earthquake (Unruh and others, 1993a).

References Cited:

Hansen, W.R., 1971, Geologic map of the Black Canyon of the Gunnison River and vicinity, western Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-584.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Unruh, J.R., Noller, J.S., Lettis, W.R., Sawyer, T.L., and Bott, J.D.J., 1993a, Quaternary faults of the Central Rocky Mountains, Colorado; a new seismotectonic evaluation [abs.]: Geological Society of America Abstracts with Programs, v. 25, no. 5, p. 157.

Structure type: Sectioned fault

Structure number: Q40 b

Comments: Fault 2290b in the U.S. Geological Survey Quaternary fault and fold database

Structure name: Cimarron Fault

Comments: The Cimarron Fault is a northeast-trending fault between Montrose and Blue Mesa Reservoir. Much of the fault is parallel to Highway 50 and the Gunnison River. The fault begins at the south end of the Black Canyon of the Gunnison National Monument and continues southeast past Iron Hill where it terminates south of Huntsman Mesa. This description addresses only the Ellison Gulch Scarp section of the fault, which is defined by a scarp that delineates a northwest-trending fault that lies south of the main fault trace and south of the east end of the Bostwick Park. The scarp was first mapped and named by Lettis and others (1996).

Synopsis:

Lettis and others (1996) were the first to map the Ellison Gulch Scarp section of the Cimarron Fault. It is defined by a 1- to 2-m-high scarp and a possible spring-fed pond at the base of the scarp. Late Pleistocene to Holocene fan deposits are offset by the fault. They suggested the scarp may reflect secondary deformation related to the Bostwick Park section of the Cimarron Fault or may reflect slope failure at the south end of Bostwick Park. They tentatively concluded the scarp is not tectonic based on the slightly arcuate nature of the south end of the scarp. However, the fault is herein included as a Quaternary structure based on its association with other sections of the Cimarron Fault that have evidence of Quaternary movement.

Date of compilation: 5/15/97

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

State: Colorado

County: Montrose

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T49N, R92W

Strike: N31W

Number of traces: 1

End to end length: 1.20 km

Cumulative length: 1.18 km

Geologic setting:

The Cimarron Fault was described by Lettis and others (1996) as a high-angle reverse fault with late Tertiary to possibly Holocene normal movement. The Ellison Gulch Scarp section lies south of the main trace of the Cimarron Fault and is down to the southwest. Throw on the fault is consistant with local topography. The fault may reflect secondary deformation related to the Bostwick Park section of the Cimarron Fault or may reflect slope failure at the south end of Bostwick Park (Lettis and others, 1996).

Q40b - Cimarron Fault: Ellison Gulch Scarp Section

Number of sections: 4

The Cimarron Fault was described as segmented by Lettis and others (1996), but studies were not extensive enough on each section of the fault to warrant designation as a segmented fault in this database. The Cimarron Fault is herein divided into four sections that show evidence for Quaternary movement. They include include from west to east, the Bostwick Park section, the Ellison Gulch section, the Poverty Mesa section, and the Blue Mesa section. A fifth section, the Powderhorn section, has moved during the late Tertiary but lacks evidence of Quaternary movement. Therefore, it is not discussed herein.

Structure number: Q40b

Section name: Ellison Gulch Scarp Section

Lettis and others (1996) referred to this section as the Ellison Gulch scarp of the northwest end of the Cimarron Fault.

Reliability of location: Good

Comments: The Ellison Gulch Scarp section of the Cimarron Fault was mapped at 1:250,000 by Lettis and others (1996). The trace used herein is from Lettis and others (1996).

Sense of movement: N

Comments:

Dip:

Comments:

Dip direction:

Geomorphic expression:

This section of the Cimarron Fault is marked by a 1- to 2-m-high scarp in late Pleistocene to Holocene fan deposits near Ellison Gulch (Lettis and others, 1996).

Age of faulted deposits:

Late Pleistocene to Holocene fan deposits are offset by the scarp (Lettis and others, 1996).

Detailed studies:

No detailed studies have been conducted on this section.

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

Comments: Lettis and others (1996) indicated late Pleistocene to Holocene fan deposits are offset by the Ellison Gulch Scarp section. Although they tentatively concluded that the scarp is related to slope failure they also suggested "it may reflect secondary deformation along the southern end of the Bostwick Park section."

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Lettis and others (1996) reported a 1- to 2-m-high scarp in late Pleistocene to Holocene deposits. Based on this information a slip rate of <0.2 mm/yr is estimated for this section of the Cimarron Fault.

Earthquake notes:

References Cited:

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Q40c - Cimarron Fault: Poverty Mesa Section

Structure type: Sectioned fault

Structure number: Q40c

Comments: Fault 2290c in the U.S. Geological Survey Quaternary fault and fold database

Structure name: Cimarron Fault

Comments: The Cimarron Fault is a northeast-trending trending fault between Montrose and Blue Mesa Reservoir. Much of the fault is parallel to Highway 50 and the Gunnison River. The fault begins at the south end of the Black Canyon of the Gunnison National Monument and continues southeast past Iron Hill where it terminates south of Huntsman Mesa. This description addresses only the Poverty Mesa section of the fault, which extends for about 23 km from Ellison Gulch to Fitzpatrick Mesa.

Synopsis:

Lettis and others (1996) referred to this section as the Poverty Mesa section of the Cimarron Fault. It is defined by a 300-m-high escarpment as well as multiple uphill-facing scarps, lineations, and ponded sediments. This section of the fault was studied in detail at two locations. A scarp at their site 11 on the flank of Poverty Mesa was examined but not trenched. This scarp was determined to be a tectonic feature of late Quaternary age. Four trenches were excavated across a scarp at the Curecanti site (their site 12) southeast of Morrow Point Dam. Offset of late Pleistocene colluvium and a Bt soil (100 to 200 ka) was revealed by the trench investigations. Lettis and others (1996) concluded that uphill-facing scarps at site 12 were probably the result of slope failure but did not rule out the possibility of tectonic activity along the larger escarpment. The Poverty Mesa section is herein considered a possible late Quaternary feature.

Date of compilation: 11/17/97

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

State: Colorado

County: Montrose, Gunnison

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T48N,R93W-T49N,R91W

Strike: N58W

Number of traces: 2

End to end length: 24.09 km

Cumulative length: 27.39 km

Geologic setting:

The Cimarron Fault was described by Lettis and others (1996) as a high-angle normal fault. This section of the fault is down to the northeast. Throw on this section is not consistent with local topography, as Poverty Mesa forms a topographic high on the down-thrown (northeast) side of the fault. Lettis and others (1996) suggested this section of the Cimarron Fault may merge with the Red Rocks Fault at a depth of 5 to 9 km and then may flatten to merge with a blind thrust or detachment at a depth of 8 to 10 km.

Number of sections: 4

The Cimarron Fault was described as segmented by Lettis and others (1996), but studies were not extensive enough on each section of the fault to warrant designation as a segmented fault in this database. The Cimarron Fault is herein divided into four sections that show evidence for Quaternary movement. They include include from west to east, the Bostwick Park section, the Ellison Gulch section, the Poverty Mesa section, and the Blue Mesa section. A fifth section, the Powderhorn section, has moved during the late Tertiary but lacks evidence of Quaternary movement. Therefore, it is not discussed herein.

Structure number: Q40c

Section name: Poverty Mesa Section

Lettis and others (1996) referred to this section as the Poverty Mesa segment of the Cimarron Fault. As discussed previously, fault segments described by Lettis and others (1996) are herein refered to as sections.

Reliability of location: Good

Comments: This section of the Cimarron Fault was mapped at a scale of 1:31,680 by Hansen (1971), 1:24,000 and 1:250,000 by Lettis and others (1996), and 1:250,000 by Tweto and others (1976). The trace used herein is from Lettis and others (1996).

Sense of movement: N

Comments: The Poverty Mesa section of the Cimarron Fault is a northeast-dipping fault with reverse movement during the Laramide (Hansen, 1971) and normal movement during the Neogene (Lettis and others, 1996).

Dip: 65°-70°NE

Comments: A cross section by Hansen (1971) showed a dip of about 70° for the Poverty Mesa section.

Dip direction: NE

Geomorphic expression:

The Poverty Mesa section is well defined by a south-facing, 300-m-high escarpment, numerous north-facing (uphill), 5- to 20-m-high scarps in landslide deposits, vegetation lineaments, and ponded sediments (Lettis and others, 1996).

Age of faulted deposits:

Quaternary landslide deposits and middle to late Pleistocene colluvium (50 to 100 ka) are offset across the fault, but Holocene deposits are not offset (Lettis and others, 1996).

Detailed studies:

Lettis and others (1996) conducted paleoseismic investigations in four trenches that they labeled CST-1 through CST-4, located at the Curecanti site (their site 12) southeast of the town of Cimarron. The location of these trenches is generalized and represented by a single trench labeled Q40-C-1 on the accompanying map. The trenches cross a northeast-facing scarp which ranges from 8-35 m high, and a linear trough in between the scarp and the southwest-facing escarpment. The trenches were not described individually by Lettis and others (1996), rather a geologic summary is given based on the combined findings in the four trenches. They presented the following sequence of events for activity along the fault trace:

1. Deposition of late Pleistocene colluvium.
2. Formation of a Bt soil horizon estimated to be 100 to 200 ka or slightly younger.

3. Development of the scarp and back-tilting of Pleistocene deposits toward the axis of the trough.
4. Deposition of undeformed Holocene colluvial and fluvial sediments.

Lettis and others (1996) concluded that the fault scarp at this location is 50 to100 ka but is probably not tectonic in origin. Formation of the scarp was attributed to slope failure based on the following:

- Most scarps in this area were discontinuous and closely associated with landslides.
- Scarps were coincident with the steepest part of the escarpment in an area of extensive slope failure in the Mancos Shale.
- There was no evidence for brittle faulting or shearing in Pleistocene or Holocene deposits.
- The scarp formed during a discrete time period (between 100 to 400 ka and 8 ka), which suggested a single-event landslide origin rather than a multiple-event tectonic origin.
- A single-event tectonic origin would require about a magnitude 8 earthquake to produce the 8- to 35-m-high scarp. Such a large earthquake is unlikely for a relatively short section of fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: The scarp at their site 11 was considered by Lettis and others (1996) to be a tectonic feature based on offset at the toe of a landslide, ponded sediments, and extension of the scarp and lineaments beyond the margins of the landslide. Trench investigations at the Curecanti site (site 12) revealed offset of a Bt soil horizon dated at 100 to 200 ka, with no offset of Holocene or younger deposits. Lettis and others (1996) suggested that most of the uphill-facing scarps at their site 12 were related to landslides rather than to tectonic forces but did not rule out the possibility of tectonic movement along the larger escarpment.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: A slip rate of <0.2 mm/yr is estimated for this section of the fault based on a maxium scarp height of 35 m and an average scarp age of 150 ka (Lettis and others, 1996).

Earthquake notes:

The Cimarron Fault may be capable of generating a magnitude 6 3/4 earthquake (Unruh and others, 1993a).

References Cited:

Hansen, W.R., 1971, Geologic map of the Black Canyon of the Gunnison River and vicinity, western Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-584.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Unruh, J.R., Noller, J.S., Lettis, W.R., Sawyer, T.L., and Bott, J.D.J., 1993a, Quaternary faults of the Central Rocky Mountains, Colorado; a new seismotectonic evaluation [abs.]: Geological Society of America Abstracts with Programs, v. 25, no. 5, p. 157.

Q40d - Cimarron Fault: Blue Mesa Section

Structure type: Sectioned fault

Structure number: Q40 d

Comments: Fault 94 in Kirkham and Rogers (1981); fault 2290d in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Cimarron Fault

Comments: The Cimarron Fault is a northeast-trending trending fault between Montrose and Blue Mesa Reservoir. Much of the fault is parallel to Highway 50 and the Gunnison River. The fault begins at the south end of the Black Canyon of the Gunnison National Monument and continues southeast past Iron Hill where it terminates south of Huntsman Mesa. This description addresses only the Blue Mesa section of the fault, which extends for about 22 km from Fitzpatrick Mesa to Gateview as defined by Lettis and others (1996).

Synopsis:

Lettis and others (1996) refer to this 22-km-long section as the Blue Mesa section of the Cimarron Fault. It is defined by a 1-km-wide graben with low relief. Three trenches were excavated across this section by Lettis and others (1996) near Willow Creek Mesa. Trenching investigations revealed Oligocene to Pliocene volcanics are offset across the fault and Quaternary deposits dated at 33.4 ka. are back-tilted against the fault.

Date of compilation: 11/17/97

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

State: Colorado

County: Gunnison

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T47N,R90W-T48N,R88W

Strike: N63W

Number of traces: 2

End to end length: 22.47 km

Cumulative length: 38.21 km

Geologic setting:

The Cimarron Fault was described by Lettis and others (1996) as a high-angle reverse fault with late Tertiary to possibly Holocene normal movement. The Blue Mesa section of the Cimarron Fault forms a graben with throw down to the northeast and southwest on northwest-trending high-angle faults.

Number of sections: 4

The Cimarron Fault was described as segmented by Lettis and others (1996), but studies were not extensive enough on each section of the fault to warrant designation as a segmented fault in this database. The Cimarron Fault is herein divided into four sections that show evidence for Quaternary movement. They include include from west to east, the Bostwick Park section, the Ellison Gulch section, the Poverty Mesa section, and the Blue

Mesa section. A fifth section, the Powderhorn section, has moved during the late Tertiary but lacks evidence of Quaternary movement. Therefore, it is not discussed herein.

Structure number: Q40d

Section name: Blue Mesa Section

Lettis and others (1996) referred to this section as the Blue Mesa segment of the Cimarron Fault. As discussed previously, fault segments described by Lettis and others (1996) are herein refered to as sections.

Reliability of location: Good

Comments: This section of the Cimarron Fault was mapped at a scale of 1:31,680 by Hansen (1971), 1:24,000 and 1:250,000 by Lettis and others (1996), 1:250,000 by Tweto and others (1976), and 1:1,000,000 by Colman (1985). Part of this section was also mapped at1:24,000 by Olson and Hedlund (1973). The trace used herein is from Lettis and others (1996).

Sense of movement: N

Comments: Lettis and others (1996) suggested normal Neogene movement on the Cimarron Fault.

Dip: 65°-70°

Comments: A cross section by Hansen (1971) showed a dip of 65° to 70° NE for the southern fault in this section.

Dip direction: NE,SW

Geomorphic expression:

The Blue Mesa section is defined by a 1-km-wide graben with low relief, low scarps, closed depressions, and poorly developed drainages (Lettis and others, 1996).

Age of faulted deposits:

Oligocene to Pliocene volcanics are offset across the fault and late Pleistocene (33.4 ka) carboniferous sediments are back-tilted against the fault (Lettis and others, 1996).

Detailed studies:

Lettis and others (1996) conducted paleoseismic investigations in three trenches near Willow Creek Mesa. Two trenches (their WCT-1 and WCT-3) are on prominent northeast-facing scarps, and one trench (their WCT-2) is on a more subtle southwest-facing scarp and vegetation lineament. These trenches are labeled Q40-d-1 through Q40-d-3 on the accompanying map for this database.

Q40-d-1 (WCT-1): This trench revealed that the Blue Mesa section offsets Tertiary volcanic tuff against Tertiary rhyolitic tuff. These rocks were overlain by 1.5 m of scarp-derived colluvium that contains two burried Bt soil horizons. The absense of faulting in the upper soil indicated that the fault has not been active during the late Pleistocene or Holocene.

Q40-d-2 (WCT-2): This trench exposed coarse fluvial deposits over Tertiary volcanic tuff. The lineament and scarp at this location coincide with the coarse fluvial deposits. Lettis and others (1996) concluded that these features originated from non-tectonic fluvial deposits.

Q40-d-3 (WCT-3): Quaternary colluvial and fluvial deposits overlie Tertiary volcanics in this trench. The contact between the Quaternary deposits and bedrock was sheared and some of the Quaternary beds are back-tilted against the fault. The youngest tilted bed yielded a C-14 age of 33,400 B.P. The shear plane dips gently at the base of the trench and steepens near the surface, suggesting listric movement of a rotational slump block. Striations on the shear plane indicated nearly pure dip slip.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Trenching investigations and age dating by Lettis and others (1996) indicated that 33.4 ka Quaternary deposits are tilted against the fault. The most most recent movement on the fault occurred after deposition of the 33.4 ka sediments and prior to the formation of a Bt soil horizon estimated to be 10 ka.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Scarp height in late Pleistocene deposits was not reported by Lettis and others (1996). Based on slip rates calculated for others sections on the Cimarron Fault, a slip rate of <0.2 mm/yr is estimated for this section.

Earthquake notes:

The Cimarron Fault may be capable of generating a magnitude 6 3/4 earthquake (Unruh and others, 1993a).

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Hansen, W.R., 1971, Geologic map of the Black Canyon of the Gunnison River and vicinity, western Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-584.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

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Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Unruh, J.R., Noller, J.S., Lettis, W.R., Sawyer, T.L., and Bott, J.D.J., 1993a, Quaternary faults of the Central Rocky Mountains, Colorado; a new seismotectonic evaluation [abs.]: Geological Society of America Abstracts with Programs, v. 25, no. 5, p. 157.

Structure type: Sectioned fault

Structure number: Q56 a-b

Comments: Faults 159, 160, 164, and 165 in Kirkham and Rogers (1981); fault 'G' in Knepper (1974b); faults 148, 149, 151, 184, 185, and 357 in Witkind (1976); faults 2308a-b in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Sawatch Fault

Comments: The Sawatch Fault is comprised of a series of more than 16 generally north-trending faults. The faults form the eastern margin of the Sawatch Range between Leadville and Salida. Until recently, the south section of the fault was known as the Sawatch Fault (e.g. Witkind, 1976; Kirkham and Rogers, 1981), and the faults comprising the north section of the fault were as yet unnammed. Ostenaa and others (1981) described the Sawatch Fault as bounding the upper Arkansas Valley, which they further subdivided into the north Arkansas Graben and the south Arkansas Graben. Unruh and others (1992) used these physiographic divisions to define their north and south segments of the Sawatch Fault, which they termed the Northern Sawatch Fault and the Southern Sawatch Fault. Although this fault has been described in the literature as segmented (Unruh and others, 1992; Lettis and others, 1996), studies are not extensive enough on each section of the fault to warrant designation as a segmented fault. The fault is therefore herein described as a sectioned fault.

Synopsis:

The Sawatch Fault is a range-front fault on the east side of the Sawatch Range from about Leadville south to the South Arakansas River west of Salida. The faults comprise the western boundary of the upper Arkansas Valley Graben, a Neogene west-tilted structure that forms the northernmost topographically prominent expression of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. The fault is divided into two sections, a northern section and a southern section. Subdued scarps are present in Bull Lake deposits on the northern section of the fault. On the southern section, scarps up to 10 m high are present in Bull Lake deposits, and scarps average about 2 m high in Pinedale deposits. Trenching investigations on the southern section of the fault indicated six surface ruptures since about 150 ka, suggesting a recurrence interval of 10 to 40 ka; the most recent faulting event occurred less than 4 ka (Ostenaa and others, 1981).

Date of compilation: 12/31/97

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

State: Colorado

County: Chaffee

1° x 2° Sheet: Montrose, Leadville

Province: Southern Rocky Mountains

Township and Range: T8S,R81W-T49N,R79W

Strike: N3W

Number of traces: 18

End to end length: 83.68 km

Cumulative length: 85.22 km

Q56a-b - Sawatch Fault: Overview

Geologic setting:

The Sawatch Fault is a high-angle, down-to-the-east normal fault. It lies on the eastern margin of the Sawatch Range between Leadville and Salida and forms the western boundary of the upper Arkansas Valley Graben, a Neogene west-tilted structure that forms the northernmost topographically prominent expression of the Rio Grande Rift. The graben developed along the axial crest of the Laramide Sawatch Anticline. The fault is one of the larger faults in the northern Rio Grande Rift.

Number of sections: 2

Ostenna and others (1981) described the Sawatch fault as bounding two coeval grabens which they referred to as the north Arkansas Graben and the south Arkansas Graben. Unruh and others (1992) used these physiographic divisions to define their northern and southern segments of the Sawatch fault. As discussed previously, fault segments described by Unruh and others (1992), and Lettis and others (1996) are herein refered to as sections.

Structure number: Q56 a-b

Section name: Overview

Unruh and others (1992) used the terms Northern Sawatch fault and Southern Sawatch fault to describe parts of the fault to the north and south of the Twin Lakes area. Herein these sections are simply referred to as the northern and southern sections.

Reliability of location: Good

Comments: Parts of the fault were mapped at a scale of 1:24,000 by Tweto (1974c), 1:62,500 by Tweto and Reed (1973b), 1:125,000 by Tweto and Case (1972), and 1:250,000 by Tweto and others (1976; 1978). The fault was also mapped by Scott (1975b) and Scott and others (1975) at a scale of 1:62,500. The southern section of the fault was mapped by Colman and others (1985) at a scale of 1:125,000.

Sense of movement: N

Comments:

Dip:

Comments: Witkind (1976) reported a NE dip for faults on the east flank of the Collegiate Peaks.

Dip direction: NE

Geomorphic expression:

There are minor scarps in Bull Lake deposits at the south end of the northern section. There are several scarps up to 10 m high in Bull Lake deposits, and 2 m high in Pinedale deposits on the southern section (Ostenaa and others, 1981).

Age of faulted deposits:

Bull Lake deposits are offset on the northern section of the fault, and Bull Lake and Pinedale deposits are offset on the southern section of the fault.

Detailed studies:

Ostenaa and others (1981) conducted paleoseismic trenching investigations in five trenches on the southern section of the Sawatch Fault. See data sheet for Q56b for details.

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

Comments: Scarps are present in Bull Lake (100 to 140 ka) deposits on the northern section, and Bull Lake and Pinedale (10 to 40 ka) glacial deposits on the southern section. Carbon-14 dating by Ostenaa and others (1981) suggested most recent movement on the fault occurred less than 4 ka. Lettis and others (1996) reported latest movement on the fault during the late Pleistocene to Holocene. The northern section of the fault, however, probably has not ruptured during the Holocene (Lettis and others, 1996). The latest movement on the northern section is considered to have occurred during the late Quaternary.

Recurrence interval: 10-40 ka

Comments: Ostenaa and others (1981) calculated a recurrence interval of 10 to 40 ka based on trenching investigations which revealed six surface ruptures since about 150 ka.

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Quaternary displacement on the northern section is less than or comparable to that of the southern section (Ostenaa and others, 1981). Based on 2 m of offset in Pinedale deposits on the southern section, a slip rate of <0.2 mm/yr is estimated for both sections of the fault.

Earthquake notes:

A moment magnitude (Mw) 7 1/4 maximum credible earthquake was reported by Lettis and others (1996) for the Sawatch Fault, assuming both sections rupture during a single event .

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

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Tweto, Ogden, and Reed, J.C., Jr., 1973b, Reconnaissance geologic map of the Mount Elbert 15-minute quadrangle, Lake, Chaffee, and Pitkin Counties, Colorado: U.S. Geological Survey Open-file Report, 73-5279.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

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Unruh, J.R., Sawyer, T.L, and Lettis, W.R., 1992, Seismotectonic evaluation of Green Mountain Dam, Shadow Mountain Dam, Grandby Dam, and Willow Creek Dam, Colorado-Big Thompson Project: unpublished preliminary report prepared by William Lettis & Associates for U.S. Bureau of Reclamation, Denver, Colorado, 78 p.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Sectioned fault

Structure number: Q56 a

Comments: Faults 164 and 165 in Kirkham and Rogers (1981); fault 184 in Witkind (1976); fault 2308a in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Sawatch Fault

Comments: The Sawatch Fault is comprised of a series of more than 16 generally north-trending faults. The faults form the eastern margin of the Sawatch Range between Leadville and Salida. Until recently, the south section of the fault was known as the Sawatch Fault (e.g. Witkind, 1976; Kirkham and Rogers, 1981), and the faults comprising the north section of the fault were as yet unnammed. Ostenaa and others (1981) described the Sawatch Fault as bounding the upper Arkansas Valley, which they further subdivided into the north Arkansas Graben and the south Arkansas Graben. Unruh and others (1992) used these physiographic divisions to define their north and south segments of the Sawatch Fault, which they termed the Northern Sawatch Fault and the Southern Sawatch Fault. Although this fault has been described in the literature as segmented (Unruh and others, 1992; Lettis and others, 1996), studies are not extensive enough on each section of the fault to warrant designation as a segmented fault. The fault is therefore herein described as a sectioned fault. This description addresses only the northern section of the Sawatch Fault, which extends from near Leadvile to Quail Mountain south of the Twin Lakes area.

Synopsis:

The Sawatch Fault is a range-front fault on the east side of the Sawatch Range between Leadville and Salida. The fault is divided into two sections, a north section and a south section. This description addresses only the northern section of the Sawatch Fault, which extends from near Leadvile to Quail Mountain south of the Twin Lakes area. Subdued scarps are present in Bull Lake deposits at the south end of the northern section of the Sawatch Fault. A recurrence interval of 10 to 40 ka was reported for both sections of the Sawatch Fault based on trenching investigations conducted on the southern section by Ostenaa and others (1981).

Date of compilation: 12/31/97

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

State: Colorado

County: Lake, Chaffee

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T8S,R81W-T12S,R80W

Strike: N3W

Number of traces: 6

End to end length: 33.95 km

Cumulative length: 55.73 km

Geologic setting:

Q56a - Sawatch Fault: Northern Section

The Sawatch Fault is a high-angle, down-to-the-east normal fault. The northern section of the Sawatch Fault extends from near Leadville to the area south of Twin Lakes and bounds the west side of the north Arkansas Graben (Ostenaa and others, 1981).

Number of sections: 2

Ostenna and others (1981) described the Sawatch fault as bounding two coeval grabens which they referred to as the north Arkansas Graben and the south Arkansas Graben. Unruh and others (1992) used these physiographic divisions to define their north and south segments of the Sawatch fault. As discussed previously, fault segments described by Unruh and others (1992), and Lettis and others (1996) are herein refered to as sections.

Structure number: Q56 a

Section name: Northern Section

Unruh and others (1992) used the term Northern Sawatch fault to describe that part of the Sawatch fault that extends north from the Twin Lakes area. Herein this section of the fault is simply referred to as the northern section.

Reliability of location: Good

Comments: The northern section of the Sawatch Fault was mapped by Tweto (1974c) and Tweto and Reed (1973b) at a scale of 1:62,500, by Tweto and Case (1972) at a scale of 1:125,000, and by Tweto and others (1978) and Unruh and others (1992) at a scale of 1:250,000. The trace used herein is from Tweto and others (1978) and Lettis and others (1996).

Sense of movement: N

Comments:

Dip: 72°E

Comments: A dip of 72°E was measured from a cross section by Tweto (1974c).

Dip direction: E

Geomorphic expression:

Minor scarps are present in Bull Lake deposits at the south end of the northern section of the Sawatch Fault (Ostenaa and others, 1981). No scarps or lineaments were found to indicate late Pleistocene activity along the north end of this section (Unruh and others, 1992)

Age of faulted deposits:

Quaternary Bull Lake deposits are displaced on the south end of the northern section of the Sawatch Fault (Ostenaa and others, 1981). Much of the fault is concealed by Holocene and Pleistocene alluvium and glacial drift. About 30% of the fault lies in Precambrian and Miocene bedrock, and the remainder of the fault lies in or beneath Quaternary deposits.

Detailed studies:

No detailed studies have been conducted on this section of the fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: Bull Lake deposits estimated to be 100 to 140 ka are offset at the south end of the northern section of the Sawatch Fault, but 10 to 40 ka Pinedale deposits are not offset, indicating this section of the fault has not been active during the late Pleistocene and Holocene (Ostenaa and others, 1981). Howard and others (1978), Kirkham and Rogers

(1981), and Colman (1985) indicated late Quaternary movement on the north end of this section of the fault.

Recurrence interval: 10-40ka

Comments: Ostenaa and others (1981) calculated a recurrence interval of 10 to 40 ka for both sections of the Sawatch Fault based on trenching investigations on the south section which revealed six surface ruptures since about 150 ka.

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Slip rates for the northern section of the Sawatch Fault have not been published. Quaternary displacement on the northern section is less than or comparable to that of the southern section (Ostenaa and others, 1981). Based on 2 m of offset of 10 to 40 ka Pinedale deposits, a slip rate of 0.05 to 0.2 mm/yr can be calculated for the southern section of the fault. The slip rate for the northern section is therefore also estimated to be <0.2 mm/yr.

Earthquake notes:

Maximum credible earthquake moment magnitudes (Mw) 7 and 6 3/4 were reported for the northern section of the Sawatch fault by Unruh and others (1993) and Lettis and others (1996), respectively.

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Tweto, Ogden, and Reed, J.C., Jr., 1973b, Reconnaissance geologic map of the Mount Elbert 15-minute quadrangle, Lake, Chaffee, and Pitkin Counties, Colorado: U.S. Geological Survey Open-file Report, 73-5279.

Unruh, J.R., Sawyer, T.L, and Lettis, W.R., 1992, Seismotectonic evaluation of Green Mountain Dam, Shadow Mountain Dam, Grandby Dam, and Willow Creek Dam, Colorado-Big Thompson Project: unpublished preliminary report prepared by William Lettis & Associates for U.S. Bureau of Reclamation, Denver, Colorado, 78 p.

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Structure type: Sectioned fault

Structure number: Q56 b

Comments: Fault 159 in Kirkham and Rogers (1981); fault 'G' in Knepper (1974b); faults 148, 149, 151 and 357 in Witkind (1976); fault 2308b in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Sawatch Fault

Comments: The Sawatch Fault is comprised of a series of more than 16 generally north-trending faults. The faults form the eastern margin of the Sawatch Range between Leadville and Salida. Until recently, the south section of the fault was known as the Sawatch Fault (e.g. Witkind, 1976; Kirkham and Rogers, 1981), and the faults comprising the north section of the fault were as yet unnammed. Ostenaa and others (1981) described the Sawatch Fault as bounding the upper Arkansas Valley, which they further subdivided into the north Arkansas Graben and the south Arkansas Graben. Unruh and others (1992) used these physiographic divisions to define their northern and southern segments of the Sawatch Fault which they termed the Northern Sawatch Fault and the Southern Sawatch Fault. Although this fault has been described in the literature as segmented (Unruh and others, 1992; Lettis and others, 1996), studies are not extensive enough on each section of the fault to warrant designation as a segmented fault. The fault is therefore herein described as a sectioned fault. This description addresses only the southern section of the Sawatch Fault which extends from south of the Twin Lakes area to the South Arkansas River west of Salida.

Synopsis:

The Sawatch Fault is a range-front fault on the east side of the Sawatch Range between Leadville and Salida. The fault is divided into two sections, a northern section and a southern section. This description addresses only the southern section of the Sawatch Fault, which extends from south of the Twin Lakes area to the South Arkansas River west of Salida. The youngest and greatest amount of movement on the fault is on the southern section. Scarps up to 10 m high are present in Bull Lake deposits, and scarps average about 2 m high in Pinedale deposits. Trenching investigations at Cottonwood Creek and south of Chalk Creek indicated six surface ruptures since about 150 ka suggesting a recurrence interval of 10 to 40 ka; the most recent faulting event occurred less than 4 ka (Ostenaa and others, 1981).

Date of compilation: 12/31/97

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

State: Colorado

County: Chaffee

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains

Township and Range: T11S,R80W-T49N,R79W

Strike: N3W

Number of traces: 12

End to end length: 41.07 km

Cumulative length: 29.49 km

Q56b - Sawatch Fault: Southern Section

Geologic setting:

The Sawatch Fault is a high-angle, down-to-the-east normal fault. The southern section of the Sawatch Fault extends from the area south of Twin Lakes to the South Arkansas River west of Salida and bounds the west side of the south Arkansas Graben (Ostenaa and others, 1981). En echelon scarps show a left-lateral component of slip (Kirkham and Rogers, 1981).

Number of sections: 2

Ostenna and others (1981) described the Sawatch fault as bounding two coeval grabens which they referred to as the north Arkansas Graben and the south Arkansas Graben. Unruh and others (1992) used these physiographic divisions to define their north and south segments of the Sawatch fault. As discussed previously, fault segments described by Unruh and others (1992), and Lettis and others (1996) are herein refered to as sections.

Structure number: Q56 b

Section name: Southern Section

Unruh and others (1992) used the term Southern Sawatch fault to describe that part of the Sawatch fault that extends south from the Twin Lakes area. Herein this section of the fault is simply referred to as the southern section.

Reliability of location: Good

Comments: The southern section of the Sawatch Fault was mapped by Limbach (1975) at a scale of 1:24,000, by Scott (1975b), and Scott and others (1975) at 1:62,500, by Arestad (1977) at 1:187,500, by Colman and others (1985) at 1:125,000, and by Tweto and others (1976) at 1:250,000. The trace used herein is from Colman and others (1985).

Sense of movement: N

Comments: Limbach (1975) and Witkind (1976) indicated normal movement on this fault system.

Dip: 70°E

Comments: Witkind (1976) reported a NE dip for faults on the east flank of the Collegiate Peaks. A cross section by Limbach (1975) showed a dip of about 70°E just north of Cottonwood Creek.

Dip direction: E

Geomorphic expression:

Numerous scarps are present on the southern section of the Sawatch Fault. Scarps are 8 to 10 m high in Bull Lake deposits and about 2 m high in Pinedale deposits (Ostenaa and others, 1981). The scarps form an en echelon series of left-stepping faults (Kirkham and Rogers, 1981).

Age of faulted deposits:

Scarps up to 10 m high cut Bull Lake deposits and scarps in Pinedale deposits average about 2 m high (Ostenaa and others, 1981). Offset of Quaternary deposits was also shown by Scott (1975b), Scott and others (1975), and Tweto and others (1976). Limbach (1975) reported 3,000 m of Neogene displacement across this section of the Sawatch Fault.

Detailed studies:

Ostenaa and others (1980; 1981) excavated five trenches across scarps in the southern section of the Sawatch Fault. Trench investigations were not discussed individually by

Ostenaa and others (1981), rather, summaries of their findings were presented. The exact location of the trenches was not indicated, therefore, the trench sites are not shown on the accompanying map for this database. Trenches at the Cottonwood trench site near Cottonwood Creek and at the Eddy trench site south of Chalk Creek revealed at least six episodes of surface faulting on the south section in the past 100 to 150 ka. Each event was inferred to have produced less than 0.2 to 0.3 m of surface displacement. The latest event on this section of the fault was carbon-14 dated at less than 4 ka. A recurrence interval of 10 to 40 ka was calculated based on the fault history revealed by the trenching investigations.

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

Comments: Ostenaa and others (1980) carbon-14 dated the most recent faulting event at less than 4 ka. Scarps in Pinedale deposits also suggest Holocene activity on the fault (Ostenaa and others, 1981; Unruh and others, 1992; Lettis and others, 1996). Howard and others (1978) and Kirkham and Rogers (1981) indicated late Quaternary movement on this section of the fault, while Colman (1985) indicated Holocene movement.

Recurrence interval: 10-40ka

Comments: Ostenaa and others (1981) calculated a recurrence interval of 10 to 40 ka based on trenching investigations which revealed six surface ruptures since about 150 ka.

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Maximum slip has been concentrated along the southern section of the fault (Ostenaa and others, 1981). Based on 2 m of offset in 10 to 40 ka Pinedale deposits on the southern section, a slip rate of 0.05 to 0.2 mm/yr can be calculated for this section.

Earthquake notes:

A moment magnitude (Mw) 6 3/4 maximum credible earthquake was assigned to the southern section of the Sawatch Fault (Lettis and others, 1996). Ostenaa and others (1981) reported this section of the fault is capable of an earthquake with a local magnitude of 6.25 to 7.25 based on a maximum probable rupture length of 29 km.

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Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

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Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Sectioned fault

Structure number: Q69 a-d

Comments: Faults 113, 115, and 116 in Kirkham and Rogers (1981); fault 131 in Witkind (1976); fault 3 of Colman (1985); faults 2321a-d in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Northern Sangre de Cristo Fault

Comments: The Sangre de Cristo Fault zone borders the east side of San Luis basin from near Poncha Pass, Colorado, to near Taos, New Mexico. This fault zone has been subdivided into two discrete faults for this compilation; the Northern Sangre de Cristo Fault and the Southern Sangre de Cristo Fault. Most of the Southern Sangre de Cristo Fault lies within New Mexico. The Northern Sangre de Cristo Fault is further subdivided into four sections: the Crestone section; the Zapata section; the Blanca section; and the San Luis section.

Synopsis:

The Northern Sangre de Cristo Fault is a west-dipping normal fault that is the structural boundary between the Sangre de Cristo Range / Culebra Range on the east and the San Luis basin on the west. The fault is divided into four sections for this compilation based on mountain-front geometry and fault-scarp morphology. All four sections show evidence of multiple late Quaternary movements, including ruptures during the Holocene. Scarp profiles are available for all of the sections. The Crestone and Zapata sections have been trenched.

Date of compilation: 6/22/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Saguache, Costilla, Alamosa

1° x 2° Sheet: Trinidad, Pueblo

Province: Southern Rocky Mountains

Township and Range: Costilla County

Strike: N19W

Number of traces: ~6

End to end length: 163.58 km

Cumulative length: 203.36 km

Geologic setting:

The Northern Sangre de Cristo Fault is a major down-to-west normal fault within the Rio Grande Rift. It forms the eastern boundary of the east-tilted half-graben of San Luis basin. The deepest part of San Luis basin lies adjacent to the Northern Sangre de Cristo Fault (Gaca and Karig, 1965). Estimates of the maximum thickness of synorogenic basin fill in that part of San Luis basin have widely ranged. Gaca and Karig (1965) suggested a maximum thickness of about 9.7 km; Huntley (1976a; 1976b) reported it at about 5 km; Stoughton

(1977) at 6,000 m; and Kluth and Schaftenaar (1994) at 6.4 km. Estimates of the amount of vertical displacement on the Northern Sangre de Cristo Fault also vary widely. Recently Kluth and Schaftenaar (1994) suggested the Northern Sangre de Cristo Fault has approximately 9.2 km of vertical separation.

Number of sections: 4

McCalpin (1982) defined three segments for part of the Northern Sangre de Cristo Fault from Poncha Pass to the south side of the Blanca Peak Massif. These three segments are herein called sections. A fourth section extends generally southward from the south side of the Blanca Peak Massif to Jarosa Creek near the Colorado - New Mexico state line. Jack Benjamin and Associates and Geomatrix Consultants (1996) suggested the Crestone section used herein should be sub-segmented into a 38-km-long segment north of the Major Creek / Kerber Creek thrust fault zone, and a 52-km-long segment south of it, but this additional sub-segmenting, although perhaps valid, has not been used in this compilation.

Structure number: Q69 a-d

Section name: Overview

The Northern Sangre de Cristo Fault is subdivided into four sections. They include from north to south: the Crestone section; the Zapata section; the Blanca section; and the San Luis section.

Reliability of location: Good

Comments: Portions of the Northern Sangre de Cristo Fault were mapped by Wychgram (1972; scale 1:24,000), Tweto and others (1976; scale 1:250,000), Witkind (1976; scale 1:500,000), Scott and others (1978; scale 1:250,000), Kirkham and Rogers (1981; scale 1:500,000), McCalpin (1982; scale 1:50,000), Colman and others (1985; scale 1:125,000) and Wallace (1997a; scale 1:24,000). Fault traces are primarily from McCalpin (1982) and Colman and others (1985).

Sense of movement: N

Comments: All four sections show normal movement.

Dip: 60°W

Comments: A dip of 60° is reported for the Crestone and Zapata sections (Kluth and Schaftenaar, 1994). Fault dip on the Blanca and San Luis sections is not reported in the literature. Morel and Watkins (1997) described evidence that the Crestone section is a low-angle detachment fault that flattens to subhorizontal in Precambrian rocks.

Dip direction: W

Geomorphic expression:

The Northern Sangre de Cristo Fault is defined by several discontinuous scarps on all four sections of the fault.

Age of faulted deposits:

Trenching investigations and carbon-14 dating by McCalpin (1981a; 1982) indicated offset of Holocene fan alluvium along the Crestone section. Similar age deposits are offset by 2 m across the Zapata section, and deposits ranging in age from mid-late Pinedale to Bull Lake are displaced by the Blanca section (McCalpin, 1981a; 1982). Pre-Bull Lake to Holocene deposits are offset by the San Luis section (Kirkham and Rogers, 1981; Colman and others, 1985; Wallace, 1997a).

Detailed studies:

Trenching investigations were conducted on the Crestone and Zapata sections of the Northern Sangre de Cristo Fault. See data sheets Q69a and Q69b for more details. Scarp profiles were measured at all four sections by McCalpin (1981a; 1982) and Colman and others (1985).

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

Comments: All four sections of the Northern Sangre de Cristo Fault show evidence of Holocene movement. Age of movement is well constrained by trenching investigations, carbon-14 dating, and scarp profiling conducted by McCalpin (1981a; 1982).

Recurrence interval:

Comments: See data presented for each section.

Slip rate: unknown; (D) <0.2 mm/yr

Comments: McCalpin (1981a; 1982) calculated an average slip rate of 44 mm in 1 ka (0.044 mm/yr) for the Willow Creek area of the Crestone section. Based on this calculation and geologic information for the other sections, a slip rate of <0.2 mm/yr is estimated for each of the sections of the Northern Sangre de Cristo Fault.

Earthquake notes:

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Structure type: Sectioned fault

Structure number: Q69a

Comments: Fault 116 in Kirkham and Rogers (1981); fault 131 in Witkind (1976); fault 3 of Colman (1985); fault 2321a in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Northern Sangre de Cristo Fault

Comments: The Sangre de Cristo Fault zone borders the east side of San Luis basin from near Poncha Pass, Colorado, to near Taos, New Mexico. This fault zone has been subdivided into two discrete faults for this compilation; the Northern Sangre de Cristo Fault and the Southern Sangre de Cristo Fault. Most of the Southern Sangre de Cristo Fault lies within New Mexico. The Northern Sangre de Cristo Fault is further subdivided into four sections: the Crestone section; the Zapata section; the Blanca section; and the San Luis section. This description focuses on the Crestone section, which extends from near Poncha Pass on the north to the Great Sand Dunes National Monument on the south.

Synopsis:

The Northern Sangre de Cristo Fault is a west-dipping normal fault that is the structural boundary between the Sangre de Cristo Range / Culebra Range on the east, and the San Luis Basin on the west. The Crestone section of the fault is marked by several discontinuous, prominent, west-facing scarps and striking triangular faceted spurs on the mountain front. Holocene fan alluvium are the youngest deposits offset by the fault. McCalpin (1981a; 1982) and Colman and others (1985) profiled several scarps on this section, and three trenches were excavated by McCalpin (1981a; 1982).

Date of compilation: 6/22/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Saguache

1° x 2° Sheet: Pueblo, Trinidad

Province: Southern Rocky Mountains

Township and Range: Costilla County

Strike: N30W

Number of traces: ~2

End to end length: 79.01 km

Cumulative length: 78.75 km

Geologic setting:

The Northern Sangre de Cristo Fault is a major down-to-west normal fault within the Rio Grande Rift. It forms the eastern boundary of the east-tilted half-graben of San Luis basin. The deepest part of San Luis basin lies adjacent to the Northern Sangre de Cristo Fault (Gaca and Karig, 1965). Estimates of the maximum thickness of synorogenic basin fill in that part of San Luis basin have widely ranged. Gaca and Karig (1965) suggested a maximum thickness of about 9.7 km; Huntley (1976a; 1976b) reported it at about 5 km; Stoughton

(1977) at 6,000 m; and Kluth and Schaftenaar (1994) at 6.4 km. Estimates of the amount of vertical displacement on the Northern Sangre de Cristo Fault also vary widely. Recently Kluth and Schaftenaar (1994) suggested the Northern Sangre de Cristo Fault has approximately 9.2 km of vertical separation.

Number of sections: 4

McCalpin (1981a; 1982) defined three segments for part of the Northern Sangre de Cristo Fault from near Poncha Pass to the south side of the Blanca Peak Massif. These three segments are herein called sections. A fourth section extends generally southward from the south side of the Blanca Peak Massif to Jarosa Creek near the Colorado - New Mexico state line. Jack Benjamin and Associates and Geomatrix Consultants (1996) suggested the Crestone section used herein should be sub-segmented into a 38-km-long segment north of the Major Creek / Kerber Creek thrust fault zone, and a 52-km-long segment south of it, but this additional sub-segmenting, although perhaps valid, has not been used in this compilation.

Structure number: Q69a

Section name: Crestone Section

The Crestone section of the Northern Sangre de Cristo Fault corresponds to segment 'A' of McCalpin (1982). The name "Crestone section" is first used in this compilation. This section was recognized as a young fault by Scott (1970) and has been studied by several investigations, including Wychgram (1972), Huntley (1976a; 1976b), Kirkham and Rogers (1981), McCalpin (1981a; 1982), and Colman and others (1985).

Reliability of location: Good

Comments: All or parts of this section were mapped by Wychgram (1972; scale 1:24,000), McCalpin (1982; scale 1:50,000), Colman and others (1985; scale 1:125,000), Tweto and others (1976; scale 1:250,000), Scott and others (1978; scale 1:250,000), Witkind (1976; scale 1:500,000), Kirkham and Rogers (1981; scale 1:500,000), and Colman (1985; scale 1:1,000,000). The trace used for this compilation is from Colman and others (1985).

Sense of movement: N

Comments:

Dip: 60°W

Comments: The dip of the Crestone section of the Northern Sangre de Cristo Fault is debatable. Scott (1970) suggested it is near vertical. Tweto (1979a), Burroughs (1981), and Brister and Gries (1994) described it as a high-angle fault, a value supported by trench exposures mapped by McCalpin (1981a; 1982). Based on seismic reflection and gravity data, Kluth and Schaftenaar (1994) concluded the fault dip is about 60°, the value used herein. Morel and Watkins (1997), using seismic reflection and drill hole data, reported it is a low-angle detachment fault that flattens to subhorizontal in Precambrian rocks.

Dip direction: W

Geomorphic expression:

A series of discontinuous, prominent, west-facing scarps are developed in late Quaternary deposits along the Crestone section of this fault. The mountain front is marked by striking triangular faceted spurs (Kirkham and Rogers, 1981; McCalpin, 1982).

Age of faulted deposits:

Scarps associated with the Crestone section cut pre-Bull Lake, Bull Lake, Pinedale, and

Holocene fan alluvium in several areas along the fault (Kirkham and Rogers, 1981; McCalpin, 1981a; 1982).

Detailed studies:

McCalpin (1981a; 1982) and Colman and others (1985) profiled several scarps on the Crestone section. Three trenches were also excavated across this section by McCalpin (1981; 1982) and are herein labeled trenches Q69a-1 to Q69a-3. Trench Q69a-1 was excavated at Major Creek, and trenches Q69a-2 and Q69a-3 were excavated at Willow Creek.

Q69a-1: This trench crossed the fault at Major Creek and displayed evidence of two fault movements that were constrained in time by two carbon-14-dates.

Q69a-2: This trench was excavated in Holocene fan alluvium near Willow Creek and contained evidence of one fault rupture with 2.3 m of displacement.

Q69a-3: This trench was excavated in Bull Lake alluvium near Willow Creek and exposed evidence of perhaps three rupture events.

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

Comments: Trench Q69a-1 at Major Creek (McCalpin, 1981a; 1982) indicated the latest rupture occurred shortly before 7.66 ± 0.12 ka and that a second movement occurred before 10.1 ± 0.11 ka.

Recurrence interval: 5.0-11.7 ka

Comments: McCalpin (1981a; 1982) suggested the part of the Crestone section south of the Major Creek / Kerber Creek fault zone has a recurrence interval of 5.0 to 11.7 ka during post-early Pinedale time, whereas the part north of this fault zone has a slower uplift rate and longer recurrence interval. He reported that the recurrence interval appears to be longer during Pinedale to Bull Lake time and during pre-Bull Lake time.

Slip rate: (D) <0.2 mm/yr

Comments: McCalpin (1981a; 1982) reported an average slip rate of 44 mm in 1 ka (0.044 mm/yr) for the Willow Creek area.

Earthquake notes:

References cited:

Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa Basin (northern San Luis Basin), Rio Grande Rift, south-central Colorado, 'in' Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift: Structure, stratigraphy and tectonic setting: Geological Society of America Special Publication 291, p. 39-58.

Burroughs, R.L., 1981, A summary of the geology of the San Luis Basin, Colorado-New Mexico, with emphasis on the geothermal potential for the Monte Vista Graben: Colorado Geological Survey Special Publication 17, 30 p.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Colman, S.M., McCalpin, James, Ostenaa, D.A., and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande Rift, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1594.

Gaca, J.R., and Karig, D.E., 1965, Gravity survey in the San Luis Valley area, Colorado: U.S. Geological Survey Open-file Report.

Huntley, David, 1976a, Groundwater recharge to the aquifers of the northern San Luis Valley, Colorado: Golden, Colorado, Colorado School of Mines, Ph.D. dissertation T-1864, 298 p.

Huntley, David, 1976b, Ground water recharge to aquifers of northern San Luis Valley, Colorado--a remote sensing investigation: Colorado School of Mines Remote Sensing Report, v. 76-3, 247 p.

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Kluth, C.F., and Schaftenaar, C.H., 1994, Depth and geometry of the northern Rio Grande Rift in the San Luis Basin, south-central Colorado, 'in' Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift - Structure, stratigraphy and tectonic setting: Geological Society of America Special Paper 291, p. 27-37.

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McCalpin, J.P., 1982, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Colorado School of Mines Quarterly, v. 77, no. 3, 97 p.

Morel, J., and Watkins, T., 1997, More data point to potential in S. Colorado sub-basin: Oil and Gas Journal, v. 95, no. 35, p. 78-80.

Scott, G.R., 1970, Quaternary faulting and potential earthquakes in east-central Colorado, in Geological Survey research 1970, chapter C: U.S. Geological Survey Professional Paper 700-C, p. C11-C18.

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Stoughton, Dean, 1977, Interpretation of seismic reflection data from the San Luis Valley, south-central Colorado: Golden, Colorado, Colorado School of Mines, M.S. Thesis T-1960, 100 p.

Tweto, Ogden, 1979a, The Rio Grande Rift system in Colorado, 'in' Riecker, R.E., ed., Rio Grande Rift: Tectonics and magmatism: American Geophysical Union, Washington, D.C., p. 33-56.

Tweto, Ogden, Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Wychgram, D.C., 1972, Geologic remote sensing study of the Hayden Pass-Orient mine area, northern Sangre de Cristo Mountains, Colorado: Colorado School of Mines Remote Sensing Report, v. 72-3.

Structure type: Sectioned fault

Structure number: Q69 b

Comments: Fault 116 in Kirkham and Rogers (1981); fault 131 in Witkind (1976); fault 3 of Colman (1985); fault 2321b in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Northern Sangre de Cristo Fault

Comments: The Sangre de Cristo Fault zone borders the east side of San Luis basin from near Poncha Pass, Colorado, to near Taos, New Mexico. This fault zone has been subdivided into two discrete faults for this compilation; the Northern Sangre de Cristo Fault and the Southern Sangre de Cristo Fault. Most of the Southern Sangre de Cristo Fault lies within New Mexico. The Northern Sangre de Cristo Fault is further subdivided into four sections: the Crestone section; the Zapata section; the Blanca section; and the San Luis section. This description focuses on the Zapata section, which extends from the Great Sand Dunes National Monument on the north to Hobrook Creek on the south.

Synopsis:

The Northern Sangre de Cristo Fault is a west-dipping normal fault that is the structural boundary between the Sangre de Cristo Range / Culebra Range on the east, and the San Luis Basin on the west. The Zapata section of the fault is marked by several discontinuous scarps. Pinedale and Holocene deposits are offset by the fault. McCalpin (1982) and Colman and others (1985) profiled several scarps on this section, and one trench was excavated across the fault by McCalpin (1981a; 1982).

Date of compilation: 6/22/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Alamosa, Saguache

1° x 2° Sheet: Trinidad

Province: Southern Rocky Mountains

Township and Range: Costilla County

Strike: N3E

Number of traces: 18

End to end length: 25.81 km

Cumulative length: 29.90 km

Geologic setting:

The Northern Sangre de Cristo Fault is a major down-to-west normal fault within the Rio Grande Rift. It forms the eastern boundary of the east-tilted half-graben of San Luis basin. The deepest part of San Luis basin lies adjacent to the Northern Sangre de Cristo Fault (Gaca and Karig, 1965). Estimates of the maximum thickness of synorogenic basin fill in that part of San Luis basin have widely ranged. Gaca and Karig (1965) suggested a maxium thickness of about 9.7 km; Huntley (1976a; 1976b) reported it at about 5 km; Stoughton (1977) at 6,000 m; and Kluth and Schaftenaar (1994) at 6.4 km. Estimates of the amount of vertical displacement on the Northern Sangre de Cristo Fault also vary widely. Recently Kluth and Schaftenaar (1994) suggested the Northern Sangre de Cristo Fault has approximately 9.2 km of vertical separation.

Number of sections: 4

McCalpin (1981a; 1982) defined three segments for part of the Northern Sangre de Cristo Fault from near Poncha Pass to the south side of the Blanca Peak Massif. These three segments are herein called sections. A fourth section extends generally southward from the south side of the Blanca Peak Massif to Jarosa Creek near the Colorado - New Mexico state line.

Structure number: Q69b

Section name: Zapata Section

The Zapata section was named during this compilation. It corresponds to segment 'B' of McCalpin (1982).

Reliability of location: Good

Comments: All or parts of this section were mapped by McCalpin (1982; scale 1:50,000), Colman and others (1985; scale 1:125,000), Witkind (1976; scale 1:500,000), and Kirkham and Rogers (1981; scale 1:500,000). The trace used for this compilation is from Colman and others (1985).

Sense of movement: N

Comments:

Dip: 60°W

Comments: The dip of the Zapata section is poorly understood. Tweto (1979a), Burroughs (1981), and Brister and Gries (1994) described the fault as high angle, an interpretation supported by the trench exposures mapped by McCalpin (1981a; 1982). Using seismic reflection and gravity data, Kluth and Schaftenaar (1994) concluded the fault dip is about 60°, the value used herein.

Dip direction: W

Geomorphic expression:

The northern part of this section of the fault is characterized by fairly prominent, discontinuous scarps, but they are less numerous south of North Zapata Creek (McCalpin, 1982; Colman and others, 1985). In the northern part, the scarps are generally at or near the range front, but the most prominent scarp in the southern part lies about 1.2 km west of the range front (1981a; McCalpin, 1982).

Age of faulted deposits:

McCalpin (1981a; 1982) reported that Pinedale and Holocene deposits are faulted along the Zapata section.

Detailed studies:

McCalpin (1981a; 1982) and Colman and others (1985) profiled several scarps on the Zapata section. One trench was also excavated across this section by McCalpin (1981a; 1982) and is herein labeled as trench Q69b-1. This trench was excavated at Uracca Creek.

Q69b-1: This trench was excavated across a Holocene scarp near Uracca Creek that is about 1.2 km west of the range front. The fault exposed in this trench moved about 2.0 m during a single event between 8.0 and 5.64 ka (McCalpin, 1981a; 1982), which is similar in time and perhaps contemperaneous with the last fault event at Major Creek on the Crestone section.

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

Comments: Based on trenching of a scarp on Uracca Creek about 1.2 km west of the range front, McCalpin (1981a; 1982) reported the last rupture on this section occurred between 8.0 and 5.64 ± 0.1 ka.

Recurrence interval: 8.0 ka

Comments: McCalpin (1981a; 1982) suggested the post-Pinedale recurrence interval for this section is about 8.0 ka, but may be much longer (21.5 to 47.5 ka) during pre-Bull Lake or Pinedale to Bull Lake time.

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa Basin (northern San Luis Basin), Rio Grande Rift, south-central Colorado, 'in' Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift: Structure, stratigraphy and tectonic setting: Geological Society of America Special Publication 291, p. 39-58.

Burroughs, R.L., 1981, A summary of the geology of the San Luis Basin, Colorado-New Mexico, with emphasis on the geothermal potential for the Monte Vista Graben: Colorado Geological Survey Special Publication 17, 30 p.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Colman, S.M., McCalpin, James, Ostenaa, D.A., and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande Rift, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1594.

Gaca, J.R., and Karig, D.E., 1965, Gravity survey in the San Luis Valley area, Colorado: U.S. Geological Survey Open-file Report.

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Huntley, David, 1976b, Ground water recharge to aquifers of northern San Luis Valley, Colorado--a remote sensing investigation: Colorado School of Mines Remote Sensing Report, v. 76-3, 247 p.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Kluth, C.F., and Schaftenaar, C.H., 1994, Depth and geometry of the northern Rio Grande Rift in the San Luis Basin, south-central Colorado, 'in' Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift - Structure, stratigraphy and tectonic setting: Geological Society of America Special Paper 291, p. 27-37.

McCalpin, James, 1981a, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Golden, Colorado, Colorado School of Mines, Ph. D. dissertation.

McCalpin, J.P., 1982, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Colorado School of Mines Quarterly, v. 77, no. 3, 97 p.

Stoughton, Dean, 1977, Interpretation of seismic reflection data from the San Luis Valley, south-central Colorado: Golden, Colorado, Colorado School of Mines, M.S. Thesis T-1960, 100 p.

Tweto, Ogden, 1979a, The Rio Grande Rift system in Colorado, 'in' Riecker, R.E., ed., Rio Grande Rift: Tectonics and magmatism: American Geophysical Union, Washington, D.C., p. 33-56.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Sectioned fault

Structure number: Q69c

Comments: Fault 116 in Kirkham and Rogers (1981); fault 131 in Witkind (1976); fault 3 of Colman (1985); fault 2321c in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Northern Sangre de Cristo Fault

Comments: The Sangre de Cristo Fault zone borders the east side of San Luis basin from near Poncha Pass, Colorado, to near Taos, New Mexico. This fault zone has been subdivided into two discrete faults for this compilation; the Northern Sangre de Cristo Fault and the Southern Sangre de Cristo Fault. Most of the Southern Sangre de Cristo Fault lies within New Mexico. The Northern Sangre de Cristo Fault is further subdivided into four sections: the Crestone section; the Zapata section; the Blanca section; and the San Luis section. This description focuses on the Blanca section, which extends from Hobrook Creek eastward around the south flank of the Blanca Peak massif.

Synopsis:

The Northern Sangre de Cristo Fault is a west-dipping normal fault that is the structural boundary between the Sangre de Cristo Range / Culebra Range on the east, and the San Luis Basin on the west. The Blanca section of the fault is marked by a prominent graben with scarps up to 28.3 m high. Deposits ranging in age from mid-late Pinedale to Bull Lake are offset by this graben. McCalpin (1981a; 1982) measured several scarp profiles on this section.

Date of compilation: 6/22/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Costilla, Alamosa

1° x 2° Sheet: Trinidad

Province: Southern Rocky Mountains

Township and Range: Costilla County

Strike: N58W

Number of traces: 3

End to end length: 6.72 km

Cumulative length: 9.09 km

Geologic setting:

The Northern Sangre de Cristo Fault is a major down-to-west normal fault within the Rio Grande Rift. It forms the eastern boundary of the east-tilted half-graben of San Luis basin. The deepest part of San Luis basin lies adjacent to the Northern Sangre de Cristo Fault (Gaca and Karig, 1965). Estimates of the maximum thickness of synorogenic basin fill in that part of San Luis basin have widely ranged. Gaca and Karig (1965) suggested a maxium thickness of about 9.7 km; Huntley (1976a; 1976b) reported it at about 5 km; Stoughton (1977) at 6,000 m; and Kluth and Schaftenaar (1994) at 6.4 km. Estimates of the amount of vertical displacement on the Northern Sangre de Cristo Fault also vary widely. Recently Kluth and Schaftenaar (1994) suggested the Northern Sangre de Cristo Fault has approximately 9.2 km of vertical separation.

Number of sections: 4

McCalpin (1981a; 1982) defined three segments for part of the Northern Sangre de Cristo Fault from near Poncha Pass to the south side of the Blanca Peak massif. These three segments are herein called sections. A fourth section extends generally southward from the south side of the Blanca Peak massif to Jarosa Creek near the Colorado - New Mexico state line.

Structure number: Q69c

Section name: Blanca Section

The name of this section was assigned during this compilation. The Blanca section coincides with segment 'C' of McCalpin (1982).

Reliability of location: Good

Comments: The fault was mapped by McCalpin (1982; scale 1:50,000), Colman and others (1985; scale 1:125,000), and Kirkham and Rogers (1981; scale 1:500,000). The trace used for this compilation is from Colman and others (1985).

Sense of movement: N

Comments:

Dip:

Comments: This section of the Northern Sangre de Cristo Fault dips to the south, but the amount of dip is unknown.

Dip direction: S

Geomorphic expression:

A prominent 2.1-km-long graben with scarps ranging from 3.2 m to 28.3 m high cuts glacial and alluviual deposits of five ages in the Blanca section (McCalpin, 1981a; 1982). The graben stays within 200 m of the range front. The high, south-facing scarp exaggerates the net throw across the graben (McCalpin, 1981a; 1982).

Age of faulted deposits:

Deposits ranging in age from middle to late Pinedale to Bull Lake are displaced by the graben in the Blanca section.

Detailed studies:

McCalpin (1981a; 1982) measured several scarp profiles across the graben, but no trenching investigations were conducted on this section.

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

Comments: McCalpin (1981a; 1982) reported that middle to late Pinedale deposits are offset by the graben. This implies that the last movement was post-glacial.

Recurrence interval: 25.0 ka

Comments: McCalpin (1981a; 1982) reported the recurrence interval for this section is about

25.0 ka, which is roughly twice as long as the recurrence interval for the Crestone and Zapata sections. McCalpin suggested the recurrence interval during Pinedale to Bull Lake and pre-Bull Lake times was significantly larger (47.5 ka and 46.0 ka, respectively).

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

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Huntley, David, 1976a, Groundwater recharge to the aquifers of the northern San Luis Valley, Colorado: Golden, Colorado, Colorado School of Mines, Ph.D. dissertation T-1864, 298 p.

Huntley, David, 1976b, Ground water recharge to aquifers of northern San Luis Valley, Colorado--a remote sensing investigation: Colorado School of Mines Remote Sensing Report, v. 76-3, 247 p.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Kluth, C.F., and Schaftenaar, C.H., 1994, Depth and geometry of the northern Rio Grande Rift in the San Luis Basin, south-central Colorado, 'in' Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift - Structure, stratigraphy and tectonic setting: Geological Society of America Special Paper 291, p. 27-37.

McCalpin, James, 1981a, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Golden, Colorado, Colorado School of Mines, Ph. D. dissertation.

McCalpin, J.P., 1982, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Colorado School of Mines Quarterly, v. 77, no. 3, 97 p.

Stoughton, Dean, 1977, Interpretation of seismic reflection data from the San Luis Valley, south-central Colorado: Golden, Colorado, Colorado School of Mines, M.S. Thesis T-1960, 100 p.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Structure type: Sectioned fault

Structure number: Q69 d

Comments: Faults 113 and 115 in Kirkham and Rogers (1981); fault 131 in Witkind (1976); fault 3 of Colman (1985); fault 2321d in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Northern Sangre de Cristo Fault

Comments: The Sangre de Cristo Fault zone borders the east side of San Luis basin from near Poncha Pass, Colorado, to near Taos, New Mexico. This fault zone has been subdivided into two discrete faults for this compilation; the Northern Sangre de Cristo Fault and the Southern Sangre de Cristo Fault. Most of the Southern Sangre de Cristo Fault lies within New Mexico. The Northern Sangre de Cristo Fault is further subdivided into four sections: the Crestone section; the Zapata section; the Blanca section; and the San Luis section. This description focuses on the San Luis section, which extends from the Blanca Peak massif southward to Jaroso Creek near the state line. This section also includes a northeast-trending fault mapped by Wallace (1997a) north of Fort Garland that lies a short distance east of the main fault trace.

Synopsis:

The Northern Sangre de Cristo Fault is a west-dipping normal fault that is the structural boundary between the Sangre de Cristo Range / Culebra Range on the east, and the San Luis Basin on the west. The San Luis section of the fault is marked by a series of discontinuous scarps. Surficial deposits as young as Holocene are offset across this section of the fault. Kirkham and Rogers (1981) reported a carbon-14 age of 4.715 ± 0.17 ka on charcoal collected from faulted deposits along Rito Seco. Colman and others (1985) measured scarp profiles at three locations on this section.

Date of compilation: 6/22/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Costilla

1° x 2° Sheet: Trinidad

Province: Southern Rocky Mountains

Township and Range: Costilla County

Strike: N12W

Number of traces: 16

End to end length: 59.08 km

Cumulative length: 85.61 km

Geologic setting:

The Northern Sangre de Cristo Fault is a major down-to-west normal fault within the Rio Grande Rift. It forms the eastern boundary of the east-tilted half-graben of San Luis basin. The deepest part of San Luis basin lies adjacent to the Northern Sangre de Cristo Fault (Gaca and Karig, 1965). Estimates of the maximum thickness of synorogenic basin fill in that part of San Luis basin have widely ranged. Gaca and Karig (1965) suggested a maxium thickness of about 9.7 km; Huntley (1976a; 1976b) reported it at about 5 km; Stoughton (1977) at 6,000 m; and Kluth and Schaftenaar (1994) at 6.4 km. Estimates of the amount of vertical displacement on the Northern Sangre de Cristo Fault also vary widely. Recently Kluth and Schaftenaar (1994) suggested the Northern Sangre de Cristo Fault has approximately 9.2 km of vertical separation.

Number of sections: 4

McCalpin (1981a; 1982) defined three segments for part of the Northern Sangre de Cristo Fault from near Poncha Pass to the south side of the Blanca Peak Massif. These three segments are herein called sections. A fourth section extends generally southward from the south side of the Blanca Peak Massif to Jarosa Creek near the Colorado - New Mexico state line.

Structure number: Q69d

Section name: San Luis Section

The name of the San Luis section was assigned during this compilation.

Reliability of location: Good

Comments: The trace used for this compilation is chiefly based upon Colman and others (1985; scale 1:125,000) except where recent, more detailed mapping by Wallace (1997a; scale 1:24,000) is available.

Sense of movement: N

Comments:

Dip:

Comments: This section of the Northern Sangre de Cristo Fault dips to the west, but the amount of dip is unknown.

Dip direction: W

Geomorphic expression:

The San Luis section of the Northern Sangre de Cristo Fault is characterized by a discontinous series of scarps in late Quaternary deposits (Kirkham and Rogers, 1981; Colman and others, 1985; Wallace, 1997a). The section lies well to the west of the Culebra Range, which lacks the triangular faceted spurs common to the Crestone and Zapata sections. The fault lies at the western edge of low hills which for the most part are underalin by the late Tertiary Santa Fe Formation and locally capped by Pliocene Sevilleta basalt (Wallace, 1997a).

Age of faulted deposits:

Scarps within the San Luis section offset surfical deposits ranging in age from pre-Bull Lake to Holocene in age (Kirkham and Rogers, 1981; Colman and others, 1985; Wallace, 1997a).

Detailed studies:

A charcoal sample from a natural exposure of faulted deposits along Rito Seco yielded a carbon-14 age of 4.715 ± 0.17 ka (Kirkham and Rogers, 1981). Colman and others (1985) measured scarp profiles at three locations, but no trenching investigations were conducted on this section.

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

Comments: Kirkham and Rogers (1981) reported a carbon-14 age of 4.715 ± 0.17 ka on charcoal collected from a natural exposure of fan deposits along Rito Seco that were offset by the San Luis section of the Northern Sangre de Cristo Fault.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments:

Earthquake notes:

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

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Structure type: Sectioned fault

Structure number: Q71a

Comments: Fault 109 in Kirkham and Rogers (1981); fault 1 in Colman (1985); fault 2017a in Machette and others (1998); fault 2017a in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Southern Sangre de Cristo Fault

Comments: The Southern Sangre de Cristo Fault consists of five sections. Four sections are in New Mexico and one, the San Pedro Mesa section, is in Colorado. The Southern Sangre de Cristo Fault borders the eastern margin of the San Luis basin. In New Mexico the fault lies at the west edge of the Sangre de Cristo Mountains, but where is crosses into Colorado, there is an embayment in the range front that causes it to deflect eastward. The Southern Sangre de Cristo Fault bounds the western edge of San Pedro Mesa in Colorado, and other faults lie at the western range front of the Sangre de Cristo Mountains in Colorado.

Synopsis:

The Southern Sangre de Cristo Fault is a west-dipping fault that in New Mexico forms the border between the Sangre de Cristo Mountains and the San Luis basin, and in Colorado forms the border between San Pedro Mesa to the east and San Luis Valley to the west. The fault is divided into five sections, only one of which is in Colorado. In New Mexico the fault sections show evidence of multiple late Quaternary movement, including possible ruptures during the late to middle Holocene. The section of the Southern Sangre de Cristo Fault that extends into Colorado has been mapped at a scale of 1:125,000 by Colman and others (1985) and in part at 1:50,000 by Thompson and Machette (1989) but has not been evaluated in detail.

Date of compilation: 4/27/98

Compiler and affiliation: Robert Kirkham, Colorado Geological Survey

State: New Mexico, Colorado

County: Taos, Costilla

1° x 2° Sheet: Raton, Trinidad

Province: Southern Rocky Mountains

Township and Range: Costilla County

Strike: N10W

Number of traces: 3

End to end length: 21.26 km

Cumulative length: 29.66 km

Geologic setting:

The Southern Sangre de Cristo Fault is part of a major rift-margin structure of Neogene age that borders the eastern margin of the Rio Grande Rift in south-central Colorado and north-central New Mexico. The entire Sangre de Cristo Fault zone generally forms the boundary between the San Luis basin, a narrow (10 to 25 km wide), east-tilted, assymetrical half-graben on the west, and the Sangre de Cristo Mountains on the east. There is 7 to 8 km of structural relief on Precambrian basement rock across the Sangre de Cristo Fault zone (Lipman and Mehnert, 1975; Keller and others, 1984; Brister and Gries, 1994). Wong and others (1995) reported that a few well-located earthquakes appear to have occurred in the vicinity of the fault.

Number of sections: 5

Comments: The Southern Sangre de Cristo Fault is divided into 5 sections. The four sections in New Mexico are better exposed and have been studied in more detail than the section in Colorado. Menges (1988; 1990a; 1990b) defined 4 geometric segments and 13 subsegments along this fault in New Mexico on the basis of physiographic and geomorphic expression of the fault zone and the morphology of the Sangre de Cristo range front in New Mexico, but did not investigate the part of this fault that is in Colorado.

Structure number: Q71 a

Section name: San Pedro Mesa Section

Comments: The San Pedro Mesa section of the Southern Sangre de Cristo Fault is essentially the same structure as fault 109 of Kirkham and Rogers (1981). The fault begins at Costilla Creek in New Mexico, extends along the west side of San Pedro Mesa, and terminates or is covered by younger deposits along Culebra Creek.

Reliability of location: Good

Comments: The trace of this section of the fault is based on two sources. Most of the trace is from Colman and others (1985) at a scale of 1:125,000. In this reach the fault is concealed by landslide deposits and is poorly located. The splays that extend to the northwest off the northern end of the fault were mapped by Thompson and Machette (1989) at a scale of 1:50,000, and are better located. The fault was also mapped at 1:250,000 by Colton (1976), 1:500,000 by Kirkham and Rogers (1981), and 1:1,000,000 by Tweto (1978).

Sense of movement: N

Comments:

Dip: 60°W

Comments: Deep seismic-reflection data and two-dimensional modeling of gravity data suggest that the Sangre de Cristo Fault dips about 60° (Kluth and Schaftenaar, 1994). Tandon (1992) concluded the fault dips about 60° to at least 26 to 28 km depth, which is probably below the brittle-ductile transition zone. Wong and others (1995) used a preferred value of 60° for the southern Sangre de Cristo Fault and assumed other possible dips of 50° and 70° for the fault within the seismogenic crust.

Dip direction: W

Geomorphic expression:

The San Pedro Mesa section is generally obscured by Quaternary landslide deposits along most of its length. The splays that extend to the northwest off the northern end of the fault are mapped by Thompson and Machette (1989) and have subtle scarps associated with them.

Age of faulted deposits:

Thompson and Machette (1989) indicated middle Pleistocene alluvium (unit Qa) is offset by this fault.

Detailed studies:

No detailed studies have been conducted on this section of the fault.

Timing of most recent paleoevent: (2) Quaternary-late (<130ka)

Comments: The exact timing of the latest paleoevent is unknown. A late Quaternary age is postulated for this fault because it offsets middle Pleistocene alluvium but apparently is generally concealed by undifferentiated Quaternary landslide deposits (Thompson and Machette, 1989). Machette and others (1998) indicate that other sections of the Southern Sangre de Cristo Fault which lie in New Mexico have moved as recently as Holocene and post-glacial (<15 ka).

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Burroughs (1978) reported that the Servilleta Formation is offset 600 m by the fault near the Colorado - New Mexico line. Thompson and Machette (1989) reported dates ranging from 3.6 to 4.5 Ma for the Servilleta basalts, suggesting a long-term slip rate for the fault of 0.13 to 0.17 mm/yr. It is unknown whether the slip rate applies to any or all of the Quaternary.

Earthquake notes:

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SUSPECT QUATERNARY FAULTS

A fault is described as a *suspect feature* when the literature is not conclusive or when it leaves doubt as to the structure's Quaternary activity.

Structure type: Suspect feature

Structure number: Q74

Comments: This fault was previously mapped as a potentially active Quaternary fault (fault #166) by Kirkham and Rogers (1981); fault 2324 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Golden Fault

Comments: The Golden Fault is one of the structures that bounds the eastern side of the Front Range near the town of Golden, Colorado.

Synopsis:

The Golden fault is a major Laramide thrust fault along the eastern margin of the Front Range near Golden that may have been reactivated during the Neogene. Kirkham and Rogers (1981) inferred the Golden Fault was a Quaternary structure based on its possible relationship to the graben near Golden described by Scott (1970) and Kirkham (1977a). A detailed study of the Golden Fault by Dames & Moore (1981) concluded the Golden Fault was not a capable fault. Technical review of the Dames & Moore (1981) report by the Colorado Geological Survey (Rogers, 1981) and U.S. Geological Survey (Colman and others, 1981) questioned the Dames & Moore (1981) conclusions regarding possibility of Quaternary movement on the Golden Fault. Because of these remaining doubts the Golden Fault is herein considered a suspected Quaternary fault, although definitive evidence of Quaternary movement is lacking.

Date of compilation: 4/22/98

Compiler and affiliation: William P. Rogers, Colorado Geological Survey
Robert M. Kirkham, Colorado Geological Survey
Beth L. Widmann, Colorado Geological Survey

State: Colorado

County: Jefferson

1° x 2° Sheet: Denver

Province: Great Plains

Township and Range: T5S,R69W-T2S,R70W

Strike: N23W

Number of traces: 4

End to end length: 30.74 km

Cumulative length: 39.15 km

Reliability of location: Good

Comments: The Golden Fault was mapped at a scale of 1:24,000 (VanHorn, 1972; 1976), 1:100,000 by Trimble and Machette (1979), and 1:250,000 by Bryant and others (1981). The trace used herein is from Trimble and Machette (1979).

Geologic setting:

The Front Range is defined by a 500- to 1,000-m-high, east-facing escarpment that is both a tectonic and erosional feature. Estimations of Neogene offset across the Front Range are as little as 30 m and as much as 2,200 m. Scott (1970), Epis and Chapin (1975), and Trimble (1980) suggested much of the topographic relief across the escarpment is related to Neogene fault activity. Jacob and Albertus (1985), Leonard and Langford (1994), and Steven and others (1997) indicated that Neogene fault activity only acounts for a minor amount of topographic relief across the escarpment. Steven and others (1997) noted anomalies in paleo- and modern, range-front stream flow directions which they interpretted to indicate tilting of the Front Range off the northeast flank of the Rio Grande Rift during the Miocene, and regional uplift during the early Pliocene and possibly early Quaternary. Jacob and Albertus (1985) and Chapin and Kelley (1997) argued that the Front Range escarpment is primarily a product of differential erosion.

The Golden Fault is a major, down-to-the-east Laramide thrust fault along the eastern margin of the Front Range near Golden that may have been reactivated during the Neogene. Weimer and Ray (1997) suggested the Golden Fault may at least locally merge with their Basin Margin Fault.

Sense of movement: T

Comments: Style of deformation along the Golden Fault has been debated, but most current researchers believe it was predominately thrust (Weimer and Ray, 1997).

Dip: 50°-70°W

Comments: Weimer and Ray (1997) estimated the Golden Fault dips on average 50° to 70° W.

Dip direction: W

Geomorphic expression:

Geomorphic indicators of youthful faulting have not been reported.

Age of faulted deposits:

Rocks ranging in age from Precambrian to Paleocene are clearly cut by the Golden Fault (Scott, 1970; VanHorn, 1972), but the age of the most recently faulted deposits is debated. Kansan-age Verdos Alluvium and the 620 ka Lava Creek B ash are offset by the graben near Golden, which lies about 0.2 km east of the Golden Fault, but the structural relationship between this Quaternary graben and the Golden Fault is disputed (Kirkham, 1977a; Kirkham and Rogers, 1981; Dames & Moore, 1981). The origin of anomolous features in basal Verdos Alluvium near the Golden Fault exposed in trenches by Dames & Moore also is debateable (Dames & Moore, 1981; Rogers, 1981b).

Detailed studies:

The fault was studied in detail for a seismic hazards investigation for the U.S. Department of Energy's Rocky Flats Plant. The complete results of that investigation were published in Dames & Moore (1981) and summaries of it are reported in Darrow and Krusi (1981; 1982). Dames & Moore (1981) excavated six trenches across the Golden Fault at three sites (GF-1 through GF-3). They concluded there was no evidence to indicate the Golden fault had moved since deposition of the Verdos Alluvium (500 ka). Several anomalous features were observed in their trenches, including "tongues" of bedrock within Quaternary deposits and normal faults in Quaternary alluvium. They interpreted these features as being non-tectonic in origin but could not definitively rule out a tectonic origin. The three trench sites are labeled on the map that accompanies this database, from north to south, as trenches Q74-1 through Q74-3.

Q74-1 (GF-2): Two trenches and three test pits were excavated at this site located in the emergency spillway area at the northern end of Ralston Reservoir Dam. The Upper Cretaceous Pierre Shale was observed on both sides of the fault and was overlain by Verdos-age debris-flow deposits and stream deposits. Bedding in the Pierre Shale dips 60° to 80°W and three shear zones marked by clay gouge 0.5 m to 1.0 m thick, dip 85° to 90°W. The bedrock/alluvium contact is not displaced by the Golden Fault indicating no movement on the fault for at least 500 ka.

Q74-2 (GF-3): Two trenches were excavated at this site on Coors property near the mouth of Clear Creek Canyon. Precambrian metamorphic rocks and Pennsylvanian Fountain Formation were observed on the west in fault contact with Upper Cretaceous Pierre Shale on the east, and all were overlain by unfaulted Verdos gravel and pre-Pinedale (50 ka) colluvium and/or eolian deposits. The fault dips 65°E and is marked by a 20- to 30-m-wide gouge zone. A 5-m-wide shear zone was found east of the fault in Pierre Shale. Tongues of Pierre Shale were reported to project into overlying Quaternary alluvium but were not found to be bound by faults or shears. Dames & Moore (1981) concluded the tongues were non-tectonic in origin and were related to plastic deformation of the shale in response to unloading of overburden or downslope creep.

Q74-3 (GF-1): Two trenches and two test pits were excavated at this site located west of Highway 6 and Tripp Road. The Jurassic Morrison Formation was observed on the west in fault contact with the Upper Cretaceous Pierre Shale on the east, and both were overlain by unfaulted Verdos-age alluvium, debris-flow deposits, and sheetwash. The fault dips 15°W and is marked by a 10-cm-wide gouge zone; Morrison Formation bedding is overturned 20°W. Tongues of Morrison Formation were reported to project into overlying Quaternary alluvium but were not found to be bound by faults or shears. A cummulative displacement of about 15 cm was reported in gravel lenses displaced along down-to-the-west (normal) shears. Dames & Moore (1981) concluded "while a tectonic origin cannot be precluded, the tongues are interpreted to represent bedrock surface deformation due to downslope creep" and normal displacement along shears appears to be related to the tongues.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: The Golden Fault was first suggested to be a Quaternary fault by Scott (1970) based upon evidence in a clay exploration trench in a graben about 210 m east of the trace of the Golden Fault. Kirkham and Rogers (1981) classified the Golden Fault as a Quaternary fault based on its possible association to this Quaternary graben. Trenching investigations by Dames & Moore (1981) revealed that the bedrock/alluvium contact at all three trench sites was not offset by the Golden Fault. However, they did find several anomolous features in basal Verdos Alluvium that may indicate Quaternary movement on this fault. Dames & Moore (1981) concluded that these features resulted from downslope creep, but they also stated that a tectonic origin could not be precluded. They further indicated that the Golden Fault had not moved for at least 500 ka. Technical reports by Colman and others (1981) and Rogers (1981b) questioned the Dames & Moore (1981) conclusions regarding possibility of Quaternary movement on the Golden Fault. Based on the debateable origin of anomolous features in Quaternary deposits the Golden Fault is herein considered to be a suspect feature that may have moved during the Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Any estimate of the Quaternary slip rate is highly speculative as there is not a consensus of opinion on wheter or not the Golden Fault is a Quaternary fault.

Earthquake notes:

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Van Horn, Richard, 1976, Geology of the Golden quadrangle, Colorado: U.S. Geological Survey Professional Paper 872, 117 p.

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Q75 - Valmont Fault

Structure type: Suspect feature

Structure number: Q75

Comments: Fault 167 in Kirkham and Rogers (1981); fault 154 in Witkind (1976); fault 2325 in the U.S. Geological Survey Quaternary fault and fold database.

Structure name: Valmont Fault

Comments: The Valmont Fault is an east-northeast-trending fault southeast of the town of Valmont. The fault lies at the northeast end of the Valmont Reservoir and is exposed in the east side of the roadcut for North 75th Street east of Boulder. The fault is parallel in strike to the Valmont dike. The fault was discovered in 1957 by Frank Riley (U.S. Geological Survey) and was first mapped by Scott and Cobban (1965).

Synopsis:

The Valmont Fault is southeast of Valmont near the Valmont Reservoir. There is no surface expression of the fault, but the fault is exposed in a roadcut on North 75th Street. A fault zone is defined by disrupted and shingled stones of the Slocum Alluvium. Scott (1970) and Kirkham and Rogers (1981) suggested movement on the fault is Sangamon or younger. Unruh and others (1996), however, concluded that the fault is related to the Valmont dike and that the shingled stones are depositional in origin, not tectonic. Without more detailed investigation of this structure, it is herein considered to be a suspect feature, and Quaternary tectonism is not ruled out.

Date of compilation: 11/17/97

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

State: Colorado

County: Boulder

1° x 2° Sheet: Greeley

Province: Great Plains

Township and Range: T1N,R69W-T1N,R70W

Strike: N75E

Number of traces: 1

End to end length: 1.27 km

Cumulative length: 1.28 km

Reliability of location: Good

Comments: The fault was mapped at a scale of 1:24,000 by Trimble (1975), 1:48,000 by Scott and Cobban (1965) and 1:250,000 by Unruh and others (1996). The trace used herein is from Unruh and others (1996).

Geologic setting:

The Valmont Fault lies in the Great Plains province east of Boulder. It is in close proximity to and has a strike similar to the Valmont dike, but the relationship between the two features is not clear. The fault is a high-angle normal fault, down to the southeast.

Sense of movement: N

Comments: Witkind (1976) and Kirkham and Rogers (1981) reported normal movement on the fault.

Dip: Nearly vertical

Comments: The fault was described as vertical by Scott (1970).

Dip direction:

Geomorphic expression:

There is no surface expression of the fault (Scott, 1970; Kirkham and Rogers, 1981).

Age of faulted deposits:

Slocum alluvium (Illinoisan or Sangamon) is offset by 1.5 m across the fault zone according to Scott (1970).

Detailed studies:

Timing of most recent paleoevent: (3) Quaternary-middle and late (<750ka)

Comments: The fault is characterized by a 13-m-wide zone of disrupted and shingled stones in the Slocum alluvium (Scott, 1970; Kirkham and Rogers, 1981). Scott (1970) reported that the stones were shingled due to movement on the Valmont Fault as opposed to depositional shingling, and that movement on the fault was Sangamon or younger. Unruh and others (1996) concluded that the stones were imbricated in accordance with paleo-transportation direction, and that apparent movement on the fault was related to the Valmont dike and is not tectonic. With out more detailed investigation of this structure, it is herein classified as a suspect feature that may have moved as recently as the middle and late Quaternary.

Recurrence interval: ND

Comments:

Slip rate: unknown; (D) <0.2 mm/yr

Comments: Based on 1.5 m of offset of Sangamon deposits a slip rate of <0.2 mm/yr is estimated for this fault.

Earthquake notes:

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Scott, G.R., and Cobban, W.A., 1965, Geologic and biostratigraphic map of the Pierre Shale between Jarre Creek and Loveland, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-439.

Trimble, D.E., 1975, Geologic map of the Niwot quadrangle, Boulder County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1229.

Unruh, J.R., Wong, I.G., Knudsen, K.L., Bott, J.D.J., Becker, A., Silva, W.J., and Lettis, W.R., 1996, Seismotectonic evaluation, Rattlesnake and Flatiron Dams, Colorado-Big Thompson Project, north-central Colorado: unpublished report prepared by William Lettis & Associates and Woodward-Clyde Consultants for U.S. Bureau of Reclamation, Denver, Colorado, 174 p.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

DISCOUNTED QUATERNARY FAULTS

A *discounted fault* is a fault that was previously described in the literature as having been active during the Quaternary but more recent investigations have disproved Quaternary activity on the fault.

Structure type: Discounted fault

Structure number: Q00

Comments:

Structure name: Dudley Gulch Graben

Comments: The Dudley Gulch Graben is comprised of two northwest-trending faults in the Piceance Creek basin southwest of Meeker. The faults extend from just west of Ryan Gulch, southeast along Dudley Bluffs to a gas field that lies between Collins Gulch and Oldland Gulch. The graben structure is referred to as the Dudley Gulch Graben by Eckert (1982).

Reason for exclusion:

Dames & Moore (1981) suggested historical movement occurred on faults bounding the Dudley Gulch Graben during the November 7, 1882 earthquake. Eckert (1982) discounted historical movement on the fault and suggested that the graben has not been active since at least the Pleistocene.

Eckert (1982) concluded that all geomorphic features along the faults could be accounted for by processes other than recent tectonism. Eckert noted that Holocene and Pleistocene deposits were unfaulted by the graben faults. Additionally, Eckert concluded that the stress system responsible for forming the graben did not coincide with the current stress regime in the region as measured by de la Cruz and Raleigh (1972).

Date of compilation: 7/7/97

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

State: Colorado

County: Rio Blanco

1° x 2° Sheet: Grand Junction

Province: Colorado Plateaus

Township and Range: T2S,R97W-T3S,R96W

References Cited:

Cruz, R., de la, and Raleigh, C.B., 1972, Absolute stress measurements at the Rangely Anticline, northwestern Colorado: International Journal of Rock Mechanics and Mining Sciences, v. 9, p. 625-634.

Dames & Moore, 1981, Geologic and seismologic investigations for Rocky Flats Plant: unpublished report prepared for U.S. Department of Energy.

Eckert, A.D., 1982, The geology and seismology of the Dudley Gulch Graben and related faults, Piceance Creek Basin, northwestern Colorado: Boulder, Colorado, University of Colorado, M.S. Thesis, 139 p.

Q00 - Unnamed Faults South of Cathedral Bluffs

Structure type: Discounted fault

Structure number: Q00

Comments:

Structure name: Unnamed Faults South of Cathedral Bluffs

Comments: These two unnamed faults lie in the Piceance Creek basin. One west-northwest-trending fault extends across Lake, Soldier, and Canyon Creeks. A northeast- trending fault crosses Soldier Creek only.

Reason for exclusion:

The faults were mapped by Hail and Smith (1997) as offsetting Quaternary deposits. W. Hail (1997; oral communication) stated that a drafting error occurred and these faults should have been depicted as dotted (concealed) instead of solid through the Quaternary deposits.

Date of compilation: 11/24/97

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

State: Colorado

County: Rio Blanco

1° x 2° Sheet: Grand Junction

Province: Colorado Plateaus

Township and Range: T4S,R100W

References Cited:

Hail, W.J., Jr., and Smith, M.C., 1997, Geologic map of the southern part of the Piceance Creek Basin, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-2529.

Q00 - Unnamed Fault West of DeBeque

Structure type: Discounted fault

Structure number: Q00

Comments:

Structure name: Unnamed Fault West of DeBeque

Comments: This is a northeast- trending fault west of DeBeque. The fault lies between Twin Peaks and Pyramid Rocks and is parallel to the Coon Hollow drainage.

Reason for exclusion:

The faults were mapped by Hail and Smith (1997) as offsetting Quaternary deposits. W. Hail (1997; oral communication) stated that a drafting error occurred and these faults should have been depicted as dotted (concealed) instead of solid through the Quaternary deposits.

Date of compilation: 11/24/97

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

State: Colorado

County: Mesa

1° x 2° Sheet: Grand Junction

Province: Colorado Plateaus

Township and Range: T8S,R98W

References Cited:

Hail, W.J., Jr., and Smith, M.C., 1997, Geologic map of the southern part of the Piceance Creek Basin, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-2529.

Q00 - Unnamed Faults on the East Side of Williams Fork Valley

Structure type: Discounted fault

Structure number: Q00

Comments: This fault was previously mapped as a potentially active fault (fault #54) by Kirkham and Rogers (1981). It also corresponds to fault 187 in Witkind (1976).

Structure name: Unnamed Faults on the East Side of Williams Fork Valley

Comments: This series of unnamed faults includes three northwest-trending faults on the eastern margin of the Williams Fork drainage northeast of the Williams Fork Range and southeast of Kremmling. The faults are parallel to and northeast of the Laramide Williams Range Thrust Fault. They lie in the hanging wall of the Laramide Williams Range Thrust and form a graben with the Neogene Williams Fork Mountains Fault.

Reason for exclusion:

This fault series forms the eastern margin of the Neogene Williams Fork Valley Graben (Kirkham and Rogers, 1981). The faults are high-angle normal and downthrown to the southwest. The faults are parallel to the southwest-verging Laramide Williams Range Thrust to the west, and developed during Neogene extension in the hanging wall of the thrust (Unruh and others, 1993b).

Witkind (1976; scale 1:500,000) and Howard and others (1978; scale 1:5,000,000) classified these faults as Quaternary. However , Tweto and Reed (1973a; scale 1:62,500) and Tweto and others (1978; scale 1:250,000) mapped the Miocene Troublsome Formation as the youngest deposit offset by the fault. Tweto (1978), Kirkham and Rogers (1981), and Colman (1985) indicated the latest movement on the fault occurred during the late Cenozoic.

This fault series is herein discounted as a Quaternary fault based on the lack of evidence to support movement on the fault during the Quaternary.

Date of compilation: 6/12/97

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

State: Colorado

County: Grand

1° x 2° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T2S,R77W-T1N,R78W

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K, Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map, MF-916.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, 1978, Northern rift guide 1, Denver-Alamosa, Colorado, in Hawley, J.W., ed., Guidebook to the Rio Grande Rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 13-27.

Tweto, Ogden, and Reed, J.C., Jr., 1973a, Reconnaissance geologic map of the Ute Peak 15-minute quadrangle, Grand and Summit Counties, Colorado: U.S. Geological Survey Open-file Report, 73-288.

Tweto, Ogden, Moench, R.H., and Reed, J.C., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-999.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q00 - Ridgway Quarry Faults

Structure type: Discounted fault

Structure number: Q00

Comments: These faults were previously shown as a single, potentially active splay fault to the Ridgway fault (#179) in Kirkham and Rogers (1981).

Structure name: Ridgway Quarry Faults

Comments: The Ridgway Quarry Faults are located at the east end of the Ridgway Fault. They were recognized by Sullivan and others (1980) in a quarry north of the town of Ridgway. The two faults trend north to northeast and were named the western and eastern Ridgway Quarry Faults by Lettis and others (1996).

Reason for exclusion:

The Ridgway Quarry Faults are located at the east end of the Ridgway Fault. The Ridgway Fault defines the southwest margin of the Uncompahgre uplift. The western Ridgway Quarry Fault is down to the east and splays into two faults at its north end, and the eastern Ridgway Quarry Fault is down to the west, both in accordance with local topography. The eastern Ridgway Quarry Fault is defined by a west-facing scarp (Sullivan and others, 1980). Geomorphic features indicative of youthful faulting on the western Ridgway Quarry Fault are not documented. The eastern Ridgway Quarry Fault lies on the margin (headscarp) of a southwest-verging Quaternary landslide. Lettis and others (1996) reported that both faults coincide with the headscarps of landslides.

The timing of latest movement on the faults is uncertain. Sullivan and others (1980) suggested that disrupted Quaternary deposits and apparent dip-slip movement in the area implied Quaternary fault movement. However, Lettis and others (1996) later studied the faults and concluded that while Cretaceous bedrock is faulted, modern geomorphic features associated with the faults are related to landslide activity and are non-tectonic in origin. They were unable to find any evidence for Quaternary fault activity and therefore discounted the Quaternary age that was assigned by Sullivan and others (1980). The Cretaceous Dakota Sandstone and Mancos Shale are the youngest rock units that show evidence for fault movement, with up to 60 m of throw on the western Ridgway Quarry Fault (Weisser, 1982).

Date of compilation: 6/30/98

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

State: Colorado

County: Ouray

1° x 2° Sheet: Montrose

Province: Southern Rocky Mountains-Colorado Plateaus

Township and Range:

References Cited:

Cater, F.W., Jr., 1966, Age of the Uncompahgre Uplift and Unaweep Canyon, west-central Colorado, 'in' Geological Survey Research 1966, Chapter C: U.S. Geological Survey Professional Paper 550-C, p. C86-C92.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Lettis, W., Noller, J., Wong, I., Ake, J., Vetter, U., and LaForge, R., 1996, Draft report, Seismotectonic evaluation of Colorado River storage project-Crystal, Morrow Point, Blue Mesa dams, Smith Fork project-Crawford dam, west-central Colorado: unpublished draft report prepared by William Lettis & Associates, Inc., Woodward-Clyde Federal Services, and Seismotectonics and Geophysical Group of the U.S. Bureau of Reclamation in Denver, Colorado, 177 p.

Sullivan, J.T., Meeder, C.A., Martin, R.A., and West, M.W., 1980, Seismic hazard evaluation-Ridgway dam and reservoir site-Dallas Creek project, Colorado: unpublished report prepared by U.S. Water and Power Resources Service, Seismotectonic Section, 43 p.

Weisser, R.R., 1982, Supplemental seismic hazard evaluation Ridgway Dam and Reservoir site Dallas Creek Project, Colorado: U.S. Bureau of Reclamation, 14 p.

Q00 - Unnamed Fault on West Side of Alamosa Horst

Structure type: Discounted fault

Structure number: Q00

Comments: This fault was previously mapped as a potentially active Quaternary fault (fault #182) by Kirkham and Rogers (1981).

Structure name: Unnamed Fault on West Side of Alamosa Horst

Comments: This unnamed fault is a north-northwest-trending fault in the San Luis Valley. The fault begins near Russell Lakes in the northeast corner of the Durango 1° x 2° quadrangle, extends southeast towards Alamosa, and ends north of Alamosa in the Trinidad 1° x 2° quadrangle. The fault forms the western margin of the burried mid-valley Alamosa Horst block in San Luis Valley (Tweto, 1978; 1979a).

Reason for exclusion:

Huntley (1979a,b) and Brister and Gries (1994) indicated that this fault does not offset the Pliocene and Pleistocene Alamosa Formation. Burroughs (1981) suggested the fault does not cut the Oligocene Fish Canyon and Carpenter Ridge tuffs.

Date of compilation: 7/10/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Alamosa, Saguache

1° x 2° Sheet: Trinidad, Durango

Province: Southern Rocky Mountains

Township and Range: T38N,R10E-T45N,R8E

References Cited:

Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa Basin (northern San Luis Basin), Rio Grande Rift, south-central Colorado, 'in' Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift: Structure, stratigraphy and tectonic setting: Geological Society of America Special Publication 291, p. 39-58.

Burroughs, R.L., 1981, A summary of the geology of the San Luis Basin, Colorado-New Mexico, with emphasis on the geothermal potential for the Monte Vista Graben: Colorado Geological Survey Special Publication 17, 30 p.

Huntley, David, 1979a, Cenozoic faulting and sedimentation in northern San Luis Valley, Colorado: Summary: Geological Society of America Bulletin, part I, v. 90, no. 1, p. 8-10.

Huntley, David, 1979b, Cenozoic faulting and sedimentation in northern San Luis Valley, Colorado: Geological Society of America Bulletin, part II, v. 90, no. 1, p. 135-153.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, 1978, Northern rift guide 1, Denver-Alamosa, Colorado, in Hawley, J.W., ed., Guidebook to the Rio Grande Rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 13-27.

Tweto, Ogden, 1979a, The Rio Grande Rift system in Colorado, in Riecker, R.E., ed., Rio Grande Rift: Tectonics and magmatism: American Geophysical Union, Washington, D.C., p. 33-56.

Q00 - Unnamed Fault on East Side of Alamosa Horst

Structure type: Discounted fault

Structure number: Q00

Comments: This fault was previously mapped as a potentially active Quaternary fault (fault #183) by Kirkham and Rogers (1981).

Structure name: Unnamed Fault on East Side of Alamosa Horst

Comments: This unnamed fault is a north-northwest-trending fault in the San Luis Valley. The fault begins at the Saguache/Alamosa county line east of Hooper, and ends near the railroad tracks east of Alamosa where it intersects Manassa fault. The fault is one of at least two faults that form the eastern margin of the burried mid-valley Alamosa Horst block in San Luis Valley (Tweto, 1978; 1979a).

Reason for exclusion:

Huntley (1979a,b) and Brister and Gries (1994) showed that this fault does not offset the Pliocene and Pleistocene Alamosa Formation. Burroughs (1981) suggested the fault does not cut the late Eocene erosion surface.

Date of compilation: 7/10/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Alamosa

1° x 2° Sheet: Trinidad

Province: Southern Rocky Mountains

Township and Range: T37N,R12E-T40N,R11E

References Cited:

Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa Basin (northern San Luis Basin), Rio Grande Rift, south-central Colorado, 'in' Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift: Structure, stratigraphy and tectonic setting: Geological Society of America Special Publication 291, p. 39-58.

Burroughs, R.L., 1981, A summary of the geology of the San Luis Basin, Colorado-New Mexico, with emphasis on the geothermal potential for the Monte Vista Graben: Colorado Geological Survey Special Publication 17, 30 p.

Huntley, David, 1979a, Cenozoic faulting and sedimentation in northern San Luis Valley, Colorado: Summary: Geological Society of America Bulletin, part I, v. 90, no. 1, p. 8-10.

Huntley, David, 1979b, Cenozoic faulting and sedimentation in northern San Luis Valley, Colorado: Geological Society of America Bulletin, part II, v. 90, no. 1, p. 135-153.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, 1978, Northern rift guide 1, Denver-Alamosa, Colorado, in Hawley, J.W., ed., Guidebook to the Rio Grande Rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 13-27.

Tweto, Ogden, 1979a, The Rio Grande Rift system in Colorado, in Riecker, R.E., ed., Rio Grande Rift: Tectonics and magmatism: American Geophysical Union, Washington, D.C., p. 33-56.

Q00 - Manassa Fault

Structure type: Discounted fault

Structure number: Q00

Comments: This fault was previously mapped as a Quaternary fault (#107) by Kirkham and Rogers (1981) and by Witkind (1976; fault 188).

Structure name: Manassa Fault

Comments: The Manassa Fault is a northeast-trending fault in the San Luis Valley along the northwest side of the San Luis Hills. The fault begins south of Manassa and extends northeast to near the west range front of the Sangre de Cristo Range.

Reason for exclusion:

The Manassa Fault was described as a possible Quaternary fault by Witkind (1976), Kirkham and Rogers (1981) and Colman (1985), probably based on its inferred relationship to a Quaternary fault scarp at Uracca Creek. Since there is no reported evidence of Quaternary movmement on the main trace of the Manassa fault (McCalpin, 1982), and the relationship between it and the known Quaternary fault at Uracca Creek is uncertain, the Manassa Fault should be discounted as a Quaternary fault. The latest movement on this fault is considered to have occurred during the late Cenozoic.

Date of compilation: 9/24/97

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Conejos, Alamosa

1° x 2° Sheet: Trinidad

Province: Southern Rocky Mountains

Township and Range: T33N,R9E-T28S.R73W

References Cited:

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

McCalpin, J.P., 1982, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Colorado School of Mines Quarterly, v. 77, no. 3, 97 p.

Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-file Report 76-154.

Q00 - Unnamed Fault near Fort Garland

Structure type: Discounted fault

Structure number: Q00

Comments: This fault was previously mapped as a potentially active Quaternary fault (fault #114) by Kirkham and Rogers (1981). It was also shown by Colman and others (1985) as a Quaternary fault.

Structure name: Unnamed Fault near Fort Garland

Comments: This fault was previously included in the Sangre de Cristo Fault zone by Kirkham and Rogers (1981).

Reason for exclusion:

This fault was originally shown as a Holocene fault by Kirkham and Rogers (1981) and as a Quaternary fault by Colman and others (1985). Recent mapping by Wallace (1997a) indicated the fault offsets the Miocene Santa Fe Formation, but is concealed beneath Quaternary deposits.

Date of compilation: 6/24/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Costilla

1° x 2° Sheet: Trinidad

Province: Southern Rocky Mountains

Township and Range:

References Cited:

Colman, S.M., McCalpin, James, Ostenaa, D.A., and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande Rift, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1594.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Wallace, A.R., 1997a, Geologic map of the Fort Garland quadrangle, Costilla County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2312-E.

Q00 - Fault West of Morrison

Structure type: Discounted fault

Structure number: Q00

Comments:

Structure name: Fault West of Morrison

Comments: This fault was first described by Scott (1970) as a minor fault along which Precambrian gneiss is raised about 3 m above the Verdos Alluvium. Scott reported that the gravel clasts in the alluvium were "skewed" or shingled along the fault zone. Scott (1972) mapped this deposit of gravel in fault contact with Precambrian rocks.

Reason for exclusion:

The outcrop described by Scott (1970) was examined by the staff of the Colorado Geological Survey during their field work for the preparation of Kirkham and Rogers (1981). They concluded the gravels were in depositional contact with the gneiss and chose not to include it as one of their "potentially active" or late Cenozoic faults.

Date of compilation: 6/24/98

Compiler and affiliation: Robert M. Kirkham, Colorado Geological Survey

State: Colorado

County: Jefferson

1° x 2° Sheet: Denver

Province: High Plains

Township and Range:

References Cited:

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Scott, G.R., 1970, Quaternary faulting and potential earthquakes in east-central Colorado, in Geological Survey research 1970, chapter C: U.S. Geological Survey Professional Paper 700-C, p. C11-C18.

Scott, G.R., 1972, Geologic map of the Morrison quadrangle, Jefferson County, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-790-A.

Q00 - Perry Park - Jarre Canyon Fault

Structure type: Discounted fault

Structure number: Q00

Comments: This fault was previously mapped as a potentially active fault (fault #194) by Kirkham and Rogers (1981).

Structure name: Perry Park - Jarre Canyon Fault

Comments: The Perry Park - Jarre Canyon Fault system consists of six to seven faults generally oriented north-south on the east flank of the Rampart Range. The fault begins west of the Louviers/Littleton Airport northeast of Castle Rock, and extends south along the Front Range to the east flank of Storm Peak. The fault is generally known as the Perry Park - Jarre Canyon Fault (e.g., Bryant and others, 1981; Dickson and others, 1986). Kirkham and others (1981) referred to it as the Jarre Creek Fault.

Reason for exclusion:

The Perry Park - Jarre Canyon Fault forms the east flank of the Rampart Range which is part of the Colorado Front Range. It is a west-dipping, moderate-angle, range-front, Laramide reverse fault with renewed late Cenozoic displacement. Bryant and others (1981) mapped Pleistocene Rocky Flats Alluvium as faulted against Precambrian rocks. However, Tweto (1978), Kirkham and Rogers (1981), Colman (1985) and Dickson and others (1986) only recognized late Cenozoic movement on the fault. Dickson and others (1986) further stated that Pleistocene deposits are not offset across the fault.

Date of compilation: 11/17/97

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

State: Colorado

County: Douglas

1° x 2° Sheet: Denver

Province: Southern Rocky Mountains-Great Plains

Township and Range: T10S,R68W-T7S,R68W

References Cited:

Bryant, Bruce, McGrew, L.W., and Wobus, R.A., 1981, Geologic map of the Denver 1° x 2° quadrangle, north-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1163.

Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1566.

Dickson, P.A., Kewer, R.P., and Wright, J.E., 1986, Regional fault study: Central Front Range, Colorado, in Rogers, W.P. and Kirkham, R.M., eds., Contributions to Colorado tectonics and seismicity - A 1986 update: Colorado Geological Survey Special Publication 28, p. 172-185.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Tweto, Ogden, 1978, Northern rift guide 1, Denver-Alamosa, Colorado, in Hawley, J.W., ed., Guidebook to the Rio Grande Rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 13-27.

Structure type: Discounted fault

Structure number: Q00

Comments: This fault was previously mapped as a potentially active Quaternary fault (fault #172) by Kirkham and Rogers (1981).

Structure name: Fowler Fault

Comments: The fault was first named by Kirkham and Rogers (1981) although it was earlier reported as an inferred fault by Scott (1970) and mapped as a fault by Scott and others (1976). This feature is considered discounted fault because recent studies have not found compelling evidence of faulting associated with the surface scarp.

Reason for exclusion:

The Fowler Fault is considered to be a non-tectonic feature because of the lack of compelling evidence that the prominent escarpment coincides with distinctive faults in the underlying bedrock.

This N60°W-trending feature is located about 5 km northwest of the town of Fowler, Colorado, along the northeastern side of the Arkansas River Valley. The evidence originally reported by Scott (1970) to infer the presence of a Quaternary fault was two-fold: 1) mapping of Quaternary deposits suggested that early Pleistocene Rocky Flats Alluvium was vertically offset about 18 m along an abrupt, linear, 12-km-long trend; and 2) three closely spaced northward-dipping faults in Upper Cretaceous Pierre Shale were recognized in an arroyo that crosses the inferred fault line. The 18 m vertical offset does not occur across a topographically continuous surface, but rather the offset is inferred on the basis of correlating gravelly deposits of early Pleistocene Rocky Flats Alluvium that are spaced only a few tens to hundreds of meters apart but are at markedly different altitudes. The gravels and their associated soils are very similar, leading to the conclusion that these non-concordant deposits were originally contiguous and had been offset by Quaternary faulting.

In 1994, M.N. Machette and A.J. Crone conducted a brief field reconnaissance specifically in search of demonstrable evidence of Quaternary faulting. To date, the results to these reconnaissance studies are only reported in a 1994 Final Technical Report to the U.S. Nuclear Regulatory Commission. The results of their investigation of the Fowler Fault, as presented in their report, are summarized below.

Although the top of the Rocky Flats Alluvium appears to be offset about 18 m, changes in the atitude and elevation of the basal contact of the alluvium across the scarp provide evidence for a more plausible, non-tectonic explanation for the apparent offset. On the northeast (upthrown) side of the scarp, the alluvium is typically 3 to 4 m thick and has a generally planar base, which is consistent with the gravelly alluvium being deposited as a thin sheet across a low-relief piedmont surface. In contrast, on the southwest (downthrown) side the thickness of the alluvium varies considerably over a short distance, from only about 1 m adjacent to the trace of the inferred fault to several (possibly 10 m) meters thick at a point a few hundred meters southwest of the inferred fault. The geometry of the base of the alluvium adjacent (southwest of) to the fault suggested that the alluvium has filled an ancient stream channel; the base of this channel sweeps upward in the direction of the scarp (toward the northeast). Southwest of the inferred fault, the basal channel fill is comprised of calcium carbonate-cemented pebbly sandstone that is distinct compared to the typical Rocky Flats Alluvium. The relatively well sorted character of the sandstone suggests that it was deposited in a fluvial channel. Along a 4-km-long section in the central part of the suspected fault, the base and the top of the Rocky Flats Alluvium show the same pattern of upward sweeping basal and upper contacts adjacent to the inferred fault. The nature of these contacts and the presence of the carbonate-cemented sand was interpreted by Machette and Crone as evidence of a major fluvial channel that defines the boundary between two stages of Rocky Falts Alluvium, an older, higher deposit (Qrf1) and a slightly younger inset deposit (Qrf2). On the basis of their field observations, Machette and Crone interpreted the escarpment not as a fault scarp, but rather as the boundary (i.e., terrace riser) between two slightly different age deposits of Rocky Flats Alluvium whose elevations are different because of downcutting along the ancient Arkansas River.

Scott's (1970) second line of evidence favoring a fault interpretation was the presence of closely spaced northward-dipping faults in the Pierre Shale beneath the trace of the inferred fault. Machette and Crone carefully searched the arroyo walls in the area where Scott reported these north-dipping faults but could not find evidence of significant fault displacement despite nearly continuous exposures along the arroyo walls. Furthermore, bedding in the shale could be traced almost continuously across the area where the trace of the fault would be present. The only features present in the shale were several north-dipping fractures that strike 055° and dip 39° to 44°N (similar to Scott's notations). The fractures consist of 1-cm-wide disruptions in the near horizontally bedded shale, but there is no evidence of significant offset across them. The small size of the fractures and the lack of disruption in the well-bedded shale suggest that it is unlikely that the fractures could be responsible for the inferred 18 m of Quaternary throw on the fault. On the basis of stratigraphic and structural evidence, Machette and Crone concluded that the inferred "Fowler Fault" is not a product of Quaternary tectonism, but rather an erosional escarpment associated with the early Quaternary history of the Arkansas River.

Jack Benjamin and Associates and Geomatrix Consultants (1996) conducted field reconnaissance in two small drainages that cross this fault. They discovered relatively continuous bedding in the Pierre Shale across the inferred trace of the fault, and an alluvial surface remnant inset about 17 m below the upper Rocky Flats surface. This suggested the lower surface was a younger fluvial channel rather than a downdropped fault block of Rocky Flats Alluvium. Based on their observations, they concurred that the Fowler Fault is an erosional escarpment rather than a Quaternary fault.

Date of compilation: 11/4/97

Compiler and affiliation: Anthony J.Crone, U.S. Geological Survey

State: Colorado

County: Pueblo, Crowley

1° x 2° Sheet: Pueblo

Province: High Plains

Township and Range: T22S,R59W-T21S,R60W

References Cited:

Jack Benjamin and Associates and Geomatrix Consultants, 1996, Probabilistic seismic hazard assessment for the U.S. Army chemical disposal facility, Pueblo Depot Activity, Colorado: unpublished report prepared by Jack R. Benjamin and Associates, Inc. and Geomatrix Consultants, for Science Applications International Corporation, Maryland, JBA 148-130-PU-002.

Crone, A.J., and Machett, M.N., 1994, Reconnaissance investigations of Quaternary faulting in the stable interior of the west-central United States: Final Report to the Nuclear Regulatory Commission, FY 1994, 11 p.

Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p.

Scott, G.R., 1970, Quaternary faulting and potential earthquakes in east-central Colorado, 'in' Geological Survey research 1970, chapter C: U.S. Geological Survey Professional Paper 700-C, p. C11-C18.

Scott, G.R., Taylor, R.B., Epis, R.C., and Wobus, R.A., 1978, Geologic map of the Pueblo 1° x 2° quadrangle, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1022.

SIMPLE QUATERNARY FOLDS

A *simple fold* is a fold that appears to consist of a single section all of which deformed during the last paleoevent. The term *simple fault* also serves as a default category for faults that have not been studied in enough detail to warrant designation as a sectioned or segmented fold.

Structure type: Simple fold

Structure number: Qf2

Structure name: Cattle Creek Anticline

Comments: The Cattle Creek Anticline the anticlinal flexure on the upper (eastern) limb of the Grand Hogback monocline. The fold is a Laramide structure that has locally been enhanced by Neogene and Quaternary diapirism associated with evaporite flowage from beneath the Grand Hogback monocline. The fold axis generally follows the Roaring Fork River Valley south from Glenwood Springs to Carbondale, then extends up the Crystal River south from Carbondale. The Cattle Creek Anticline was recognized as a diapiric feature by Mallory (1966).

Synopsis:

The Cattle Creek Anticline is the anticlinal flexure on the upper (eastern) limb of the Grand Hogback monocline. The anticline is a Laramide structure that has been locally enhanced by Neogene and Quaternary diapirism associated with Pennsylvanian evaporitic rocks. The axis of the Laramide anticline follows the Roaring Fork Valley from Glenwood Springs to near Carbondale and then turns up the Crystal River Valley. The axial crest of the Quaternary diapiric anticline generally follows the Laramide axis, but it apparently terminates near Carbondale (Kirkham and others, 1996b; Kirkham, 1997; Kirkham and Widmann, 1997). Outwash terraces as young as Pinedale are tilted away from the fold axis, and pre-Bull Lake debris-flow deposits at the mouth of Fourmile Creek are uparched at least 30 m (Kirkham and others, 1995a; 1997a; Kirkham, 1997).

Date of Compilation: 1/23/98

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

State: Colorado

County: Garfield

1° x ° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T6S,R89W-T8S,R87W

Strike: N32W

Number of traces: 1

End to end length: 8.55 km

Cumulative length: 9.55 km

Reliability of location: Good

Comments: The Laramide axis of the Cattle Creek Anticline was mapped at a scale of 1:24,000 by Kirkham and others (1995a; 1996b; 1997a) and Kirkham and Widmann (1997). The axis of the Quaternary diapiric anticline, which is used herein as the fold trace, was mapped by Kirkham and others (1996b) and Kirkham and Widmann (1997).

Geological setting:

The Laramide Cattle Creek Anticline is the anticlinal flexure on the upper (eastern) limb of the Grand Hogback monocline. The fold has been reactivated during the Neogene and

Quaternary by diapiric uparching due to flowage of underlying Pennsylvanian evaporitic rocks (Kirkham, 1997; Kirkham and Widmann, 1997). The region is underlain by at least 900 m of evaporite deposits (Mallory, 1966).

Geomorphic expression:

Quaternary diapirism on the Cattle Creek Anticline has caused outwash terraces and locally overlying debris-flow deposits to tilt away from the axis (Kirkham and others, 1996b; 1997a; Kirkham, 1997; Kirkham and Widmann, 1997).

Age of folded deposits:

Pennsylvanian bedrock, Miocene basalt flows, and various Quaternary deposits have been folded by the Cattle Creek Anticline. Bull Lake deposits locally dip up to 12° away from the fold axis (Kirkham and others, 1996b); pre-Bull Lake debris-flow deposits at the mouth of Fourmile Creek have been uparched a minimum of 30 m (Kirkham, 1997; Kirkham and others, 1997a); and Pinedale outwash terraces are slightly tilted away from the fold axis (Kirkham and others, 1996b; Kirkham and Widmann, 1997).

Detailed studies:

There have not been any detailed studies conducted on this structure.

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

Comments: Since late Pinedale outwash terraces are slightly folded by diapirism along the crest of the Cattle Creek Anticline (Kirkham and others, 1996b), the most recent movement on this structure is probably post glacial, however, definitive folding of Holocene deposits has not been substantiated.

References Cited:

Kirkham, Bob, 1997, Late Tertiary and Quaternary collapse related to dissolution and flowage of Pennsylvanian evaporitic rocks in the Glenwood Springs area, Colorado, 'in' McCalpin, J.P., compiler, Active geologic environment of central Colorado, Aspen-Glenwood Springs-Silt, Colorado: Friends of the Pleistocene, Rocky Mountain Cell, Field Guidebook, September 12-14, 1997.

Kirkham, R.M., Streufert, R.K., and Cappa, J.A., 1995a, Geologic map of the Glenwood Springs quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 95-3.

Kirkham, R.M., Streufert, R.K., and Cappa, J.A., 1997a, Geologic map of the Glenwood Springs quadrangle, Garfield County, Colorado: Colorado Geological Survey Map Series 31.

Kirkham, R.M., Streufert, R.K., Hemborg, T.H., and Stelling, P.L., 1996b, Geologic map of the Cattle Creek quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 96-1.

Kirkham, R.M., and Widmann, B.L., 1997, Geologic map of the Carbondale quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 97-3.

Mallory, W.W., 1966, Cattle Creek Anticline, a salt diapir near Glenwood Springs, Colorado, 'in' Geological Survey Research 1966: U.S. Geological Survey Professional Paper 550-B, p. B12-B15.

Qf3 - Unnamed Synclinal Fold Southwest of Carbondale

Structure type: Simple fold

Structure number: Qf3

Structure name: Unnamed Synclinal Fold Southwest of

Comments: This unnamed structure is a northwest-southeast-trending synclinal sag southwest of Carbondale and the Crystal River. The sag lies within the Carbondale collapse center and is related to flowage and dissolution of evaporite from beneath the area (Kirkham and others, 1997b).

Synopsis:

This unnamed, northwest-southwest-trending synclinal sag lies within the Carbondale collapse center east of the Grand Hogback monocline. It cuts across a middle and early (?) outwash terrace and is roughly parallel to and west of the Crystal River. The sag is interpreted to result from flowage and dissolution of evaporite from beneath the area. Middle and early (?) Pleistocene outwash gravels and overlying 620 ka Lava Creek B ash and undivided Pleistocene "older" alluvium and colluvium are deformed by this structure (Kirkham and Widmann, 1997)

Date of Compilation: 3/5/98

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

State: Colorado

County: Garfield

1° x ° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T7S,R88W-T8S,R88W

Strike: N25W

Number of traces: 1

End to end length: 3.02 km

Cumulative length: 3.04 km

Reliability of location: Good

Comments: This synclinal sag was mapped at a scale of 1:24,000 by Kirkham and Widmann (1997).

Geological setting:

This unnamed, northwest-southeast-trending synclinal sag lies within the Carbondale collapse center, which is reported to have experienced significant Neogene collapse due to flowage and dissolution of evaporite deposits from beneath the area (Kirkham and others, 1997b; Kirkham and Widmann, 1997). The area is underlain by at least 900 m of evaporite (Mallory, 1966). This sag created a prominent, elongate depression in a middle and early (?) outwash terrace; the 620 ka Lava Creek B ash and overlying "older" alluvium and colluvium were deposited within the depression and subsequently deformed by later movement on the synclinal sag (Kirkham and Widmann, 1997). Several sink holes occur in the depression associated with the sag.

Qf3 - Unnamed Synclinal Fold Southwest of Carbondale

Geomorphic expression:

An elongate, subdued, partially sediment-filled depression marks this unnamed synclinal sag (Kirkham and Widmann, 1997). Several sink holes occur in the depression associated with the sag.

Age of folded deposits:

Middle and early (?) Pleistocene outwash gravels and overlying 620 ka Lava Creek B ash and Pleistocene "older" alluvium and colluvium are deformed by this synclinal sag (Kirkham and Widmann, 1997).

Detailed studies:

There have not been any detailed studies conducted on this structure.

Timing of most recent paleoevent: (3) Quaternary-middle and late (<750 ka)

Comments: Deformation of middle and early (?) outwash gravels, Lava Creek B ash, and overlying Pleistocene alluvium and colluvium suggests movement on this synclinal sag during the past 620 ka (Kirkham and Widmann, 1997).

References Cited:

Kirkham, R.M., Steufert, R.K., Scott, R.B., Lidke, D.J., Bryant, B., Perry, W.J., Jr., Kunk, M.J., Driver, N.E., and Bauch, N.J., 1997b, Active salt dissolution and resulting geologic collapse in the Glenwood Springs region of west-central Colorado [abs.]: Geological Society of America Abstracts with Programs, v. 29, no. 6, p. A-416.

Kirkham, R.M., and Widmann, B.L., 1997, Geologic map of the Carbondale quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 97-3.

Mallory, W.W., 1966, Cattle Creek Anticline, a salt diapir near Glenwood Springs, Colorado, 'in' Geological Survey Research 1966: U.S. Geological Survey Professional Paper 550-B, p. B12-B15.

Structure type: Simple fold

Structure number: Qf4

Structure name: Unnamed Synclinal Fold Northeast of C

Comments: This unnamed structure is an east-west-trending synclinal sag north of Highway 82 near Carbondale at the mouth of Crystal Spring Creek. The sag lies within the Carbondale collapse center and is related to flowage and dissolution of evaporite from beneath the area (Kirkham and others, 1997b).

Synopsis:

This unnamed, east-west-trending synclinal sag lies within the Carbondale collapse center east of the Grand Hogback monocline. It is on the north side of the Roaring Fork River near the mouth of Crystal Spring Creek. The sag is interpreted to result from flowage and dissolution of evaporite from beneath the area. The sag has about 9 m of structural relief in late Pleistocene, Pinedale (?) outwash deposits (Kirkham, 1997; Kirkham and Widmann, 1997). Undivided Pleistocene "older" alluvium and colluvium and Pleistocene colluvium and sheetwash also are deformed by this structure (Kirkham and Widmann, 1997).

Date of Compilation: 3/5/98

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

State: Colorado

County: Garfield

1° x ° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T7S,R88W

Strike: N86W

Number of traces: 1

End to end length: 1.45 km

Cumulative length: 1.48 km

Reliability of location: Good

Comments: This synclinal sag was mapped at a scale of 1:24,000 by Kirkham and Widmann (1997).

Geological setting:

This unnamed, east-west-trending synclinal sag lies within the Carbondale collapse center, which is reported to have experienced significant Neogene collapse due to flowage and dissolution of evaporite deposits from beneath the area (Kirkham and others, 1997b; Kirkham and Widmann, 1997). The area is underlain by at least 900 m of evaporite (Mallory, 1966).

Geomorphic expression:

This feature is a synclinal sag developed in Pinedale (?) outwash deposits and other Pleistocene deposits; a topographic depression about 9 m deep occurs in the terrace along the sag (Kirkham and Widmann, 1997).

Qf4 - Unnamed Synclinal Fold Northeast of Carbondale

Age of folded deposits:

The older of two late Pleistocene, Pinedale (?) outwash terraces and undivided Pleistocene "older" alluvium and colluvium and Pleistocene colluvium and sheetwash are deformed by this synclinal sag (Kirkham and Widmann, 1997).

Detailed studies:

There have not been any detailed studies conducted on this structure.

Timing of most recent paleoevent: (2) Quaternary-late (<130 ka)

Comments: Deformation of a late Pleistocene, Pinedale (?) outwash terrace, Pleistocene alluvium and colluvium, and Pleistocene colluvium and sheetwash suggests late Quaternary, perhaps even post-glacial or Holocene movement on this synclinal sag (Kirkham and Widmann, 1997).

References Cited:

Kirkham, Bob, 1997, Late Tertiary and Quaternary collapse related to dissolution and flowage of Pennsylvanian evaporitic rocks in the Glenwood Springs area, Colorado, 'in' McCalpin, J.P., compiler, Active geologic environment of central Colorado, Aspen-Glenwood Springs-Silt, Colorado: Friends of the Pleistocene, Rocky Mountain Cell, Field Guidebook, September 12-14, 1997.

Kirkham, R.M., and Widmann, B.L., 1997, Geologic map of the Carbondale quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 97-3.

Mallory, W.W., 1966, Cattle Creek Anticline, a salt diapir near Glenwood Springs, Colorado, 'in' Geological Survey Research 1966: U.S. Geological Survey Professional Paper 550-B, p. B12-B15.

Structure type: Simple fold

Structure number: Qf5

Structure name: Unnamed Synclinal Fold Northwest of

Comments: This unnamed structure is a northwest-trending synclinal sag northwest of Carbondale. The sag lies within the Carbondale collapse center (Kirkham, 1997; Kirkham and Widmann, 1997) and is related to flowage and dissolution of evaporite from beneath the area.

Synopsis:

This unnamed, northwest-trending synclinal sag lies within the Carbondale collapse center east of the Grand Hogback monocline. The sag is interpreted to result from flowage and dissolution of evaporite from beneath the area. Late Pleistocene "younger" and "intermediate" terrace alluvium are deformed by this structure (Kirkham and Widmann, 1997).

Date of Compilation: 9/16/98

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

State: Colorado

County: Garfield

1° x ° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T7S,R88W

Strike: N24W

Number of traces: 1

End to end length: 1.91 km

Cumulative length: 1.91 km

Reliability of location: Good

Comments: This synclinal sag was mapped at a scale of 1:24,000 by Kirkham and Widmann (1997).

Geological setting:

This unnamed, northwest-trending, synclinal sag lies within the Carbondale collapse center, which is reported to have experienced significant Neogene collapse due to flowage and dissolution of evaporite deposits from beneath the area (Kirkham and Widmann, 1997). The area is underlain by at least 900 m of evaporite (Mallory, 1966).

Geomorphic expression:

This feature is a synclinal sag developed in late Pleistocene terrace alluvium (Kirkham and Widmann, 1997).

Age of folded deposits:

Late Pleistocene "younger" and "intermediate" terrace alluvium are deformed by this structure (Kirkham and Widmann, 1997)

Detailed studies:

There have not been any detailed studies conducted on this structure.

Timing of most recent paleoevent: (2) Quaternary-late (<130 ka)

Comments: Deformation of late Pleistocene terrace alluvium suggests late Quaternary movement on this synclinal sag (Kirkham and Widmann, 1997).

References Cited:

Kirkham, Bob, 1997, Late Tertiary and Quaternary collapse related to dissolution and flowage of Pennsylvanian evaporitic rocks in the Glenwood Springs area, Colorado, 'in' McCalpin, J.P., compiler, Active geologic environment of central Colorado, Aspen-Glenwood Springs-Silt, Colorado: Friends of the Pleistocene, Rocky Mountain Cell, Field Guidebook, September 12-14, 1997.

Kirkham, R.M., and Widmann, B.L., 1997, Geologic map of the Carbondale quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 97-3.

Mallory, W.W., 1966, Cattle Creek Anticline, a salt diapir near Glenwood Springs, Colorado, 'in' Geological Survey Research 1966: U.S. Geological Survey Professional Paper 550-B, p. B12-B15.

Structure type: Simple fold

Structure number: Qf6

Structure name: Unnamed Synclinal Fold West of Carbo

Comments: This unnamed structure is an east-northeast-trending synclinal sag west of Carbondale near Edgerton Creek. The sag lies within the Carbondale collapse center (Kirkham, 1997; Kirkham and Widmann, 1997) and is related to flowage and dissolution of evaporite from beneath the area.

Synopsis:

This unnamed, east-northeast-trending synclinal sag lies within the Carbondale collapse center east of the Grand Hogback monocline. The sag is interpreted to result from flowage and dissolution of evaporite from beneath the area. Undivided Pleistocene "older" alluvium and colluvium are deformed by this structure (Kirkham and Widmann, 1997).

Date of Compilation: 9/16/98

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

State: Colorado

County: Garfield

1° x ° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T7S,R88W

Strike: N70E

Number of traces: 1

End to end length: 0.59 km

Cumulative length: 0.61 km

Reliability of location: Good

Comments: This synclinal sag was mapped at a scale of 1:24,000 by Kirkham and Widmann (1997).

Geological setting:

This unnamed, east-northeast-trending synclinal sag lies within the Carbondale collapse center, which is reported to have experienced significant Neogene collapse due to flowage and dissolution of evaporite deposits from beneath the area (Kirkham and Widmann, 1997). The area is underlain by at least 900 m of evaporite (Mallory, 1966).

Geomorphic expression:

This feature is a synclinal sag developed in Pleistocene deposits (Kirkham and Widmann, 1997).

Age of folded deposits:

Pleistocene "older" alluvium and colluvium are deformed by this synclinal sag (Kirkham and Widmann, 1997).

Detailed studies:

There have not been any detailed studies conducted on this structure.

Timing of most recent paleoevent: (4) Quaternary (<1.6 Ma)

Comments: Deformation of Pleistocene deposits suggests Quaternary movement on this synclinal sag (Kirkham and Widmann, 1997).

References Cited:

Kirkham, Bob, 1997, Late Tertiary and Quaternary collapse related to dissolution and flowage of Pennsylvanian evaporitic rocks in the Glenwood Springs area, Colorado, 'in' McCalpin, J.P., compiler, Active geologic environment of central Colorado, Aspen-Glenwood Springs-Silt, Colorado: Friends of the Pleistocene, Rocky Mountain Cell, Field Guidebook, September 12-14, 1997.

Kirkham, R.M., and Widmann, B.L., 1997, Geologic map of the Carbondale quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 97-3.

Mallory, W.W., 1966, Cattle Creek Anticline, a salt diapir near Glenwood Springs, Colorado, 'in' Geological Survey Research 1966: U.S. Geological Survey Professional Paper 550-B, p. B12-B15.

SUSPECT QUATERNARY FOLDS

A fold is described as a s*uspect feature* when the literature is not conclusive or when it leaves doubt as to the structure's Quaternary activity.

Structure type: Suspect feature

Structure number: Qf1

Structure name: Grand Hogback Monocline

Comments: The Grand Hogback monocline is a generally north-south-trending, down-to-the-west, late Laramide structure that extends from the Danforth Hills in the north to the Elk Mountains in the south. The section of the monocline that extends from near Glenwood Springs to southwest of Carbondale is herein considered a suspected Quaternary structure.

Synopsis:

The Grand Hogback monocline is a generally north-south-trending, down-to-the-west, late Laramide structure that extends from the Danforth Hills in the north to the Elk Mountains in the south. The section of the monocline from near Glenwood Springs to Thompson Creek southwest of Carbondale is suspected of unfolding or relaxation during the Quaternary based on bedding-plane faults thought to be associated with the monocline that offset Quaternary deposits, and based on Quaternary diapirism in the anticlinal limb of the monocline (Kirkham, 1997; Kirkham and Widmann, 1997). The monocline is underlain by evaporite deposits that may exceed 900 m in thickness (Mallory, 1966). Young movement on the monocline, which appears to involve relaxing or unfolding of the monocline, is probably related to flowage or dissolution of underlying evaporite deposits (Kirkham and others, 1997b; Kirkham, 1997).

Date of Compilation: 9/1/98

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

State: Colorado

County: Garfield

1° x ° Sheet: Leadville

Province: Southern Rocky Mountains

Township and Range: T6S,R89W- T8S,R88W

Strike: N27W

Number of traces: 1

End to end length: 22.30 km

Cumulative length: 21.83 km

Reliability of location: Good

Comments: The Grand Hogback Monocline was mapped at a scale of 1:20,000 by Murray (1962) and 1:250,000 by Tweto and others (1978). The section of the monocline that is herein suspected of Quaternary movement was mapped at a scale of 1:24,000 by Kirkham and others (1995a; 1996b; 1997a) and Carrol and others (1996). The trace used herein is from Tweto and others (1978) and includes only that part of the fold suspected of Quaternary movement.

Geological setting:

The Grand Hogback Monocline is a late Laramide structure suspected locally of Quaternary relaxation or unfolding (Murray, 1966; 1969; Kirkham, 1997). The section of the Grand

Hogback Monocline that is suspected of Quaternary movement extends south from Glenwood Springs to Thompson Creek southwest of Carbondale. In this area the monocline is underlain by evaporite deposits that may exceed 900 m in thickness (Mallory, 1966). Young movement on the monocline may be related to relaxation or unfolding of the monocline as evaporite deposits migrate or dissolve from beneath it. Evidence supportive of Quaternary movement on the monocline include bedding-plane faults associated with the monocline that cut Quaternary deposits and diapirically folded late Pleistocene deposits along the anticlinal upper limb (the Cattle Creek Anticline) of the monocline (Stover, 1986; Kirkham and others, 1996b; Kirkham, 1997; Kirkham and Widmann, 1997).

Geomorphic expression:

Age of folded deposits:

Individual bedding-plane faults associated with relaxation or unfolding of the Grand Hogback monocline offset Miocene basalts as much as 90 m, late Tertiary-early Quaternary basaltic gravels as much as 30 m, and Holocene (?) and Pleistocene debris-flow deposits about 3 m (Kirkham and Widmann, 1997). Pleistocene outwash terraces as young as late Pleistocene (Pinedale?) are folded by diapiric uparching along the upper anticlinal limb (the Cattle Creek Anticline) of the monocline (Kirkham and Widmann, 1997). It is possible that Quaternary deposits are being affected by the unfolding of the Grand Hogback monocline, but there is not yet any direct evidence to show that Quaternary deposits are deformed in association with this structure.

Detailed studies:

There have not been any detailed studies conducted on this section of the Grand Hogback Monocline.

Timing of most recent paleoevent: (2) Quaternary - late (<130 ka)

Comments: Although there is no direct evidence that conclusively demonstrates Quaternary movement on the Grand Hogback monocline, indirect evidence suggests that the section of the monocline between Glenwood Springs and Thompson Creek has experience Quaternary movement. Faulted and folded deposits thought to result from relaxation or unfolding of the monocline are as young as late Pleistocene or Pinedale (?), and possibly even Holocene (Kirkham and others, 1996b; Kirkham, 1997).

References Cited:

Carroll, C.J., Kirkham, R.M., and Stelling, P.L., 1996, Geologic map of the Center Mountain quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 96-2.

Kirkham, Bob, 1997, Late Tertiary and Quaternary collapse related to dissolution and flowage of Pennsylvanian evaporitic rocks in the Glenwood Springs area, Colorado, 'in' McCalpin, J.P., compiler, Active geologic environment of central Colorado, Aspen-Glenwood Springs-Silt, Colorado: Friends of the Pleistocene, Rocky Mountain Cell, Field Guidebook, September 12-14, 1997.

Kirkham, R.M., Streufert, R.K., and Cappa, J.A., 1995a, Geologic map of the Glenwood Springs quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-file Report 95-3.

Kirkham, R.M., Streufert, R.K., and Cappa, J.A., 1997a, Geologic map of the Glenwood Springs quadrangle, Garfield County, Colorado: Colorado Geological Survey Map Series 31.

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Open-File Report 98-8

QUATERNARY FAULT, FOLD AND EARTHQUAKE MAP OF COLORADO

By Beth L. Widmann, Robert M. Kirkham, and William P. Rogers
GIS & Digital cartography by Matthew L. Morgan

EXPLANATION

Q25 — Simple or suspect fault—Dashed where inferred; dotted where concealed; bar and ball on side of fault downthrown during the Quaternary; each simple or suspect fault is assigned a unique identifier that is keyed to database

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- Holocene and post-glacial (<15 ka)
- Late Quaternary (<130 ka)
- Middle and late Quaternary (<750 ka)
- Quaternary (<1.6 Ma)

SCALE 1:500 000

10 0 10 20 MILES

10 0 10 20 KILOMETERS

DATUM IS MEAN SEA LEVEL

Epicentral location of instrumentally located earthquake. Size of dot indicates magnitude.

- 1.0–1.9
- 2.0–2.9
- 3.0–3.9
- 4.0–4.9
- 5.0–5.9

Approximate epicentral location of pre-instrumental earthquake. Size of triangle indicates the modified Mercalli intensity.

- F, I, II, III
- IV
- V
- VI

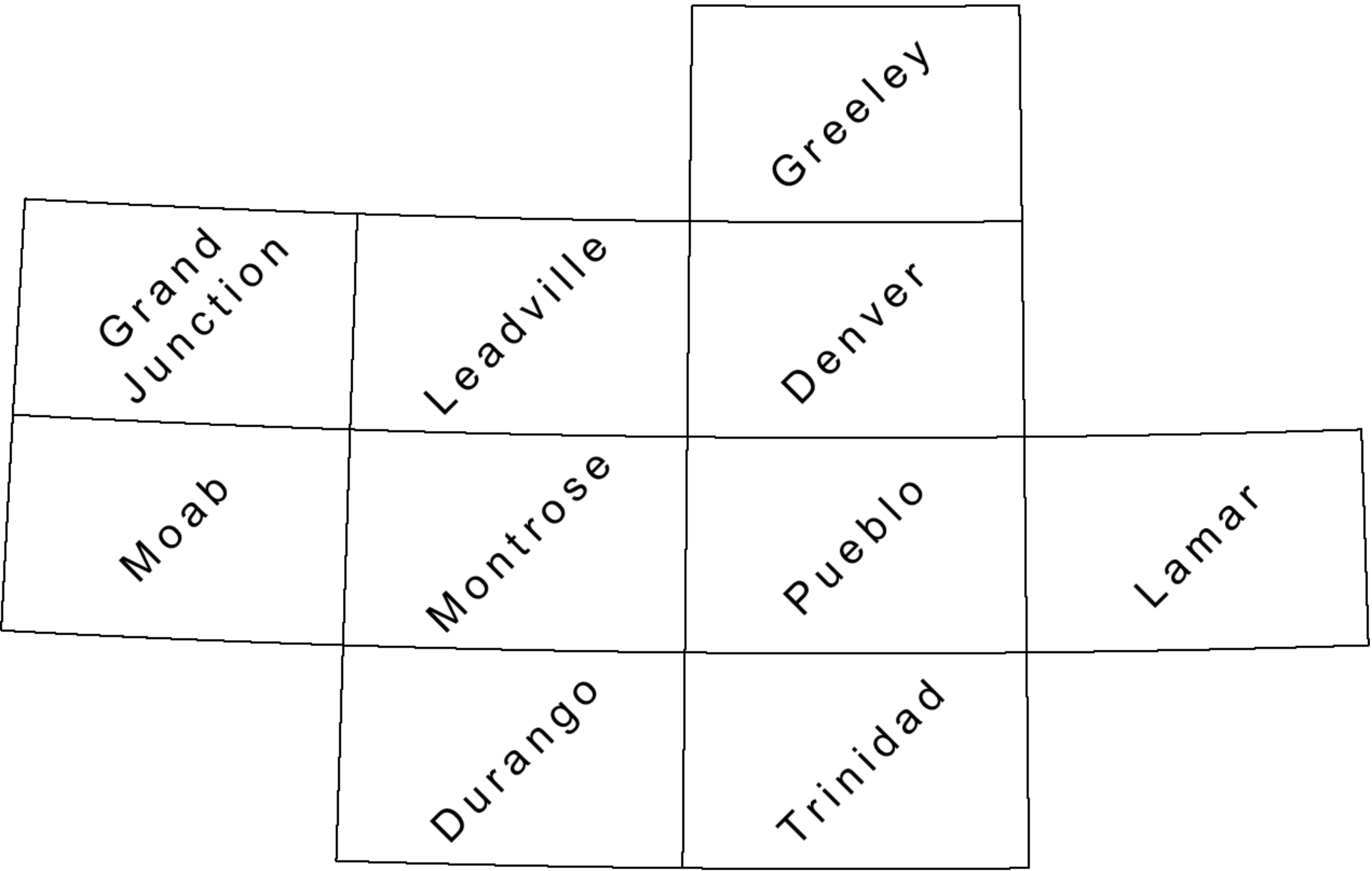
Approximate location of the November 8, 1882 (Universal Coordinated Time) earthquake. The location and magnitude of this pre-instrumental earthquake has been estimated by several researchers using felt reports. The location used herein is that reported by Kirkham and Rogers (1986) and Spence and others (1996) and is probably accurate to only 0.5 to 1 degree of latitude or longitude. Recent studies report magnitudes that range between 6.0 and 6.8 for the earthquake.

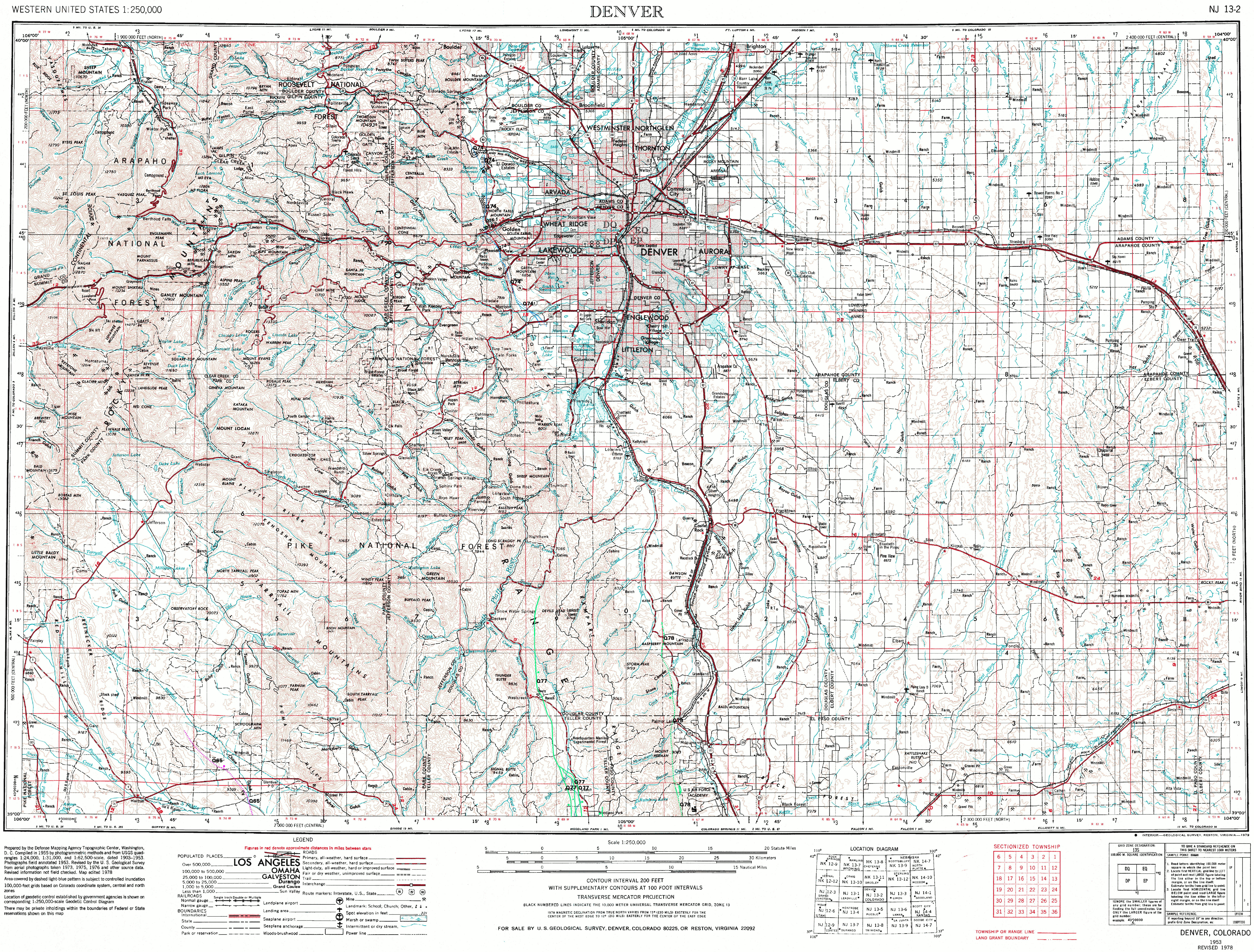
278 — Epicentral location of in-strumentally located earth-quake for which neither magnitude nor intensity are available.

351 — Location of earthquake generated by blast from mining operations or underground nuclear testing.

Vicki Cowart, State Geologist
Colorado Geological Survey
Department of Natural Resources
Denver, Colorado
1998

Index to 1°x 2° maps that have Quaternary structures





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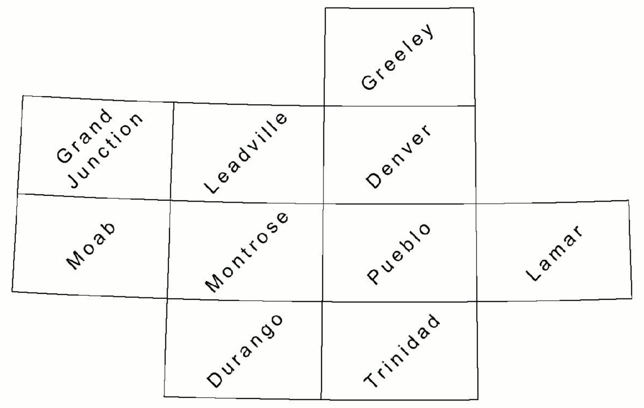

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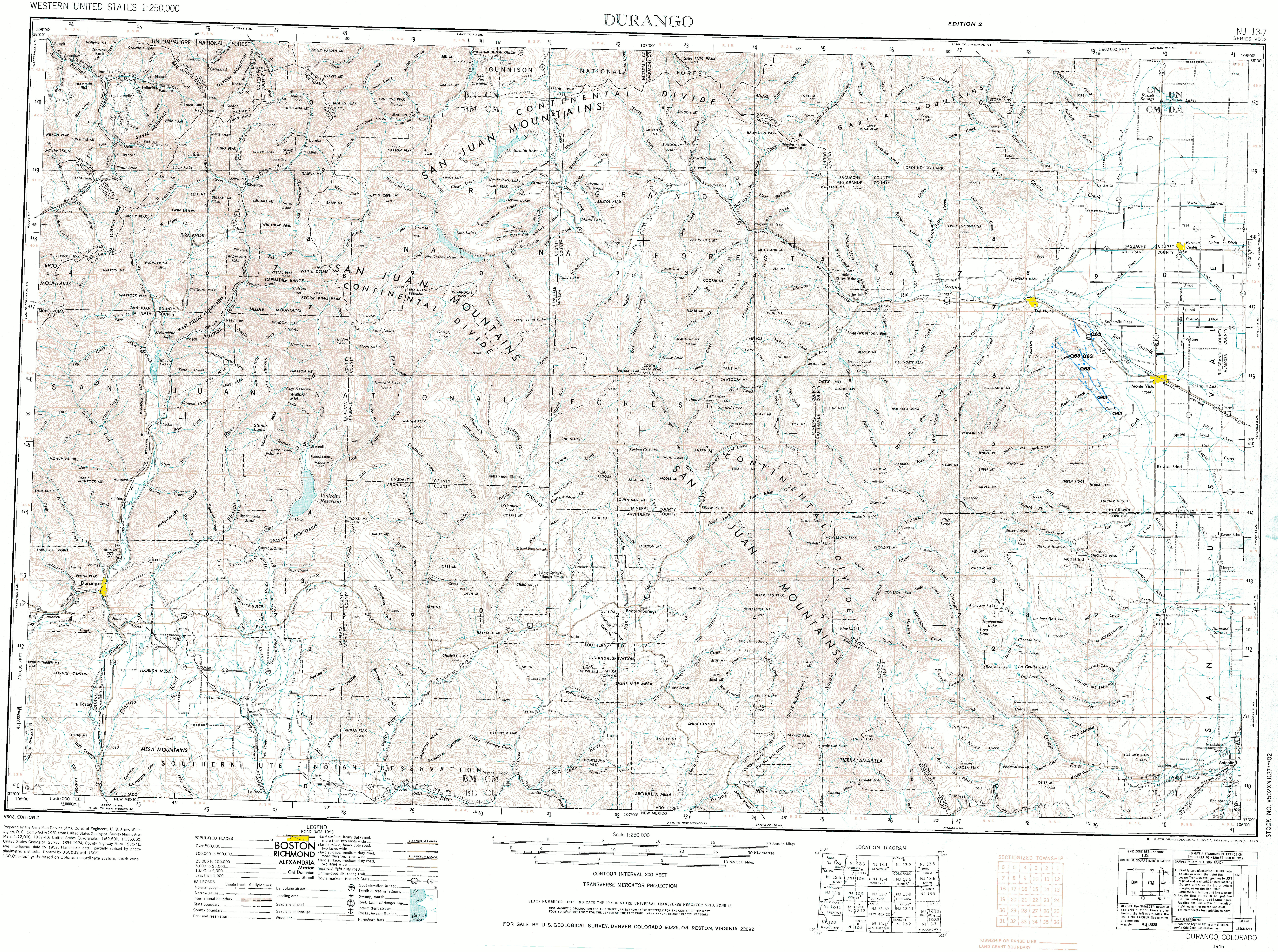

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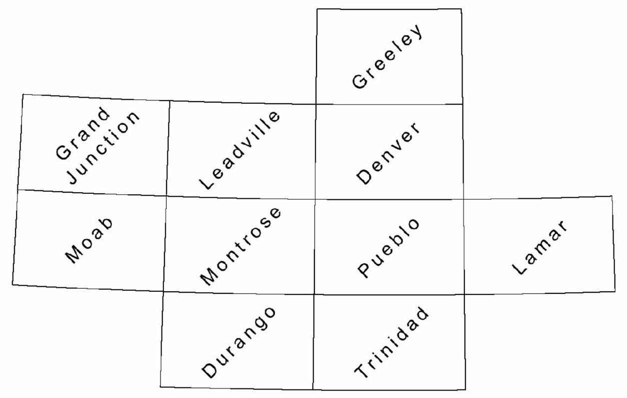

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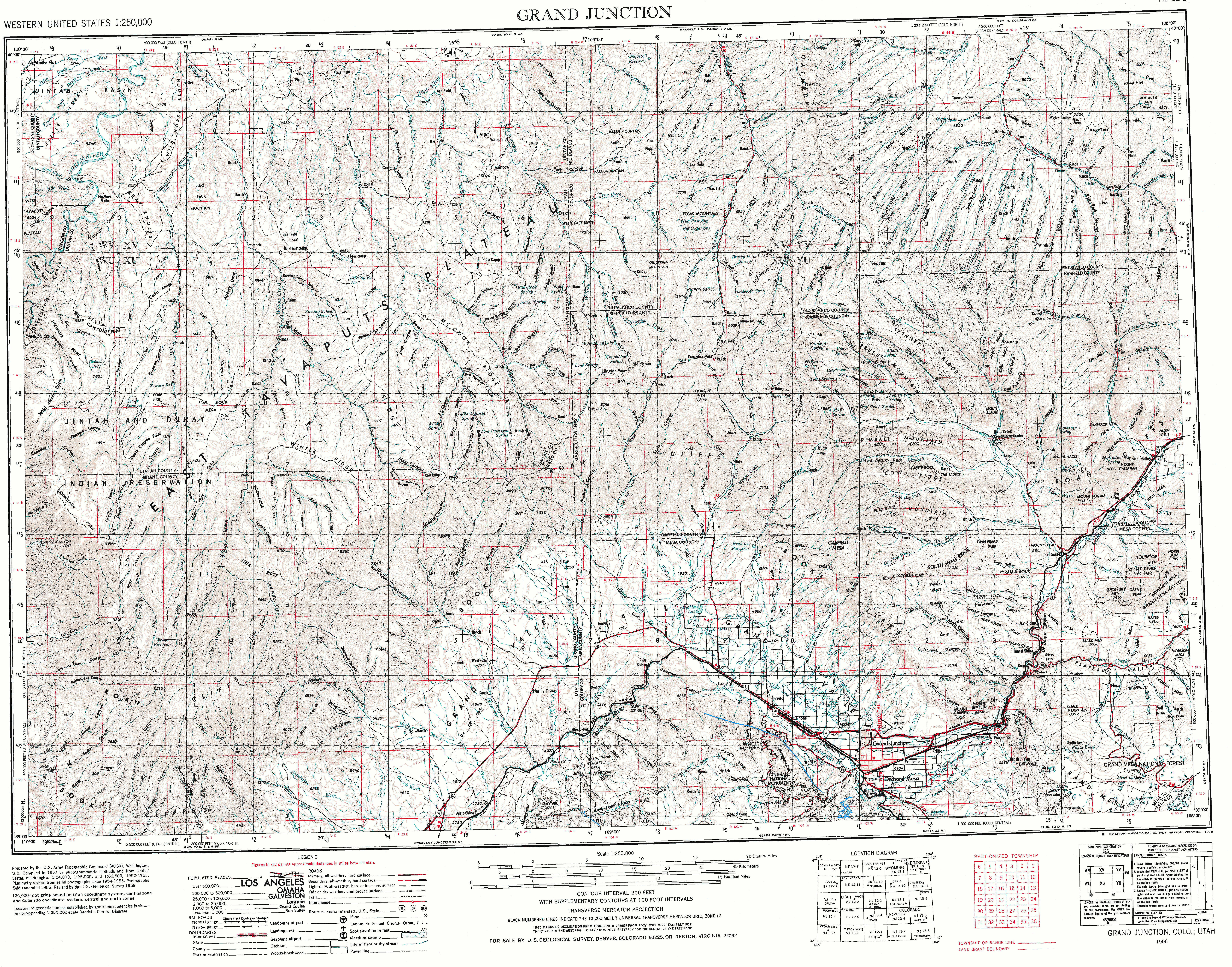

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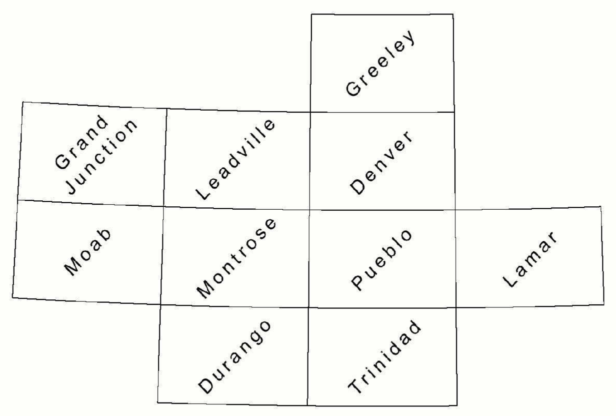

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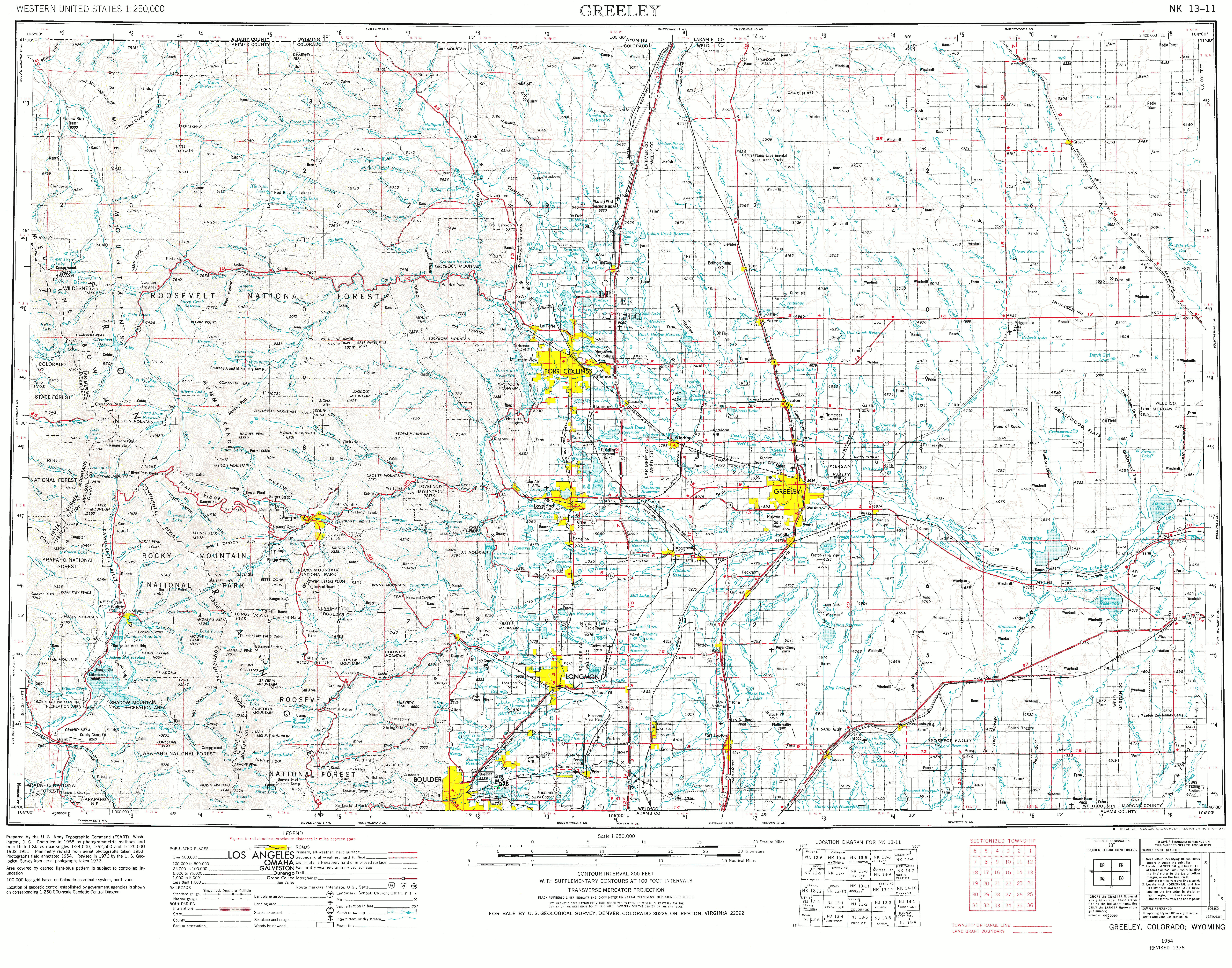

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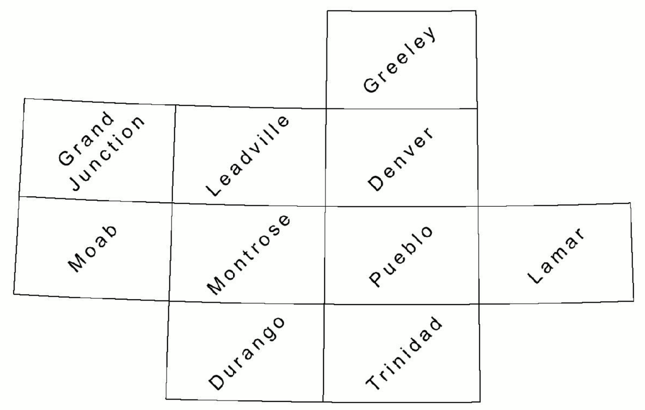
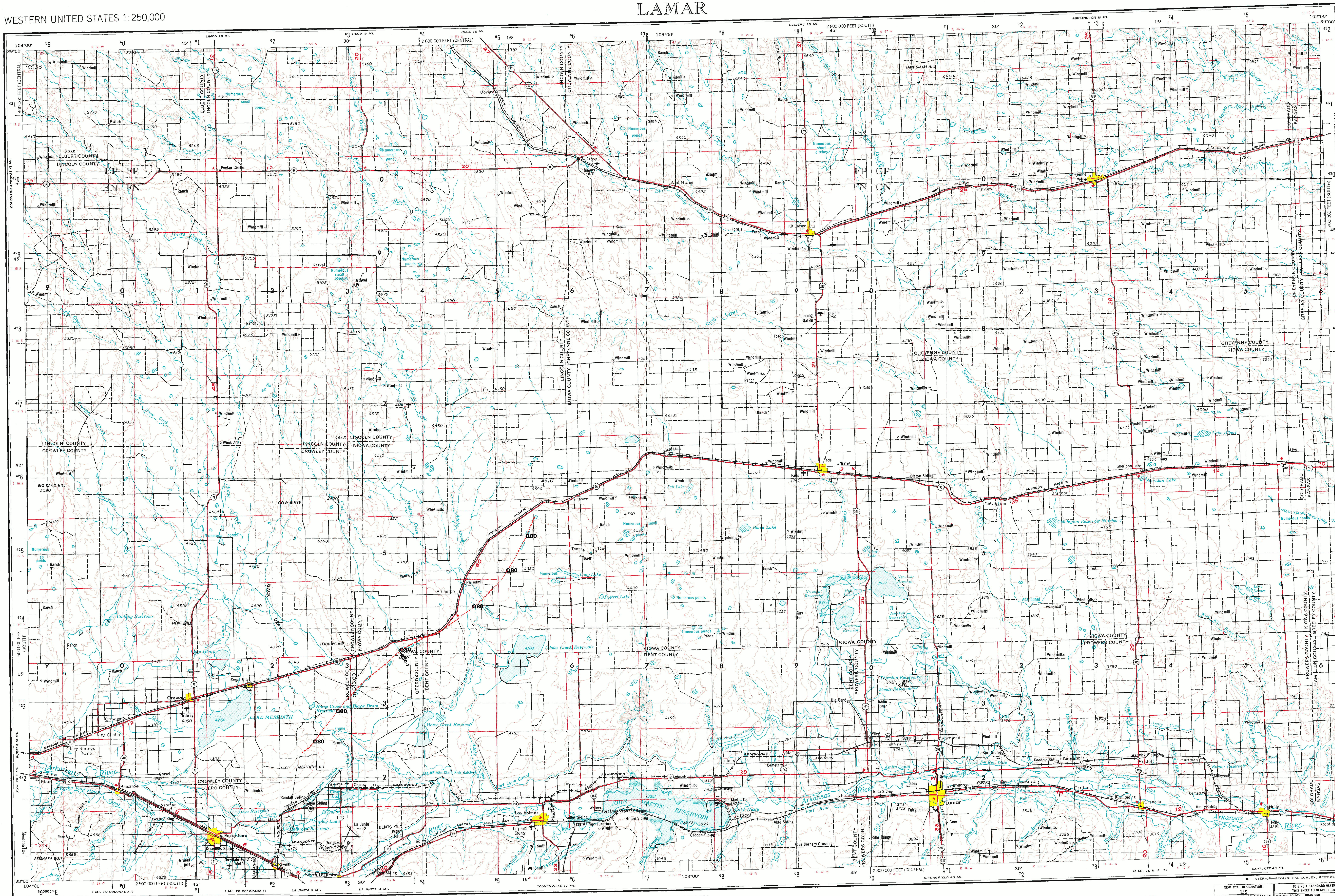


Colorado Geological Survey
Digital Cartography by Matthew L. Morgan

WESTERN UNITED STATES 1:250,000

LAMAR

NJ 13-6



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100,000-foot grids based on Colorado coordinate system, south and central zones

Location of geodetic control established by government agencies is shown on corresponding 1:250,000-scale Geodetic Control Diagram

Scale 1:250,000

CONTOUR INTERVAL 100 FEET
WITH SUPPLEMENTARY CONTOURS AT 50 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION

BLACK NUMBERED LINES INDICATE THE 10,000 METER UNIVERSAL TRANSVERSE MERCATOR GRID, ZONE 13

1975 MAGNETIC DECLINATION FROM TRUE NORTH VARIES FROM 12° (210 MILS) EASTERLY FOR THE CENTER OF THE WEST EDGE TO 11° (200 MILS) EASTERLY FOR THE CENTER OF THE EAST EDGE

FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092

LAMAR, COLORADO
1954
REVISED 1976

Open-File Report 98-8

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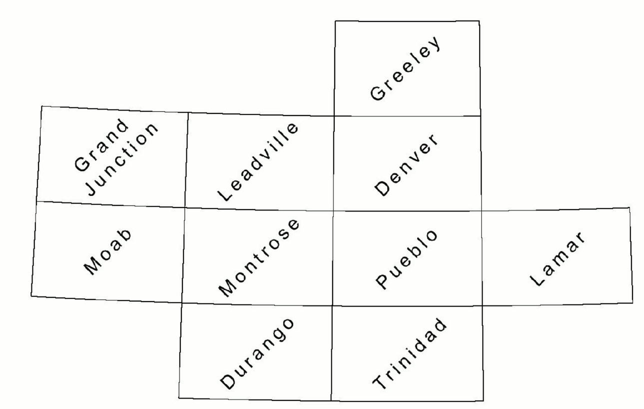

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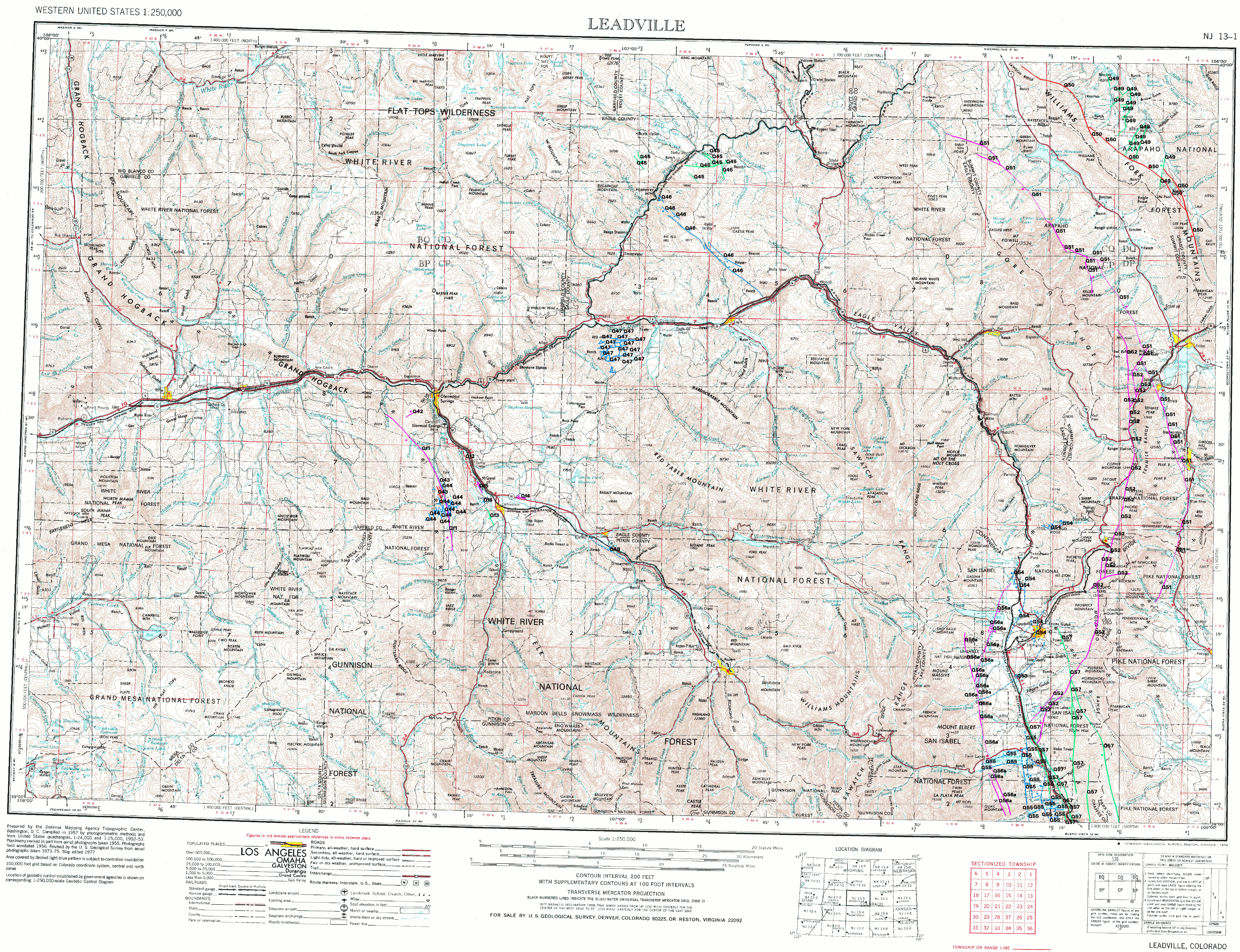

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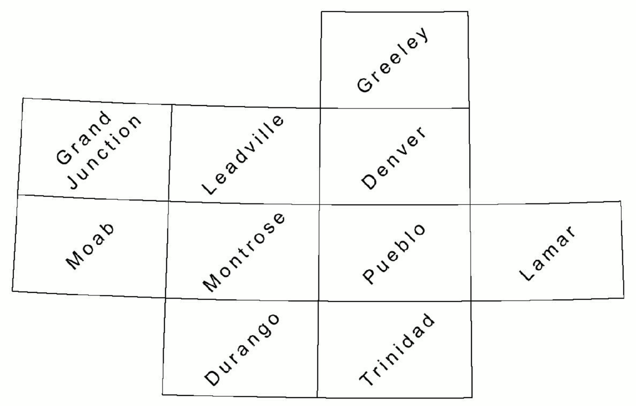

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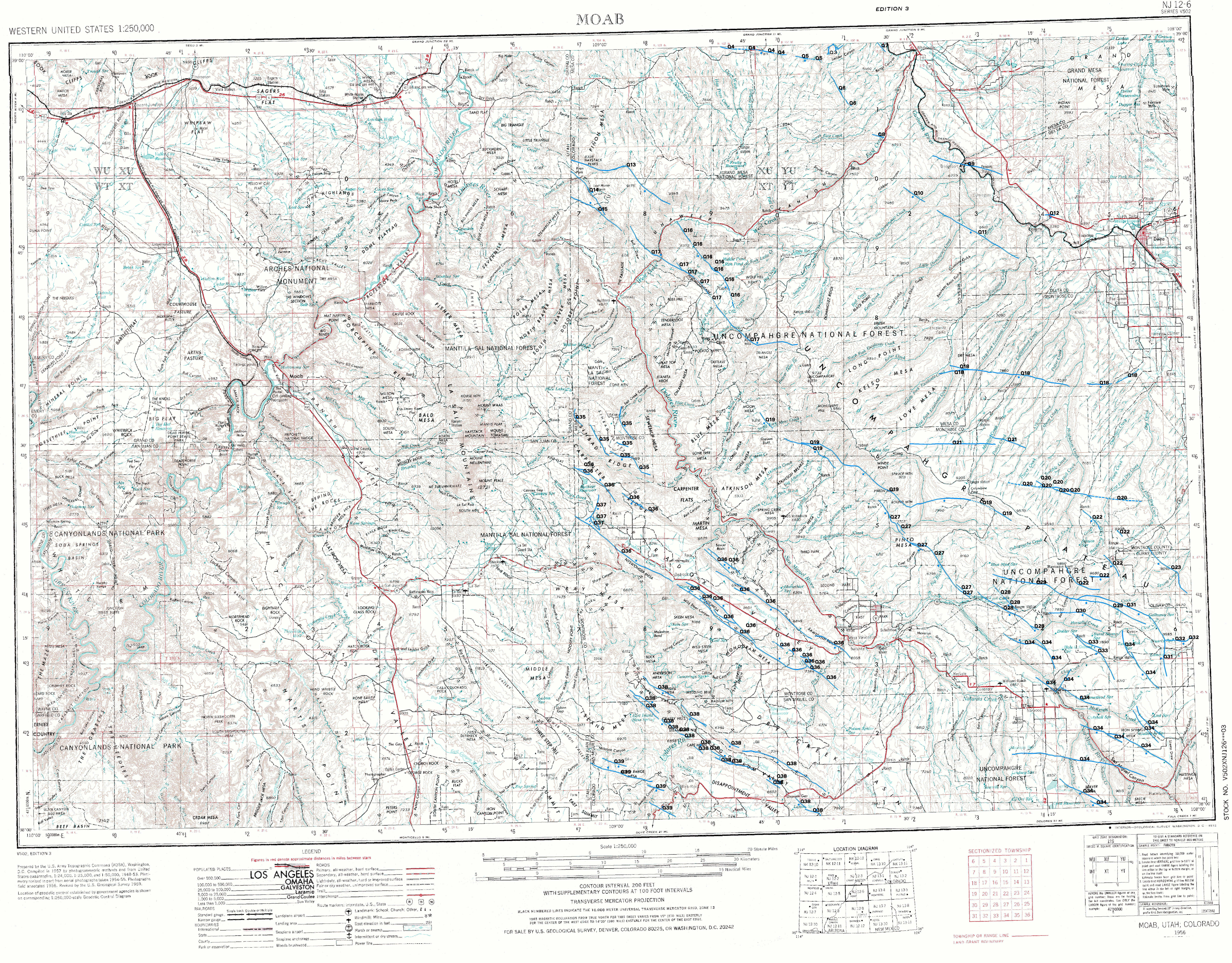

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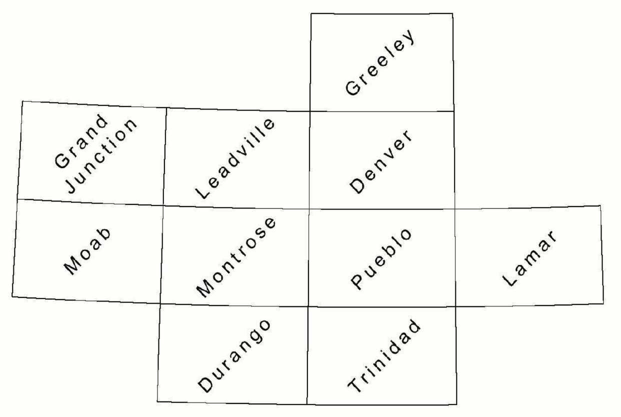

Colorado Geological Survey

Digital Cartography by Matthew L. Morgan

WESTERN UNITED STATES 1:250,000

MONTROSE

NK 13-4

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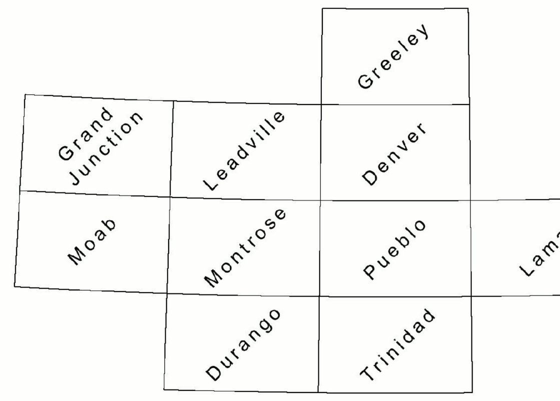

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LEGEND

Figures in red denote approximate distances in miles between stars

POPULATED PLACES
Over 500,000 — LOS ANGELES
100,000 to 500,000 — OMAHA
25,000 to 100,000 — GALVESTON
5,000 to 25,000 — Durango
1,000 to 5,000 — Grand Coulee
Less than 1,000 — Sun Valley

RAILROADS — Single track, Double or Multiple
Standard gauge
Narrow gauge

BOUNDARIES
International
State
County
Park or reservation

Landplane airport
Landing area
Seaplane airport
Seaplane anchorage
Woods-brushwood

ROADS
Primary, all-weather, hard surface
Secondary, all-weather, hard surface
Light-duty, all-weather, hard or improved surface
Fair or dry weather, unimproved surface
Trail
Interchange
Route markers: Interstate, U.S., State

Landmark: School; Church; Other
Mine
Spot elevation in feet .221
Marsh or swamp
Intermittent or dry stream
Power line

Scale 1:250,000

5 0 5 10 15 20 Statute Miles
5 0 5 10 15 20 25 30 Kilometers
5 0 5 10 15 Nautical Miles

CONTOUR INTERVAL 200 FEET
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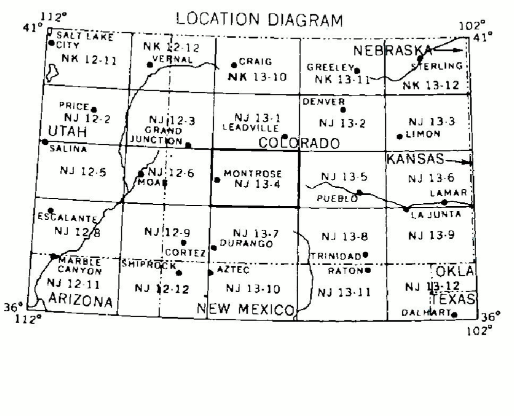
TRANSVERSE MERCATOR PROJECTION

BLACK NUMBERED LINES INDICATE THE 10,000 METER UNIVERSAL TRANSVERSE MERCATOR GRID, ZONE 13

1977 MAGNETIC DECLINATION FROM TRUE NORTH VARIES FROM 13½° (240 MILS) EASTERLY FOR THE CENTER OF THE WEST EDGE TO 12½° (220 MILS) EASTERLY FOR THE CENTER OF THE EAST EDGE

FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092

LOCATION DIAGRAM



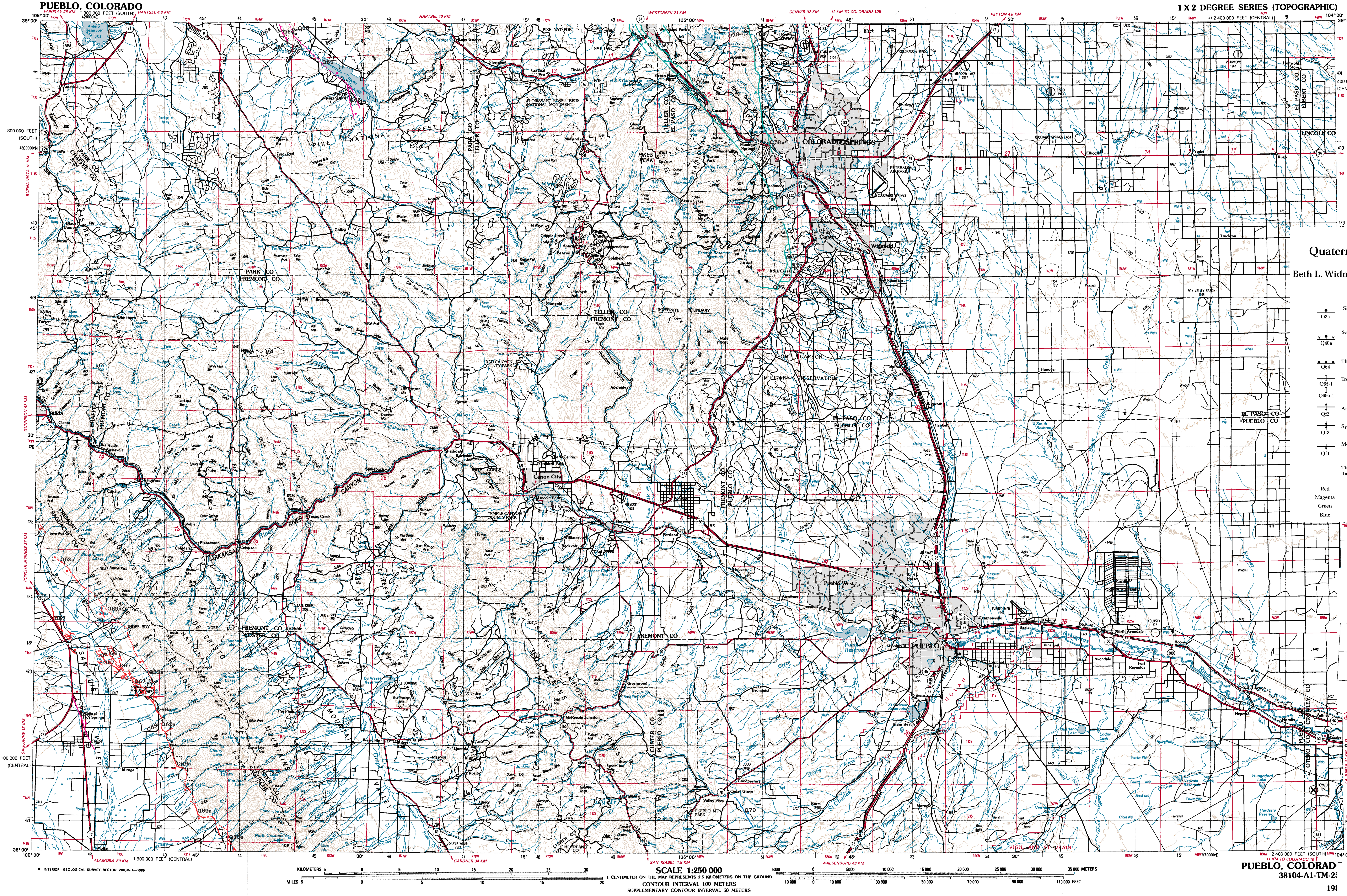
SECTIONIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

TOWNSHIP OR RANGE LINE
LAND GRANT BOUNDARY

MONTROSE, COLORADO
1956
REVISED 1977

Colorado Geological Survey
Digital Cartography by Matthew L. Morgan



Open-File Report 98-8

Quaternary Fault and Fold Map of Colorado

By

Beth L. Widmann, Robert M. Kirkham, and William P. Rogers

1998

EXPLANATION

Q25 **Simple or suspect fault** -- Dashed where inferred; dotted where concealed; bar and ball on side of fault downthrown during the Quaternary; each simple or suspect fault is assigned a unique identifier that is keyed to database

Q40a **Sectioned fault** -- Dashed where inferred; dotted where concealed; bar and ball on side of fault downthrown during the Quaternary; each sectioned fault is assigned a unique identifier that is keyed to database; arrows mark endpoints of each section of a sectioned fault

Q64 **Thrust fault** -- Sawtooth on upper plate; each thrust fault is assigned a unique identifier that is keyed to database

Q65-1, Q69a-1 **Trench** -- Showing location of excavated trench or trenches; each trench is assigned a unique identifier consisting of the fault identification number or sectioned fault identification number followed by the number for each trench on a fault or fault section

Qf2 **Anticline** -- Showing trace of axial surface; dashed where inferred; dotted where concealed; each anticline is assigned a unique identifier that is keyed to database

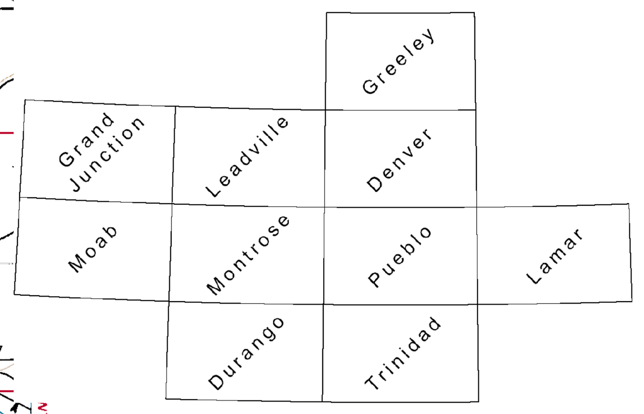
Qf3 **Syncline** -- Showing trace of axial surface; dashed where inferred; dotted where concealed; each syncline is assigned a unique identifier that is keyed to database

Qf1 **Monocline** -- Showing approximate trace of a vertical plane placed about equidistant from anticlinal and synclinal fold axes; dotted where concealed; each monocline is assigned a unique identifier that is keyed to database

Timing of the most recent paleoevent on each fault, fault section, or fold is indicated by the color of the structure trace.

Red	Holocene and post-glacial (<15 ka)
Magenta	Late Quaternary (<130 ka)
Green	Middle and late Quaternary (<750 ka)
Blue	Quaternary (<1.6 Ma)

Index to 1°x 2° maps that have Quaternary structures



Colorado Geological Survey
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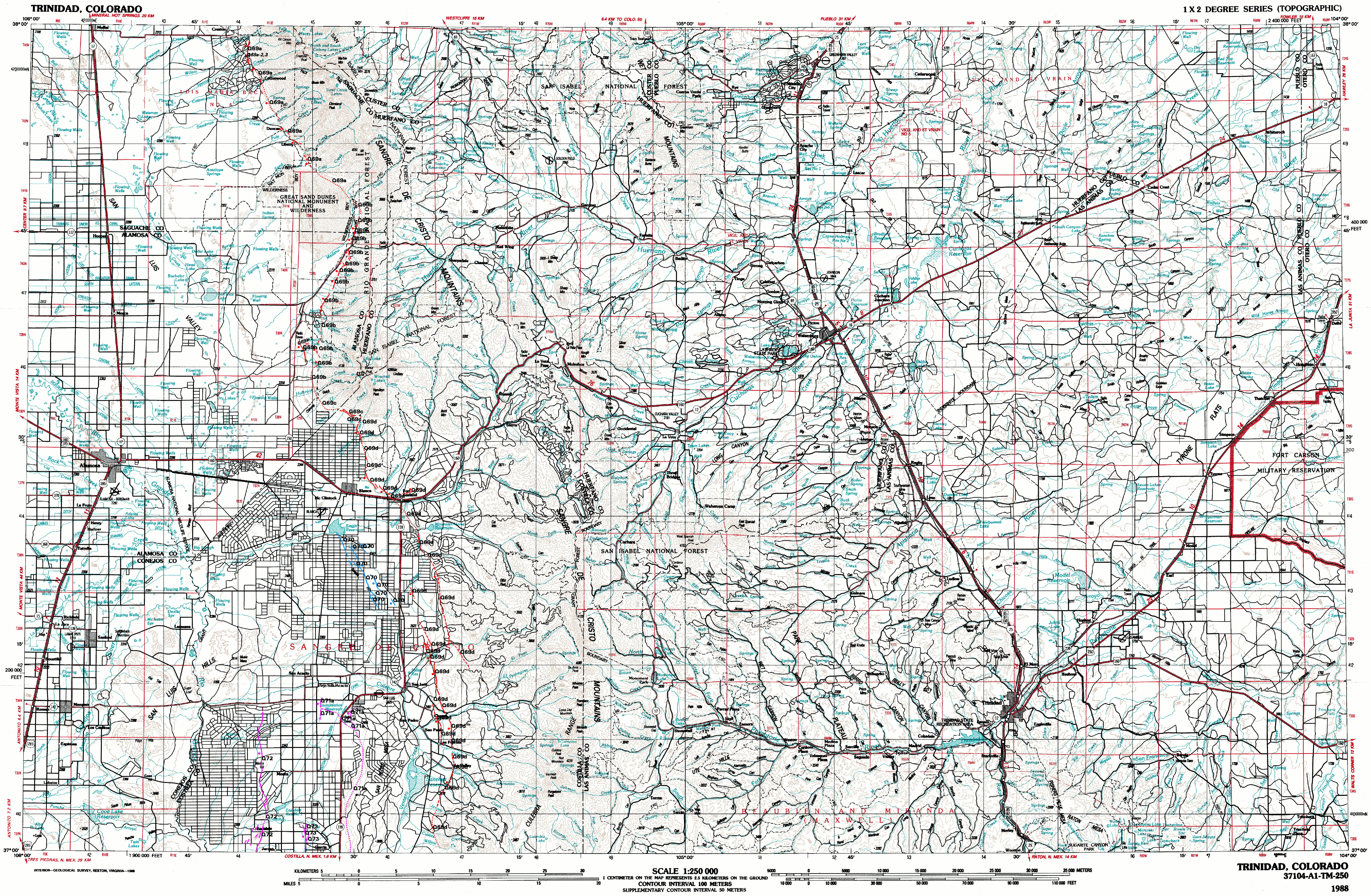

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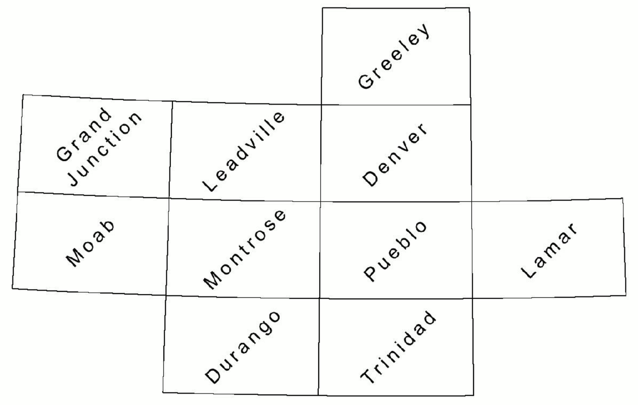

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