U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Maps of Major Active Faults, Western Hemisphere
International Lithosphere Program (ILP)
Project II-2

Guidelines for U.S. Database and Map
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by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards (or with the North American Stratigraphic Code). Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

These guidelines are a working document that is continually under revision. It provides a basis for systematically collecting data and compiling maps of active fault and fold structures. Updated versions of the guideline can be obtained from the authors, on paper or on computer disk.

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Introduction

As part of the International Lithosphere Program's "World Map of Major Active Faults," we are compiling a series of digital maps for the United States that will show the locations, ages, and activity rates of major earthquake-related features such as faults and fault-related folds, and a relational database that describes these features. The United States part of the project was started in 1992 and should be completed by the end of 1995 with the cooperation of state and regional participants. The project is a key part of the new Global Seismic Hazards Assessment Program (ILP Project II-0) for the International Decade for Natural Hazard Disaster Reduction.

The purpose of this guideline is to provide a uniform description of terms so that compilers can enter data on Quaternary faulting and folding into the catalog (database) in a systematic manner. Technical terms and data fields are described in alphabetical order and examples of usage and format are given. Some items in the alphabetic listing are grouped by general name, whereas terms that apply to "Historical Surface Faulting" are listed in the following section.

When you enter information on a database form, be brief and to the point. Write in an abbreviated style whenever possible. We don't care if sentences are complete—just that the information is complete. The type of information that should be included under each item is shown in italics. Many items have a comment section that can be used for explanatory notes.

Each compiler will be responsible for including a complete set of references (see "References" in next section); it will be our job to compile the final list of references. We request a photocopy of the title/cover page of all references that you use in order to properly format the references; please make sure that all pertinent information is contained on the photocopy, including range or number of pages, editors, volume name, etc.

Compilations such as this provide a powerful tool for making comparisons of spatial and temporal patterns of faulting at local, regional, and national scales. However, a database is powerful only if it is a systematic collection of data—one that presents fact and not interpretation on the part of the compiler. With this in mind, the compiler should strive to reference all data as completely as possible, to include all pertinent data (especially where conflicts may be apparent), and to select the most appropriate data to include. To determine what data should be included, give preference to (1) fault-related topical studies over general studies (i.e., those addressing paleoseismology versus general geology), (2) more recent studies, and (3) more detailed scale of work (i.e., 1:24,000-scale over 1:250,000-scale mapping). Some exceptions to these rules will occur, but generally one should give the most weight to recent topical studies of Quaternary faulting.

The compiler will have to make educated (but qualified) guesses for certain entries in the database. For example, the digital map requires that each fault and fold have a number, name (given or "Unnamed fault"), line type, sense of movement, slip rate, and time of most recent movement. We will provide a set of numbers to each compiler to assign to their structures (see "Number" in next section). Names will be determined by the literature and common usage. Line types will be either solid, dashed, or dotted, depending on the continuity or surface expression of the mapped structure (see section on "How to show structural features on your map"). Slip rate and time of most recent movement will each be selected from one of the designated categories, which will provide a basis for dividing younger active structures from older less active structures on the map. The compiler is forced to select a slip rate and age even when no data may exist. In the case of slip rates, you may choose "unknown", but must further qualify this with your best guess. For example, a normal fault that does not cut Holocene (<10 ka) or latest Pleistocene (<15 ka) deposits probably has a slip rate of <1 mm/yr because during the Holocene more than 10 m of slip would accumulate at rates of >1 mm/yr. Thus, the absence or presence of recent movement over some time interval may be a basis for specifying a slip rate. Major plate boundary faults will mostly fall in the >5 mm/yr category. Nevertheless, one can use a variety of geomorphic and geologic relations to place the fault in its most likely age and slip rate categories.

For the purpose of the active fault map, suspected or inferred Quaternary faults (and folds) will be shown as dotted Quaternary structures (age category 5), whereas structures with known late Tertiary (or older) movement will not be shown unless there is compelling evidence of Quaternary movement (geomorphology, offset surficial deposits, etc.). Our method of defining the time of most recent movement (paleoevent) along a fault allows one to be conservative by using categories defining maximum age. For example, if one suspects Holocene (<10 ka) movement but can only document late Pleistocene (10-130 ka) movement, then the inclusive late Quaternary (<130 ka) category should be selected.

Even though the majority of faults have rather sparse data, we have designed the database for well studied and complex faults. One of the first decisions that a compiler must make is about the type of fault: is it (1) a simple one defined by a single-age of rupture, (2) a fault with sections that may or may not be of a single age or structural style, or (3) a fault that has seismic and structural segments that act independently of one another. A segmented fault should have been well studied: by this we mean studied in a paleoseismologic sense (trenching and dating) with supporting geomorphologic and geologic data (scarp morphology, stratigraphic control on times of faulting, geologic structures that may control physical segmentation, etc.). Even though a referenced piece of work discusses "segmentation," it will be the compiler's responsibility to determine if the level of knowledge is sufficient to retain that nomenclature. If the data for independent segments are not compelling (such as those defined solely on morphologic data), then you should describe the fault as having sections. The criteria for sections are less rigorous: for example, sections may be defined on the basis of relative age criteria, by fault geometry, by the presence and preservation of scarps, by a single trench, or from other geologic data (gravity, structure, etc.). If none of these data exist, one should characterize a fault as a simple structure. Once this choice is made, the appropriate compilation form (simple fault, sectioned fault, or segmented fault) will be tailored to only the pertinent information.

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Alphabetic definition of terms

Descriptions of terms are provided in *italics*. Examples are for illustration only, but provide guidance for style and content. The types of information that should be discussed in the "Comments" sections are described for each case, where appropriate. Bold items can be found on the compilation forms. Unless otherwise noted, the following terms will appear on all three forms (simple, section, segment). Items pertaining only to "Historical Surface Faulting" are defined in the next section. Data for folds should be compiled following the examples for faults: instead of slip rate, uplift rate may be substituted.

Terms for structures

Age of faulted (or folded) surficial deposits *This section should include the ages of faulted deposits at the surface. List deposits from youngest to oldest. Don't be tempted to guess the age of deposits; document only data from referenced sources. In addition, an estimate of the extent of the fault that is in a particular age of deposit might be informative.*

Example: Quaternary alluvium, colluvium, and glacial deposits (90%); Paleozoic-Mesozoic and Precambrian bedrock (10%) (Personius, 1982a). Much of the length of the fault probably extends through late Quaternary deposits but scarps are not preserved in many locations (these sections of the fault are designated Quaternary).

Average strike *(azimuth) Determined from GIS data, leave blank*

Compiler and affiliation

Example: Michael J. Stickney, Montana Bureau of Mines and Geology

County *Spell out full county name; if more than one county, list county in which the majority of the structure is located, followed by county name(s) for the remainder of the structure.*

Example: Jefferson; Butte

Date of compilation *Give date that the data were compiled for this project (this will help us keep the information current). FORMAT: mm/dd/yr*

Example: 08/19/93

Detailed studies *This item is reserved for studies such as trenching. Documentation should follow the example given below. Number the study sites sequentially from north to south in the format of fault number, segment or section letter, and site number (i.e., 601C-3). Include references and a synopsis of the work. Reserve appropriate paleoseismic data for discussions of recurrence interval, slip rate, and timing of most recent paleoevent.*

Example: Four trenches and another excavation, which did not cross the fault, have been excavated on the Thousand Springs segment. No datable material was recovered at any of these sites. One and in some cases two prehistorical events were recognized. Many of the prehistorical structures were reactivated in 1983 in terms of style and amount of displacement (Crone, 1985; Schwartz and Crone, 1985). These studies concentrated on the West Spring, Doublespring Pass road, and Rock Creek areas.

West Spring. Trench 601C-1 about 0.8 km northwest of West Spring was excavated by Cochran in 1984? (Cochran, 1985).

Doublespring Pass road. The earliest trench (601C-2) on this segment was excavated by Hait in 1976 and predates the 1983 Borah Peak earthquake. This site (601C-3) was re-excavated by Schwartz and Crone in 1984 following the earthquake. Both trenches, which are documented in Crone (1985), were about 65 m northwest of Doublespring Pass road, which is north of the middle of the segment. Another trench excavated in 1984 by Schwartz and Crone is 0.5 km southeast of Doublespring Pass road (601C-4) (Crone, 1985; Schwartz and Crone, 1985). Although it was not logged, stratigraphic relations suggest two prehistorical events (Crone, oral comm., 1993).

Rock Creek. Excavation 601C-5, about 250 m northwest of Rock Creek access road, by Cochran in 1984? did not cross the fault but contained Mazama ash (about 6,700 yr), which provides a maximum limiting age because of its position in colluvial section (Cochran, 1985). Three faulting events, including 1983, are inferred since 40 ka, but results are preliminary and 40-ka limiting age is not substantiated by numerical dating methods.

Dip *Enter measured value or range and dip direction. For dip measurements at specific points, show location on map and label so it can be digitized for latitude and longitude. If the value comes from trenching studies, it should be included here.*

Example: 80° W. (Bonini and others, 1972); 60° W. (Personius, 1982a); 50° W. (Pardee, 1950)

Comments: *Include things like approximate location and the type of material in which the fault is exposed.*

Example: Exact location of 80° W. unknown, but probably from northernmost part of fault that Personius (1982a) describes as in bedrock. Dip of fault reported by Personius (1982a) is from exposure of fault 4 km northeast of Sixmile Canyon in unconsolidated alluvium. Pardee (1950) reports dip of fault in 6-m-deep artificial exposure probably in unconsolidated alluvium, exact location unknown but was somewhere along southernmost part of fault. Vertical fault model provides best fit for gravity data (Bonini and others, 1972).

Dip direction *Enter general dip direction of the structure* Choice of **N**, **W**, **S**, **E**, **NW**, **NE**, **SW**, **SE** ONLY

Endpoints *Determined from GIS data, leave blank*

Geologic setting *General statement about setting. Include amounts of total offset and age if known.*

Example: High-angle, down-to-southwest, range-front normal fault, with minor sinistral component, bounding southwest side of Lost River Range. There may be as much as 6.1 km of late Cenozoic displacement across the fault (Skipp and Hait, 1977).

Geomorphic expression *Describe (in general terms) the structure's geomorphic expression (fault scarps, offset streams, monoclines, shutter ridges, associated landslides, etc.)*

Example: The Drum Mountain fault forms small (1-2 m) to moderate (<10 m high) fault scarps and associated grabens preserved on a wide, gently sloping lacustrine surface.

Length *Determined from GIS data, leave blank*

Name (Structure name, segment name, section name, or name of earthquake) *Use the earliest given name for a structure, fault segment or fault section (where appropriate), and earthquake except in cases where there is a more commonly used name in the recent literature.*

Examples: Lost River fault, Thousand Springs segment, May section, Wheeler Ridge anticline, Hebgen Lake earthquake.

Comments: *Include (1) the reference in which the name was originally assigned, (2) geographic limits north to south or west to east (for all but Name of Earthquake), and (3) other names and references in which they are used.*

Example: An early reference to Emigrant fault is Pardee (1950). Fault extends from Pine Creek (north) to Yankee Jim Canyon (south). Also referred to as Deep Creek fault (Bonini, 1972; Personius, 1982a; Personius, 1982b; Personius, 1986).

Number

Structure number *Assign structure (fault or fold) a number within the limits we provide.*

Comments: *Include appropriate references to features shown in other fault compilations.*

Example: Refers to fault number 112 ("unnamed fault") in Witkind (1975). *OR:* Refers to fault 116 and 193 ("unnamed fault") of Witkind (1975) and fault 1 ("Lost River fault") of Stickney and Bartholomew (1987).

Segment number *The number assigned here is the fault number and an upper-case alpha character. Assign "A" to the northernmost or westernmost segment of a fault (i.e., fault 305 has three segments: 305A, 305B, 305C).*

Section number *The number assigned here is the fault number and a lower-case alpha character. Assign "a" to the northernmost or westernmost section of a fault.(i.e., fault 207 has three sections: 207a, 207b, 207c); use lower case to differentiate from "segments".*

Number of sections (for faults with sections only) *Numeric value for number of sections (i.e.,* 4*).*

Comments: (1) *Include reference in which sections are discussed, and (2) if the term "segment" is used in the literature, indicate why "section" is used in the database.*

Example: Although numerous authors (Witkind, 1975a; Johns and others, 1982; Stickney and Bartholomew, 1987) discuss segments of the Centennial fault, data are insufficient to define seismogenic segments. *OR*: The parts of the fault discussed in detail are nearly continuous scarps of restricted length that have similar characteristics as described by Personius (1982a). According to Personius (1982b), scarp-morphology data does not allow definition of segmentation of this fault, even though the fault has an abrupt bend and left-stepping en echelon scarps in its central part which could suggest a possible segment boundary. Segment names are given in Montana Bureau of Mines and Geology digital database (Stickney, written comm., 1992), however, they have been abandoned for original nomenclature of Personius (1982a). Sections as defined here based on apparent change in timing of most recent faulting along strike; however, section boundary does not coincide with abrupt change in strike of fault that Personius (1982a) speculates could be a segment boundary.

Number of segments (for faults with segments only) *A number should appear here (i.e.,* 6*) if recent studies indicate structure is segmented; if not, use a different form. Minimum criteria for considering a fault as segmented include: 1) trenching on all segments, 2) historical surface faulting rupturing only a part of fault, or 3) trenching on a sufficient number of segments along with clear morphologic differences where trenching has not been done. Many authors use the word "segment" in their discussions, but not in an seismogenic sense. In a case such as this, use the guidelines for a "Fault with sections" and address the apparent discrepancy in the nomenclature. If there are several models for segmentation, you will have to select a "preferred" model.*

Comments: *Include reference in which segmentation model is discussed, and if there are several models for the fault, provide a brief discussion of those models.*

Example: Detailed mapping and trenching has provided a basis for a model of 10 segments along the Wasatch fault zone (Machette and others, 1991), whereas other segmentation models suggest the presence of 6-10 segments (Swan and Schwartz, 1980; Schwartz and Coppersmith, 1984) and as many as 12 segments (Machette and others, 1986).

Province *Use Fenneman's province names (see attached map)*

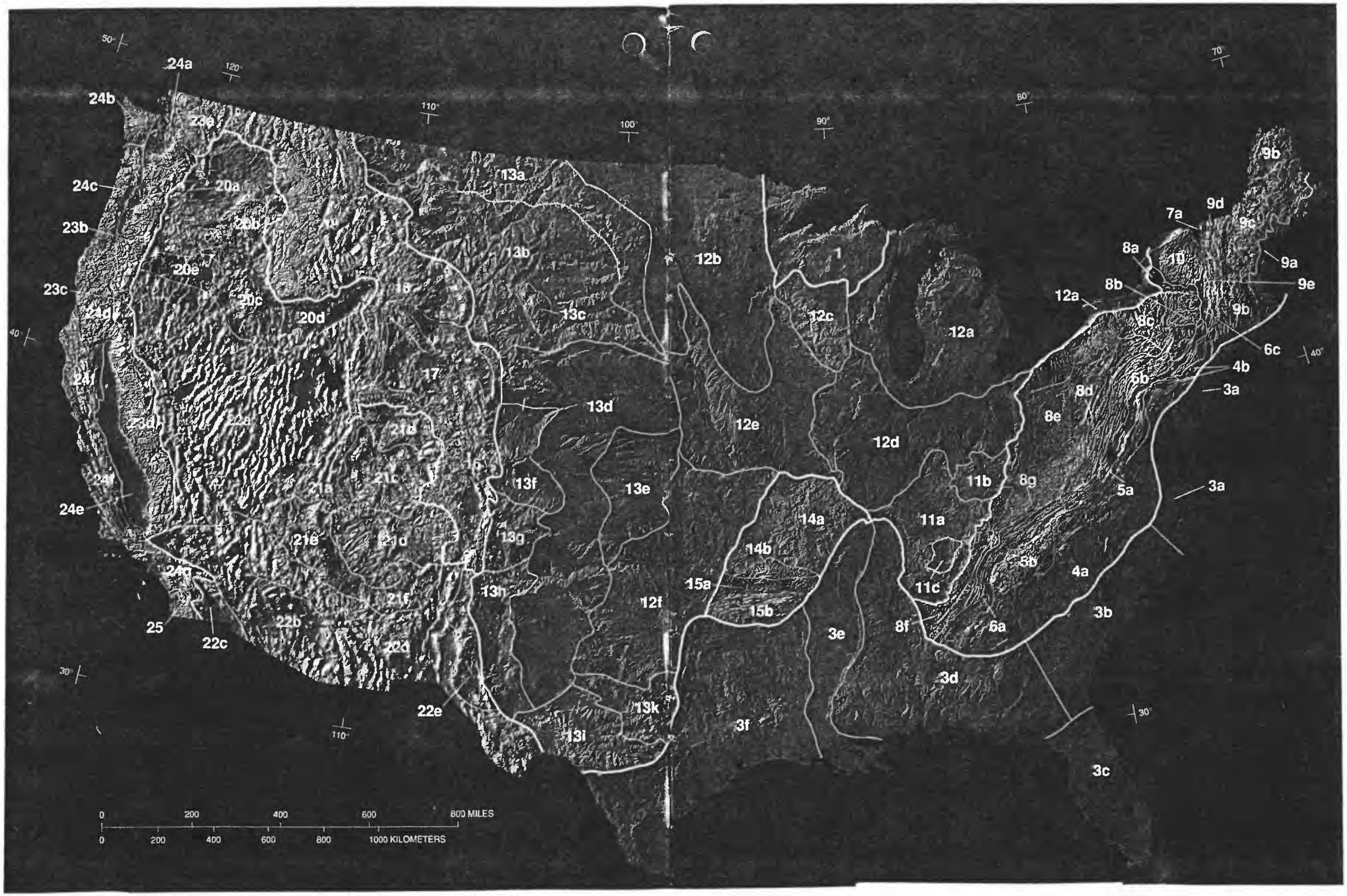


FIGURE 1. Key to Fenneman's Physical Divisions of the United States
(from Thelin and Pike, 1991, Landforms of the Conterminous United States)

Fenneman's Physical Divisions of the United States

1	Superior Upland	**14**	Ozark Plateaus
2	Continental Shelf (Atlantic)	**15**	Ouachita
3	Coastal Plain (Atlantic)	**16**	Southern Rocky Mountains
4	Piedmont	**17**	Wyoming Basin
5	Blue Ridge	**18**	Middle Rocky Mountains
6	Valley and Ridge	**19**	Northern Rocky Mountains
7	St. Lawrence Valley	**20**	Colombia Plateaus
8	Appalachian Plateaus	**21**	Colorado Plateaus
9	New England	**22**	Basin and Range
10	Adirondack	**23**	Cascade-Sierra Mountains
11	Interior Low Plateaus	**24**	Pacific Border
12	Central Lowland	**25**	Lower California
13	Great Plains		

Recurrence interval *List interval in yr (based on historic data, calendric, or calibrated radiocarbon dates), in 14C yr (based on uncalibrated radiocarbon dates), or in k.y. (based on less precise dating, stratigraphy, or geomorphology). Also include the time interval in parenthesis for which this recurrence interval is valid. Not determined (ND) is a valid entry.*

Example: 6-15 k.y. (<15 ka)

Comments: *Include pertinent information from detailed studies, references, basis of recurrence interval, etc. If there are multiple published recurrence intervals, list them all starting with that which applies to the most recent time interval.*

Example: Most investigators agree that the recurrence interval between the last two events was probably about 6-8 k.y. Time of prehistorical event is poorly constrained, but considered to be <15 ka.

References *Please provide coversheets of all references cited. We need to have complete information such as range of pages, full names of authors and editors, number of plates, map scale. The references will be added to our existing reference database and formatted there. Make it absolutely clear what reference is being cited in every case so we can avoid improper referencing.*

Examples:

Hamilton, R.M., and Johnston, A.C., eds., 1990, Tecumseh's prophecy—Preparing for the next New Madrid earthquake: U.S. Geological Survey Circular 1066, 30 p. (Citation for editors)

Johnston, A.C., 1987, Characterization of intraplate seismic source zones, *in* Crone, A.J., and Omdahl, E.M., eds., Proceedings of Conference XXXIX, Directions in paleoseismology: U.S. Geological Survey Open-File Report 87-673, p. 404-413. (Conference report)

Johnston, A.C., and Bullard, Thomas, 1990, The Ungava, Quebec, earthquake—Eastern North America's first modern surface rupture [abs.]: Seismological Research Letters, v. 61, no. 4-3, p. 152-153. (Abstract)

Kennewell, P.J., and Huleatt, M.B., 1980, Geology of the Wiso basin, Northern Territory: [Australia] Bureau of Mineral Resources, Geology and Geophysics Bulletin 205, 67 p., 1 oversize plate, scale 1:1,000,000. (Map)

Langer, C.J., Bonilla, M.G., and Bollinger, G.A., 1987, Aftershocks and surface faulting associated with the intraplate Guinea, West Africa, earthquake of 22 December 1983: Bulletin of the Seismological Society of America, v. 77, no. 5, p. 1579-1601. (Journal)

Loughnan, F.C., 1969, Chemical weathering of the silicate minerals: New York, Elsevier Publishing Co., Inc., 154 p. (Book)

Mabbutt, J.A., 1966, Landforms of the Western Macdonnell Ranges, *in* Dury, G.H., ed., Essays in geomorphology: New York, Elsevier Publishing Co., Inc., p. 83-119. (Part of book)

Reliability of location Choice of **Good** or **Poor**

Comments: *This reliability refers to the location of the trace of the structure. Include the source and scale of the mapping. Note that these judgments of reliability are separate from the map symbols (solid, dashed, dotted) that will be used.*

Good: (1) Source of trace of fault or fold is transferred from base map at 1:250,000 (or more detailed) with topographic (or bathymetric) control and was accurately located on original map using photogrammetry or similar methods, or (2) source is map at 1:100,000 or more detailed scale on topographic (or bathymetric) base, but transferred without photogrammetric methods.

Example: Good. (1) Location of scarps based on 1:250,000-scale maps of Haller (1988); original mapping at 1:24,000-62,500 scale, or (2) Location of scarps from 1:24,000 scale maps of Ostenna (1992), transferred to 1:100,000 by inspection.

Poor: Less than above standards (smaller scale, planimetric base, transfer by inspection, etc.). All concealed or inferred faults are considered poorly located.

Example: Poor. (1) Location of fault scarps based on 1:500,000-scale maps of Witkind (1975), or (2) submarine scarps from sea-beam-survey maps at 1:250,000 scale.

Section name (see Name)

Section number (see Number)

Segment name (see Name)

Segment number (see Number)

Sense of movement Choice of **T**, **R**, **D**, **S**, or **N**. *For combinations, show principle sense first.*

T Thrust (<45°)
R Reverse
D Dextral (right lateral)
S Sinistral (left lateral)
N Normal

Example: **DR**, a *reverse right-lateral strike slip fault with less vertical than horizontal slip.*

Comments: *Can show ratio between different components in order to better characterize sense of movement.*

Example: Focal plane mechanisms indicate 3:1 ratio for D:R (Dewey, 1987).

Slip rate choice of **>5 mm/yr, 5-1 mm/yr, <1 mm/yr**, or **unknown; probably** _______ (choose one of three categories). *Cite published slip rates. If there are no slip rates published, then use "unknown" and make your best guess as to which slip category characterizes fault. The three classes generally differentiate between major plate boundary structures, major intraplate structures, and minor intraplate structures.*

Example: <1 mm/yr

Comments: *Include pertinent documentation, and provide range of published values, followed by description and appropriate reference.*

Example: 0.07-0.15 mm/yr. Reported slip rate for the Arco segment (601F) is 0.12 mm/yr for past 160 k.y. based on 19 m of displacement of deposits thought to be 160 ka (Pierce, 1985). The low end of range reported here is based on 70- to 110-ka volcanic ash bed that is displaced 8 m; the high slip rate excludes past 30 k.y. of quiescence (Scott and others, 1985). P.L.K. Knuepfer (written comm., 1992) suggests a rate of 0.15 ± 0.05 mm/yr for past 160 k.y.

State *Spell out full state name; if more than one state, list state in which the majority of the structure is located, followed by state name(s) for the remainder of the structure.*

Example: Montana; Idaho; Wyoming

Structure name (See Name)

Structure number (See Number)

Synopsis *Provide a one or two sentence synopsis of fault describing level of study. This will give reader a snapshot of level of data that follows in the database.*

Example: Fault is poorly understood, no known studies have been completed at time of this compilation. Sole source of data is Witkind (1975b).

Timing of most recent paleoevent (faulting or folding) *This is for paleoevent only. If there is historical faulting or folding (category 1), it will be dealt with in "Historical Surface Faulting" form; data pertaining to the penultimate event belongs here. Choices are:*

(2) Holocene and post glacial (<15 ka)
(3) late Quaternary (<130 ka)
(4) middle and late Quaternary (<750 ka)
(5) Quaternary (<1.6 Ma)

Example: (2) Holocene and post glacial (<15 ka)

Comments: *Include pertinent documentation.*

Example: Although timing of most recent prehistorical event is not well constrained, most topical studies concur that pre-1983 faulting occurred during the middle to early Holocene. Trenching studies document evidence of only one prehistorical surface-faulting event in deposits considered about 12-15 ka, on basis of degree of soil development and position in landscape. Pre-1983 event is probably Holocene because surface was stable for several thousands of years prior to the prehistoric event (Scott and others, 1985). Morphology of pre-1983 scarps also point to same conclusion; see R.C. Bucknam, personal communication cited in Scott and others (1985), Hanks and Schwartz (1987), Salyards (1985), and Vincent (1985). Scarps at the northern end of segment that were not offset historically, the 1983 Gap in Crone and others (1985; 1987), are older than Holocene but are probably younger than late Quaternary (<130 ka).

1° x 2° sheet *Spell out full 1° x 2° sheet name; list sheet in which the majority of structure is located, followed by sheet name(s) for remainder of structure.*

Example: Dubois; Ashton

Terms for historical surface faulting

Affected structure(s), segment(s), section(s) number *List all features that were affected by surface rupture. When only a part of a fault ruptured, list only those specific segments or sections—not the fault number. First number should be the primary surface rupture, secondary ruptures should follow.*

Example: 601C; 601B, 601g, 604b
[These represent the affected areas from the Borah Peak earthquake, Idaho, including Thousand Springs (601C) and Warm Spring (601B) segments of the Lost River fault (601), Willow Creek hills strand (601g), and part of the Lone Pine fault (604b).]

Date *FORMAT: mm/dd/year. Include full year to discriminate from pre-1900's events.*

Example: 08/19/1954

Depth of epicenter

Example: 14-16 km

Comments: *Use for reference and other pertinent information*

Example: Dewey (1985; 1987) reported 14 km, whereas 16 km was reported by Doser and Smith (1985).

Dip See previous section

Geophysical average slip *This is for amount(s) of modeled slip.*

Example: 1.4-2.1 m

Comments: *Include information on type of data, location, other qualifications.*

Example: Preferred model for geodetic data (Barrientos and others, 1987) indicates 2.1 m of slip at southern end of rupture and 1.4 m of slip at the northern end of rupture on a single planar fault dipping 49° SW with dimensions of 26 km long by 18 km (south end) to 8 km (north end) wide. Calculations based on the seismic moment suggest 1.4 m of slip (Doser and Smith, 1985).

Length of surface rupture *Determined from GIS data, leave blank*

Comments: *Document published lengths as they will likely differ from GIS lengths. We will record GIS lengths so that they will be uniform in their portrayal; different authors often use different methods to determine this parameter, use comment section to document their findings.*

Example: 36.4 ± 3.1 km reported by Crone and others (1987); length is not sum of trace lengths of various parts of rupture but is a straight-line length. They believe that the 20.8-km-long rupture on Thousand Springs segment (601C) represents the primary rupture and the 7.9-km-long rupture on Warm Spring segment (601B) and 14.2 km on the nearby Willow Creek hills strand (601g) and Lone Pine fault (604b) are secondary result (triggered slip). Geodetic data (Barrientos and others, 1987) support this interpretation.

Location of epicenter *Give latitude and longitude coordinates in decimal degrees*

Example: 43.974° N; 113.916° W

Comments: *Use for reference and other pertinent information*

Example: (Dewey, 1987) Epicenter was about 14 km south-southwest of termination of recognized surface faulting. Rupture propagated up and unilaterally to northwest, contrary to eyewitness report in Wallace (1984).

Magnitude or intensity *Include type (M_S, M_b, M_w, M_L M_c, etc.) and value*

Example: $M_S = 7.3$

Comments: *Use for reference and other pertinent information*

Example: (Dewey, 1987)

Maximum slip at surface

Example: 2.7 m

Comments: *Include documentation for type and location of measurement.*

Example: Maximum is net vertical throw; average vertical throw along entire rupture 0.8 m; average vertical throw along Thousand Springs segment (601C) 1.1 m, 58% of length of rupture on Thousand Springs segment had scarps that exceeded 1 m in throw; left-lateral component was approximately 17% of vertical (Crone and others, 1985; 1987). Some individual scarps are nearly 5 m high (Crone and Haller, 1991), but were associated with grabens and local backtilting.

Moment magnitude (M) or Seismic moment (M_o) *Include type, value, and units (where applicable)*

Example: **M** = 6.0

Comments: *Use for reference and other pertinent information*

Example: (Ellsworth, 1990)

Name of earthquake See Name, previous section

References See previous section

Sense of movement See previous section

Showing structural features on your map

Please use the following guidelines when you draft your map. We will use your map to (1) digitize the features, (2) ascribe attributes (age, slip rate, etc.) to the features, and (3) check against the digitally prepared map. *Examples* are for illustration only but provide guidance for style and content. Six attributes (structure number, name, time of movement, slip-rate category, sense of movement, and line type) are needed for the digital map file as described in the preceding section. In addition, we need to know the map's projection and scale, and the author and date of the compilation.

Compiler and date *Indicate the name of the compiler and date of compilation (month and year is adequate). If there are multiple compilers, indicate by region or another method.*

Map scale and projection *Indicate the scale of the map (not critical), its projection (Transverse Mercator, Albers, etc.), and make sure that there are latitude and longitude ticks on the borders and internally. We will use the tick marks and projection information in the GIS to precisely locate all structures. Use the best available map for your base: for the United States, we are suggesting AMS maps which have topographic control and a scale of 1:250,000. Large scale maps (1:24,000 or 1:25,000) can be used, but the digital files for each structure are needlessly large and detailed. Remember that the eventual output of the digital map is designed for state and national scales (1:500,000 to 1:2,500,000).*

Numbers

Structure number *Select from preassigned number list. Example:* 111.

Segment number *The number assigned here is the fault number and an upper-case alpha character. Assign "A" to the northernmost or westernmost segment of the fault. Example:* 111A.

Section number *The number assigned here is the fault number and a lower-case alpha character. Assign "a" to the northernmost or westernmost section of the fault. Example:* 111a.

Names *Use the earliest given name for a fault, fold, segment, section (where appropriate), except in cases where there is a more commonly used name in the recent literature.*

Structure name *Examples*: Lost River fault, Wheeler Ridge anticline

Segment name *Example*: Thousand Springs segment

Section name *Example*: May section

Line types *We can use three different line types. Draw <u>all</u> lines as solid, but mark the endpoints of dashed and dotted lines with a tick mark. If a structure is not present at the surface (i.e., concealed thrust, buried Quaternary fault), then you should specify a dotted line.*

Solid Characterized by nearly continuous features (scarps).

X) **Dashed** Characterized by discontinuous features where gaps are longer than mappable features.

O) **Dotted** Feature is concealed or inferred from geologic or geophysical data.

Sense of movement *Show on map with symbol for principal sense of motion; for combinations, also include letter designation with principle sense first. A reverse right-lateral strike slip fault with less vertical than horizontal slip would be **DR**.*

T Thrust, teeth closely space on hanging wall block

R Reverse, teeth not closely spaced on hanging wall block

D Dextral, right lateral arrows

S Sinistral, left lateral arrows

N Normal, bar and ball on hanging wall block

Slip rate *Choose one of the following and code the line with the appropriate letter. If the rate is unknown, choose the most likely rate based on geologic and geomorphic data.*

A) >5 mm/yr

B) 5-1 mm/yr

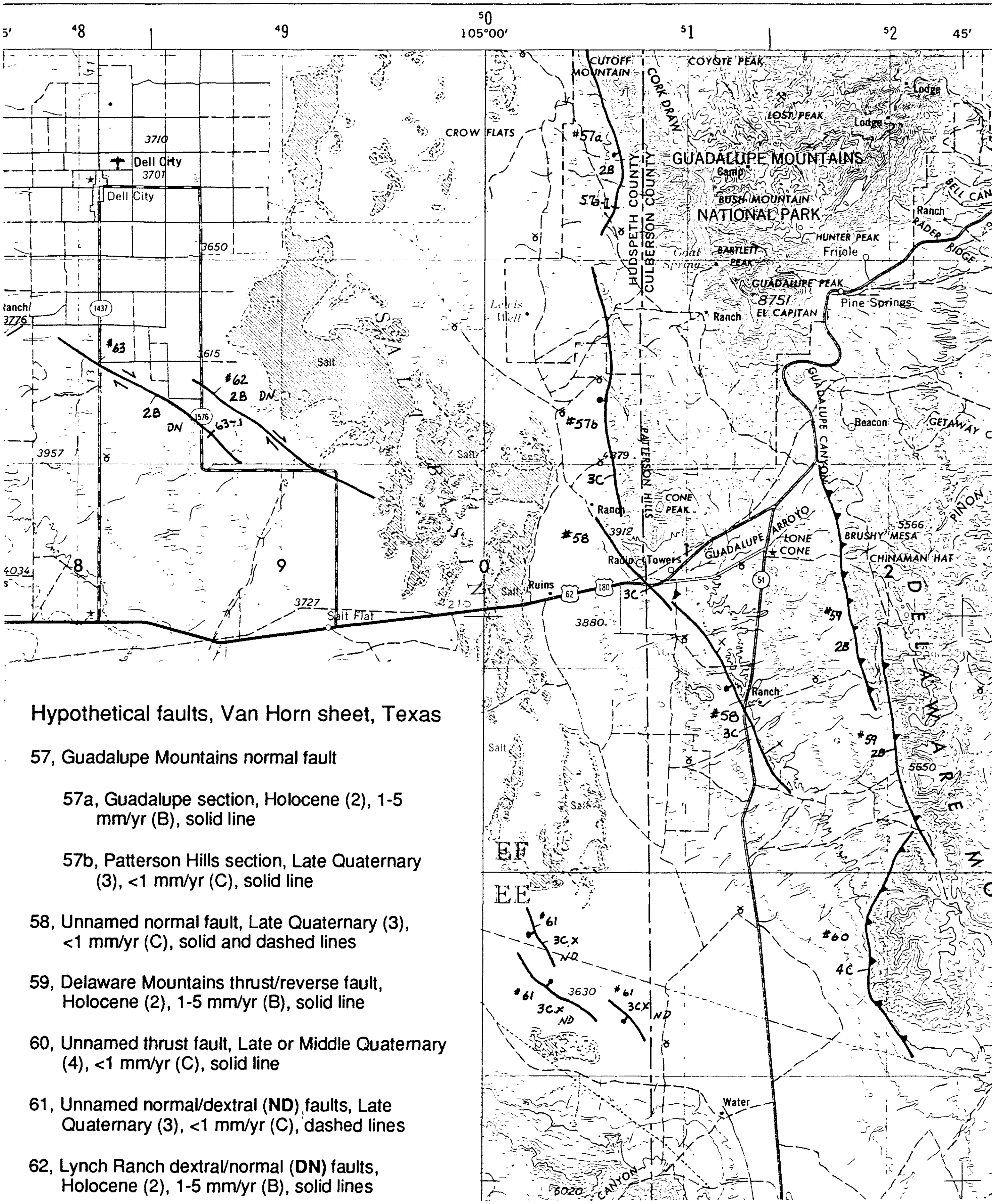
C) <1 mm/yr

Time of most recent paleoevent *Choose one of the following and code the line with the appropriate number. In addition, to help us digitize the features you may color code the lines as indicated.*

1) **Historic** (year will be recorded in database), red.
2) **Holocene and post glacial (<15 ka)**, orange.
3) **late Quaternary (<130 ka)**, green.
4) **middle and late Quaternary (<750 ka)**, blue.
5) **Quaternary (<1.6 Ma)**, black (with yellow to highlight the feature).

Sites of detailed studies *We will also include the locations of detailed studies in the digital data. Show trench sites, etc., with a line normal to the fault and label with number in format specified in discussion of "Detailed studies".*

1:250,000 Transverse Merc. proj **VAN HORN** M.N. Machette, Feb. 1993



Hypothetical faults, Van Horn sheet, Texas

57, Guadalupe Mountains normal fault

57a, Guadalupe section, Holocene (2), 1-5 mm/yr (B), solid line

57b, Patterson Hills section, Late Quaternary (3), <1 mm/yr (C), solid line

58, Unnamed normal fault, Late Quaternary (3), <1 mm/yr (C), solid and dashed lines

59, Delaware Mountains thrust/reverse fault, Holocene (2), 1-5 mm/yr (B), solid line

60, Unnamed thrust fault, Late or Middle Quaternary (4), <1 mm/yr (C), solid line

61, Unnamed normal/dextral (**ND**) faults, Late Quaternary (3), <1 mm/yr (C), dashed lines

62, Lynch Ranch dextral/normal (**DN**) faults, Holocene (2), 1-5 mm/yr (B), solid lines

FIGURE 2. Example of compiled map

Compilation form for segmented faults

STRUCTURE ATTRIBUTES

Structure number

Comments:

Structure name

Comments:

Synopsis:

Date of compilation

Compiler and affiliation

State

County

1° x 2° sheet

Province

Geologic setting

Number of segments

Comments:

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

SEGMENT ATTRIBUTES

Segment number

Segment name

Comments:

Reliability of location Good Poor

Comments:

Sense of movement **T** **R** **D** **S** **N**

Comments:

Dip

Comments:

Dip direction

Geomorphic expression

Age of faulted deposits

Detailed studies

Timing of most recent paleoevent CHOOSE ONE
(2) Holocene and post glacial (<15 ka)
(3) late Quaternary (<130 ka)
(4) middle and late Quaternary (<750 ka)
(5) Quaternary (<1.6 Ma)

Comments:

Recurrence interval

Comments:

Slip rate
(A) >5 mm/yr
(B) 5-1 mm/yr
(C) <1 mm/yr
unknown; probably

Comments:

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

REFERENCES

Example of data for segmented fault

SEGMENTED FAULT ATTRIBUTES

Structure number 601
Comments: Refers to faults 116 and 193 ("unnamed fault") of Witkind (1975) and fault 1 ("Lost River fault") of Stickney and Bartholomew (1987).

Structure name Lost River fault
Comments: Baldwin (1951) recognized Basin-and-Range style faulting in this area, as well as recent movement and large amounts of throw across this and nearby faults. His 1951 article is probably one of earliest to use Lost River fault for this structure. Fault extends along entire length of southwest flank of Lost River Range.

Synopsis: Extensive investigation of this long, range-front fault in central Idaho began after the 1983 Borah Peak earthquake that resulted in surface rupture on 2 segments and a subsidiary strand of the Lost River fault. Development of a segmentation model evolved from earthquake data and earlier mapping of the fault.

Date of compilation 11/12/92

Compiler and affiliation Kathleen M. Haller, U.S. Geological Survey

State Idaho

County Custer; Butte

1° x 2° sheet Dubois; Idaho Falls; Challis

Province Northern Rocky Mountains

Geologic setting High-angle, down-to-southwest, range-front normal fault, with minor sinistral component, bounding southwest side of Lost River Range. There may be as much as 6.1 km of late Cenozoic displacement across the fault (Skipp and Hait, 1977).

Number of segments 6
Comments: Scott and others (1985) defined segmentation of Lost River fault and is source of segment names except northernmost segment, which was renamed in Crone and others (1985; 1987) for consistency. Scarps formed during Borah Peak earthquake across Willow Creek hills (601g) are included as part of this fault.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

SEGMENT ATTRIBUTES

Segment number 601A

Segment name Challis segment
Comments: Also called Northern segment as defined by Scott and others (1985); was renamed Challis segment for consistency by Crone and others (1985; 1987). Extends from the northern end of Lost River Range southeast to Devils Canyon.

Reliability of location Poor
Comments: Location of fault generally based on topography, scarps on alluvium are absent. Source of map trace based on 1:24,000-scale maps of Crone (unpublished data).

Sense of movement N
Comments:

Dip
Comments:

Dip direction SW

Geomorphic expression No scarps are on alluvium (Scott and others, 1985); local topography suggests the fault has at least two subparallel strands at south end of segment (Crone and Haller, 1991).

Age of faulted deposits

Detailed studies

Timing of most recent paleoevent
(5) Quaternary (<1.6 Ma)
Comments: Faulting history of segment poorly understood, but reconnaissance studies indicate no evidence of late Quaternary movement (Scott and others, 1985). Crone and Haller (1991) suggest Quaternary movement, but no data are available to provide more constraint.

Recurrence interval ND
Comments:

Slip rate
unknown; probably <1 mm/yr
Comments: Slip rate is inferred to be low based on absence of scarps on late Quaternary deposits. Long-term slip rate is probably lowest of any segment on Lost River fault as reflected by low topographic and structural relief.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Segment number 601B

Segment name Warm Spring segment
Comments: Defined and named by Scott and others (1985). Extends from Devils Canyon southeast to Willow Creek hills. Also shown as Gooseberry Creek segment in Montana Bureau of Mines and Geology digital database (Stickney and Bartholomew, written commun. 1992).

Reliability of location Good
Comments: Location of scarps based on 1:24,000-scale maps of Crone and others (1985; 1987).

Sense of movement N
Comments:

Dip
Comments:

Dip direction SW

Geomorphic expression Nearly continuous, morphologically young scarps, many of which were offset less than 1 m in 1983 (Crone and others, 1987). Pre-1983 scarps are as much as 5.7 m high (Crone and Haller, 1991).

Age of faulted deposits

Detailed studies
Two trenches 7.5 km apart have been excavated on the Warm Spring segment. Trench 601B-1 (Schwartz and Crone, 1988) on south side of an unnamed creek approximately 7 km south of northem segment boundary. Trench 601B-2 (Schwartz and Crone, 1988) on south side of small drainage approximately 2 km north of southern segment boundary.

Timing of most recent paleoevent
(2) Holocene and post glacial (<15 ka)
Comments: Trenching studies (Schwartz and Crone, 1988) suggest one pre-1983 faulting event in past 12 k.y. that occurred prior to 5,200-6,200 14C yr. Morphology of scarps that did not rupture in 1983 also suggests an age younger than pre-1983 scarps on Thousand Springs segment (601C, also estimated to be Holocene).

Recurrence interval ND
Comments: Rupture of this segment during the 1983 earthquake is not considered primary and thus the historic rupture is not considered for determining recurrence interval. Trenching has documented only one older surface rupture.

Slip rate
unknown; probably <1 mm/yr
Comments: No published slip rate is known, but based on maximum 5.7-m-high scarps on latest Pleistocene (<12 ka) deposits, slip rate in excess of 1 mm/yr is not indicated.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Segment number 601C

Segment name Thousand Springs segment
Comments: Defined and named by Scott and others (1985). Extends from Willow Creek hills southeast to Elkhorn Creek.

Reliability of location Good
Comments: Location of scarps based on 1:24,000-scale maps of Crone and others (1985; 1987).

Sense of movement NS
Comments: Crone and others (1987) report about 17% of slip component was sinistral at the surface, which agrees with small component of sinistral slip inferred from fault plane solution (Doser and Smith, 1985).

Dip
Comments:

Dip direction SW

Geomorphic expression Continuous historic fault scarps having discontinuous but prominent free face along southwest front of Lost River Range. Locally, faulting is expressed in numerous subparallel scarps across a 140-m-wide zone.

Age of faulted deposits Holocene and older alluvium, locally bedrock.

Detailed studies

Four trenches and another excavation, which did not cross the fault, have been excavated on the Thousand Springs segment. No datable material was recovered at any of these sites. One and in some cases two prehistorical events were recognized. Many of the prehistorical structures were reactivated in 1983 in terms of style and amount of displacement (Crone, 1985; Schwartz and Crone, 1985). These studies concentrated on the West Spring, Doublespring Pass road, and Rock Creek areas.

West Spring. Trench 601C-1 about 0.8 km northwest of West Spring was excavated by Cochran in 1984? (1985).

Doublespring Pass road. The earliest trench (601C-2) on this segment was excavated by Hait in 1976 and predates the 1983 Borah Peak earthquake. This site (601C-3) was re-excavated by Schwartz and Crone in 1984 following the earthquake. Both trenches, which are documented in Crone (1985), were about 65 m northwest of Doublespring Pass road, which is north of the middle of the segment. Another trench excavated in 1984 by Schwartz and Crone is 0.5 km southeast of Doublespring Pass road (601C-4) (Crone, 1985; Schwartz and Crone, 1985). Although it was not logged, stratigraphic relations suggest two prehistorical events (Crone, oral comm., 1993).

Rock Creek. Excavation 601C-5, about 250 m northwest of Rock Creek access road, by Cochran in 1984? did not cross the fault but contained Mazama ash (about 6,700 yr), which provides a maximum limiting age because of its position in colluvial section (Cochran, 1985). Three faulting events, including 1983, are inferred since 40 ka, but results are preliminary and 40-ka limiting age is not substantiated by numerical dating methods.

Timing of most recent paleoevent
(2) Holocene and post glacial (<15 ka)
Comments: Although timing of most recent prehistorical event is not well constrained, most topical studies concur that pre-1983 faulting occurred during the middle to early Holocene. Trenching studies document evidence of only one prehistorical surface-faulting event in deposits considered about 12-15 ka, on basis of degree of soil development and position in landscape. Pre-1983 event is probably Holocene because surface was stable for several thousands of years prior to the prehistoric event (Scott and others, 1985). Morphology of pre-1983 scarps also point to same conclusion; see R.C.

Bucknam, personal communication cited in Scott and others (1985), Hanks and Schwartz (1987), Salyards (1985), and Vincent (1985). Scarps at the northern end of segment that were not offset historically, the 1983 Gap in Crone and others (1985; 1987), are older than Holocene but are probably younger than late Quatemary (<130 ka).

Recurrence interval 6-15 k.y. (<15 ka)
Comments: Most investigators agree that the recurrence interval between the past two events was probably about 6-8 k.y.; however, timing of prehistorical event is poorly constrained but considered <15 ka.

Slip rate
(C) <1 mm/yr
Comments: 0.18-0.3 mm/yr. Hanks and Schwartz (1987) suggest that slip rate may be 0.18-0.25 mm/yr based on displacements of 1.5-2.0 m occurring every 8 k.y. Scott and others (1985) calculate a slip rate of 0.3 mm/yr based on 3.5-4.5 m total offset during the past 15 k.y., which includes 1.5-2.0 m in 1983.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Segment number 601D

Segment name Mackay segment
Comments: Defined and named by Scott and others (1985). Extends from Elkhorn southeast to near Lower Cedar Creek.

Reliability of location Good
Comments: Location of scarps based on 1:24,000-scale maps of Crone (unpublished data).

Sense of movement N
Comments: (Scott and others, 1985)

Dip
Comments:

Dip direction SW

Geomorphic expression Generally continuous, morphologically young fault scarps on alluvium along entire length of segment (Crone and Haller, 1991).

Age of faulted deposits Holocene to middle Pleistocene fan alluvium (Scott, 1982).

Detailed studies
Three trenches at two sites about 16 km apart have been excavated on the Mackay segment. Trench 601D-1 (Schwartz and Crone, 1988) north of Lower Cedar Creek, near north end of segment, on pre-15-ka fan. Trench 601D-2 (Hait and Scott, 1978; Scott and others, 1985) and Trench 601D-3 (Schwartz and Crone, 1988), north of Lone Cedar Creek, near south end of segment, on pre-15-ka fan.

Timing of most recent paleoevent
(2) Holocene and post glacial (<15 ka)
Comments: Collectively, trenching data indicate one faulting event has occurred in past 11 k.y., timing of which was between 4 and 6.8 ka. Faulted Mazama ash (approximately 6,800 yr) found in trenches at both ends of segment (Crone and Haller, 1991). Radiocarbon age of organic matter buried by scarp-derived colluvium in Trench 601D-2 suggests that the most recent event occurred about 4 ka (Scott and others, 1985). Trench 601D-3 contained Glacier Peak ash (11,300 yr), which is displaced by only one event (Schwartz and Crone, 1988).

Recurrence interval ND
Comments:

Slip rate
(C) <1 mm/yr
Comments: 0.35 ± 0.1 mm/yr (P.L.K. Knuepfer, written comm., 1992) for unspecified time interval. Scott and others (1985) do not provide values for slip rate on Mackay segment (601B), they indicate that long-term rate may be lower than that for Thousand Springs segment (601C). However, latest Quaternary slip rate is probably slightly higher.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Segment number 601E

Segment name Pass Creek segment
Comments: Defined and named by Scott and others (1985). Extends from near Lower Cedar Creek southeast to approximately 3 km north of King Canyon.

Reliability of location Poor
Comments: Location of fault based on 1:24,000-scale maps of Crone (unpublished data). Segment has few scarps, inferred location of fault is at bedrock-alluvial contact.

Sense of movement N
Comments: (Scott and others, 1985)

Dip
Comments:

Dip direction SW

Geomorphic expression Scarps on Quaternary deposits are generally absent, but most deposits along range front are thought to be younger than 15 ka (Scott and others, 1985; Crone and Haller, 1991). Range-front morphology is similar to that along adjacent segments, including a steep faceted front and high structural relief. Segment spans a major embayment in range front at Elbow Canyon.

Age of faulted deposits

Detailed studies

Timing of most recent paleoevent
(3) late Quaternary (<130 ka)
Comments: Scott and others (1985) state that most recent faulting event probably occurred 30-50 ka, but also note that a firm estimate is difficult to make due to general absence of surficial deposits older than 30 ka.

Recurrence interval ND
Comments:

Slip rate
unknown; probably <1 mm/yr
Comments: Because of the general absence of scarps and poorly understood history of faulting, a slip rate is difficult to determine. P.L.K. Knuepfer (written comm., 1992) suggests a rate of <0.01-0.05 mm/yr for an unspecified interval of time, although he believes the lower value is more likely.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Segment number 601F

Segment name Arco segment
Comments: Defined and named by Scott and others (1985). Extends from approximately 3 km north of King Canyon to southern end of Lost River Range. Also referred to as the Arco fault by Kuntz and others (1984).

Reliability of location Good
Comments: Location of scarps based on 1:24,000-scale maps of Crone (unpublished data).

Sense of movement N
Comments: (Scott and others, 1985)

Dip
Comments:

Dip direction SW

Geomorphic expression Segment is generally characterized by high scarps along much of range front. Scarps range from 2 to 25 m in height (Pierce, 1985) but most are about 12 m (Malde, 1985; 1987). High scarps are on deposits thought to be less than 600 ka, whereas 2- to 3-m-high scarps are on 30-ka deposits (Pierce, 1985). Deposits thought to be about 15 ka are unfaulted (Pierce, 1985; Scott and others, 1985).

Age of faulted deposits Undifferentiated Holocene and upper and middle Pleistocene alluvium and colluvium (Scott, 1982). Scarps along southern part of segment are on 30 ka and older deposits; along northern part of segment, scarps are on bedrock (Malde, 1985).

Detailed studies
One trench was excavated on the Arco segment. Trench 601F-1 (Malde, 1985; 1987) located on south side of unnamed stream approximately 6.5 km south of northern segment. boundary The 8- to 11-m-deep trench crosses a 15-m-high scarp that has evidence of at least 2 faulting events. The oldest event resulted in 4.6-6 m of displacement and the younger event resulted in at least 3 m of displacement.

Timing of most recent paleoevent
(3) late Quaternary (<130 ka)
Comments: Most recent faulting event thought to have occurred about 30 ka, based on uranium-series dating of carbonate coats on clasts, which estimates soil age (23-30 ka) of fan gravels displaced by a 3-m-high scarp (Pierce, 1985). Multiple-event scarps are on older Pleistocene alluvium (Pierce, 1985).

Recurrence interval 15.2 k.y. (30-160 k.y.)
Comments: Recurrence intervals documented by Pierce (1985) indicate an average recurrence of 13.8 k.y. (<160 ka) assuming 2 m of displacement per event, 15.2 k.y. (30-160 ka) is indicated if past 30 k.y. of quiescence is excluded, and a longer-term recurrence interval of 25 k.y. (<600 ka) is suggested from trenching.

Slip rate
(C) <1 mm/yr
Comments: 0.07-0.15 mm/yr. Reported slip rate for segment 0.12 mm/yr for past 160 k.y. based on 19 m of displacement of deposits thought to be 160 ka (Pierce, 1985). Low end of range based on 70- to 110-ka volcanic ash displaced 8 m; high slip rate excludes past 30 k.y. of quiescence (Scott and others, 1985). P.L.K. Knuepfer (written comm., 1992) suggests a rate of 0.15 ± 0.05 mm/yr for the past 160 ky.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Section number 601g

Section name Willow Creek hills strand
Comments: Refers to discontinuous scarps in Willow Creek hills that formed during 1983 Borah Peak earthquake. They extend from the range-front part of Lost River fault (near Arentson Gulch) northwest over crest of Willow Creek hills (to near Sheep Creek). Also referred to as the Willow Summit segment in Montana Bureau of Mines and Geology digital database (Stickney and Bartholomew, written commun. 1992).

Reliability of location Good
Comments: Location of scarps based on 1:24,000-scale maps of Crone and others (1985; 1987).

Sense of movement NS
Comments: Although predominantly normal with small sinistral component, localized dextral and reverse movement were also noted (Crone and others, 1987).

Dip
Comments:

Dip direction SW

Geomorphic expression Surface ruptures from Borah Peak earthquake are superimposed on older scarps of unknown age along much of the Willow Creek hills strand. The complex and discontinuous 1983 surface ruptures that characterize the Willow Creek hills strand (601g) are a surficial representation of the complexity of the fault at depth. The concentration and distribution of aftershocks, as well as inconsistent focal mechanisms, suggest that slip was accommodated on a complex network of faults near a bedrock asperity (Crone and others, 1987).

Age of faulted deposits

Detailed studies

Timing of most recent paleoevent

Recurrence interval ND
Comments:

Slip rate
unknown; probably <1 mm/yr
Comments:

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

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Compilation form for sectioned faults

STRUCTURE ATTRIBUTES

Structure number

Comments:

Structure name

Comments:

Synopsis:

Date of compilation

Compiler and affiliation

State

County

1° x 2° sheet

Province

Geologic setting

Number of sections

Comments:

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

SECTION ATTRIBUTES

Section number

Section name

Comments:

Reliability of location (Good, Poor)

Comments:

Sense of movement **T** **R** **D** **S** **N**

Comments:

Dip

Comments:

Dip direction

Geomorphic expression

Age of faulted deposits

Detailed studies

Timing of most recent paleoevent CHOOSE ONE
(2) Holocene and post glacial (<15 ka)
(3) late Quaternary (<130 ka)
(4) middle and late Quaternary (<750 ka)
(5) Quaternary (<1.6 Ma)

Comments:

Recurrence interval

Comments:

Slip rate
(A) >5 mm/yr
(B) 5-1 mm/yr
(C) <1 mm/yr
unknown; probably

Comments:

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

REFERENCES

Example of data for sectioned fault

SECTIONED FAULT ATTRIBUTES

Structure number 603

Comments: Refers to number 112 ("unnamed fault") in Witkind (1975).

Structure name Beaverhead fault

Comments: Although Beaverhead fault was mapped and discussed by numerous authors, Skipp (1985) may be one of the earliest to name this structure. Fault extends from east of town of Tendoy, Idaho (north), where range front steps to east, to north margin of Snake River Plain (south).

Synopsis Detailed mapping of the southern part of the fault and reconnaissance studies of scarp morphology are the sole source of data for this fault; segmentation model has been proposed based on these data. No detailed site studies, such as trenching, have been conducted.

Date of compilation 11/12/92

Compiler and affiliation Kathleen M. Haller, U.S. Geological Survey

State Idaho

County Lemhi; Clark

1° x 2° sheet Dubois

Province Northern Rocky Mountains

Geologic setting High-angle, down-to-southwest, range-front normal fault bounding west side of Beaverhead Mountains.

Number of sections 6

Comments: Haller (1988) defined 6 segments of Beaverhead fault, but because of reconnaissance nature of study, Haller's segments are considered here as sections.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

SECTION ATTRIBUTES

Section number 603a

Section name Lemhi section

Comments: Defined as Lemhi segment by Haller (1988). Extends from northern end of fault east of Tendoy, Idaho, to north of Peterson Creek (south).

Reliability of location Good

Comments: Location of scarps based on 1:250,000-scale maps of Haller (1988), original mapping at 1:24,000 or 1:62,500 scale.

Sense of movement N

Comments:

Dip

Comments:

Dip direction SW

Geomorphic expression This section of fault characterized by discontinuous poorly preserved scarps (Haller, 1988).

Age of faulted deposits

Detailed studies

Timing of most recent paleoevent
(4) middle and late Quaternary (<750 ka)

Comments: History of this section is poorly understood; however, reconnaissance studies show no evidence of scarps on latest Quaternary deposits (Haller, 1988). Scarps are present on middle? Quaternary deposits (Crone and Haller, 1991), but recurrent movement may not have occurred in past 100 k.y. based on range-front morphology (Haller, 1988).

Recurrence interval ND

Comments:

Slip rate
unknown; probably <1 mm/yr

Comments: Long-term slip rate for section is probably one of the lower for Beaverhead fault as reflected in low topographic relief, maximum 1.19 km (Haller, 1988).

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Section number 603b

Section name Mollie Gulch section

Comments: Defined as Mollie Gulch segment by Haller (1988). Extends from north of Peterson Creek (north) to west of Jakes Canyon (south).

Reliability of location Good

Comments: Location of scarps based on 1:250,000-scale maps of Haller (1988), original mapping at 1:24,000 or 1:62,500 scale.

Sense of movement N

Comments:

Dip

Comments:

Dip direction SW

Geomorphic expression Scarps are generally poorly defined and high on mountain front, no scarps on alluvium (Haller, 1988; Crone and Haller, 1991).

Age of faulted deposits

Detailed studies

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

Comments: Scarps are preserved on steep (25°) colluvial slopes, which lead Haller (1988) to propose that faulting may have occurred between 10-15 ka (post-glacial time).

Recurrence interval ND

Comments:

Slip rate
unknown; probably <1 mm/yr

Comments: Long-term slip rate for this section is probably lowest for Beaverhead fault as reflected in low topographic relief, maximum 0.98 km (Haller, 1988).

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Section number 603c

Section name Leadore section

Comments: Defined as Leadore segment by Haller (1988). Extends from west of Jakes Canyon (north) to near Eighteenmile Creek (south). Includes Canyon Creek and Hawley Creek segments in Montana Bureau of Mines and Geology digital database (Stickney and Bartholomew, written commun. 1992) and Hawley Creek scarp of Stickney and Bartholomew (1987).

Reliability of location Good

Comments: Location of scarps based on 1:250,000-scale maps of Haller (1988), original mapping at 1:24,000 or 1:62,500 scale.

Sense of movement N

Comments:

Dip

Comments:

Dip direction SW

Geomorphic expression Section spans major embayment in range front and is characterized by generally continuous morphologically young scarps on alluvium. Grabens are well preserved and as much as 0.3 km wide (Haller, 1988; Crone and Haller, 1991).

Age of faulted deposits Scarps are formed on all but late Holocene alluvial deposits.

Detailed studies

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

Comments: Morphology of probable single-event fault scarps indicate a middle Holocene age for most recent faulting event. Probable multiple-event scarps are thought to be less than approximately 30 ka (Haller, 1988). Stickney and Bartholomew (1987) state that scarps on this section of fault (called Hawley Creek scarp) are poorly preserved on late Pleistocene(?) deposits and are probably older than age cited here.

Recurrence interval 15-25 k.y. (<30 ka)

Comments: Interval is based on Haller's (1988) estimate of two events in past 30 k.y. with most recent event occurring in middle Holocene.

Slip rate
(C) <1 mm/yr

Comments: 0.1-0.5 mm/yr. Scott and others (1985) suggested slip rate of 0.3 mm/yr for central part of Beaverhead fault, and P.L.K. Knuepfer (written commun., 1992) suggested a rate of 0.5 ± 0.3 mm/yr with error reflecting uncertainty in slip measurements and age data. A much lower rate of about 0.1 mm/yr is not precluded by Haller's data.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Section number 603d

Section name Baldy Mountain section

Comments: Defined as Baldy Mountain segment by Haller (1988). Extends from near Eighteenmile Creek (north) to west of Eighteenmile Peak, near Gilmore Summit (south). Includes Dry Canyon segment in the Montana Bureau of Mines and Geology digital database (Stickney and Bartholomew, written commun. 1992).

Reliability of location Poor

Comments: Inferred location of fault at bedrock-alluvial contact, source of trace based on 1:250,000-scale maps of Haller (1988), original mapping at 1:24,000 or 1:62,500 scale.

Sense of movement N

Comments:

Dip 80° SW

Comments: Fault exposed on north side of Chamberlain Creek in approximately 14-m-deep stream cut (Haller, 1988). Dip cited is apparent dip of bedrock-alluvial contact.

Dip direction SW

Geomorphic expression Fault defined by aligned springs and discontinuous scarps on bedrock. Scarps on Quaternary deposits are generally absent, but most deposits along range front are thought to be younger than about 25 ka (Haller, 1988). Range-front morphology is similar to that along adjacent sections including a steep faceted profile, high structural relief, and unembayed mountain front.

Age of faulted deposits

Detailed studies

Timing of most recent paleoevent
(3) late Quaternary (<130 ka)

Comments: Based on range-front morphology, most recent faulting may have been approximately 100 ka (Haller, 1988; Crone and Haller, 1991).

Recurrence interval ND

Comments:

Slip rate
(C) <1 mm/yr

Comments: 0.3-0.5 mm/yr. Scott and others (1985) suggested slip rate of 0.3 mm/yr for central part of Beaverhead fault, and P.L.K. Knuepfer (written commun., 1992) suggested a slip rate of 0.5 ± 0.3 mm/yr with error reflecting uncertainty in amount of slip and age data.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Section number 603e

Section name Nicholia section

Comments: Defined as Nicholia segment by Haller (1988). Northern end of section is near Gilmore Summit, and scarps are absent along northern 8 km. Scarps extend from near Mud Creek (north) to Timber Canyon (south). Includes North Nicholia, Nicholia, South Nicholia, and Scott Canyon segments in Montana Bureau of Mines and Geology digital database (Stickney and Bartholomew, written commun. 1992) and Nicholia scarp of Stickney and Bartholomew (1987).

Reliability of location Good

Comments: Location of scarps based on 1:250,000-scale maps of Haller (1988), original mapping at 1:24,000 or 1:62,500 scale.

Sense of movement ND

Comments: (Scott and others, 1985)

Dip

Comments:

Dip direction SW

Geomorphic expression Section spans major embayment in range front. Nearly continuous, prominent scarps characterize southern 34 km (Haller, 1988; Crone and Haller, 1991).

Age of faulted deposits Upper Pleistocene (~15 ka) glacial outwash, and upper Pleistocene and undifferentiated Pleistocene alluvium (Scott, 1982).

Detailed studies

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

Comments: Age estimates for most recent event are poorly constrained between Holocene and approximately 30 ka, but inferred age of faulted deposits suggest <15 ka. Morphology of probable single-event fault scarps indicate most recent faulting event occurred approximately 30 ka. But deposits thought to be latest Pleistocene (<15 ka), based on soil characteristics, have single-event scarps, thus Haller (1988) concludes movement probably occurred shortly after late glacial deposits were emplaced (~15 ka). In contrast, Stickney and Bartholomew (1987) suggest that a 2-km-long section of scarps south of the old town site of Nicholia (called Nicholia scarp) are Holocene in age, and a combined length of 13 km of scarps north and south of Nicholia are older than 15 ka.

Recurrence interval 15 k.y. (<25-30 ka)

Comments: Probable single-event scarps on 15 ka deposits, multiple-event scarps on deposit thought to be approximately 30 ka (Haller, 1988).

Slip rate
(C) <1 mm/yr

Comments: 0.1-0.5 mm/yr. Scott and others (1985) suggested slip rate of 0.3 mm/yr for central part of the Beaverhead fault, and P.L.K. Knuepfer (written commun., 1992) suggested slip rate of 0.5 ± 0.3 mm/yr with error reflecting uncertainty in the amount of slip and age data. However, a much lower rate of 0.1-0.2 mm/yr is not precluded by Haller's data.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

Section number 603f

Section name Blue Dome section

Comments: Defined as Blue Dome segment by Haller (1988). Extends from near the town of Lone Pine, Idaho (north), to southern end of the fault at north margin of Snake River Plain. Rodgers and Anders (1990) refer to this section as Blue Dome segment of Birch Creek fault.

Reliability of location Poor

Comments: Inferred location of fault at bedrock-alluvial contact, source of trace based on 1:250,000-scale maps of Haller (1988), original mapping at 1:24,000 or 1:62,500 scale.

Sense of movement N

Comments:

Dip

Comments:

Dip direction SW

Geomorphic expression Fault extends along southernmost part of range at bedrock-alluvium contact. Topographic relief is low and scarps on alluvium rare. Locally, Paleozoic limestone is present at the surface on both sides of fault (Crone and Haller, 1991).

Age of faulted deposits

Detailed studies

Timing of most recent paleoevent
(5) Quaternary (<1.6 Ma)

Comments: History of this section of fault poorly understood; reconnaissance studies indicate no evidence of late Quaternary movement (Haller, 1988). Crone and Haller (1991) suggested that this section had Quaternary movement, but no data are available to provide more constraint.

Recurrence interval ND

Comments:

Slip rate
(C) <1 mm/yr

Comments: ≤0.1 mm/yr. Scott and others (1985) suggest slip rate of 0.1 mm/yr for southeast end of Beaverhead fault, and P.L.K. Knuepfer (written commun., 1992) suggests a slip rate of <0.01 mm/yr during past 130 k.y.

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

REFERENCES

Crone, A.J., and Haller, K.M., 1991, Segmentation and the coseismic behavior of Basin and Range normal faults—Examples from east-central Idaho and southwestern Montana, *in* Hancock, P.L., Yeats, R.S., and Sanderson, D.J., eds., Characteristics of active faults: Journal of Structural Geology, v. 13, p. 151-164.

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Witkind, I.J., 1975, Preliminary map showing known and suspected active faults in Idaho: U.S. Geological Survey Open-File Report 75-278, 71 p. pamphlet, 1 sheet, scale 1:500,000.

Compilation form for simple faults

STRUCTURE ATTRIBUTES

Structure number

Comments:

Structure name

Comments:

Synopsis:

Date of compilation

Compiler and affiliation

State

County

1° x 2° sheet

Province

Reliability of location (Good, Poor)

Comments:

Geologic setting

Sense of movement T R D S N

Comments:

Dip

Comments:

Dip direction

Geomorphic expression

Age of faulted deposits

Detailed studies

Timing of most recent paleoevent CHOOSE ONE:
(2) Holocene and post glacial (<15 ka)
(3) late Quaternary (<130 ka)
(4) middle and late Quaternary (<750 ka)
(5) Quaternary (<1.6 Ma)

Comments:

Recurrence interval

Comments:

Slip rate
(A) >5 mm/yr
(B) 5-1 mm/yr
(C) <1 mm/yr
unknown; probably

Comments:

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

REFERENCES

Example of data for simple fault

SIMPLE FAULT ATTRIBUTES

Structure number 605

Comments: Refers to number 226 ("unnamed fault") in Witkind (1975).

Structure name Unnamed fault

Comments: Main branch of fault extends from Deadwood Summit (north) to flank of Wild Buck Peak (south). Eastern branch extends across irregular topography from headwaters of Sulphur Creek (north) to near Deadwood Lodge (south) where it intersects with main branch.

Synopsis Fault is poorly understood, no known work has been completed at time of compilation.

Date of compilation 12/17/92

Compiler and affiliation Kathleen M. Haller, U.S. Geological Survey

State Idaho

County Valley

1° x 2° sheet Challis

Province Northern Rocky Mountains

Reliability of location Poor

Comments: Location of fault based on 1:500,000-scale map of Witkind (1975).

Geologic setting High-angle, down-to-southeast, normal faults along west side of Deadman River and east side of East Fork Deadman River. Sense of movement on eastern branch generally opposes local topography.

Sense of movement N

Comments: (Witkind, 1975)

Dip

Comments:

Dip direction SE

Geomorphic expression

Age of faulted deposits Pleistocene moraines (Schmidt and Mackin, 1970).

Detailed studies

Timing of most recent paleoevent
(3) late Quaternary (<130 ka)

Comments: Schmidt and Mackin (1970) mapped area around intersection of fault branches and indicated that at least the eastern branch cuts Pleistocene moraines (glacial till).

Recurrence interval ND

Comments:

Slip rate
unknown; probably <1 mm/yr

Comments:

Length (km) Determined from GIS data

Average strike (azimuth) Determined from GIS data

Endpoints (lat. - long.) Determined from GIS data

REFERENCES

Schmidt, D.L., and Mackin, J.H., 1970, Quaternary geology of Long and Bear Valleys, west-central Idaho: U.S. Geological Survey Bulletin 1311-A, 22 p., 2 pls.

Witkind, I.J., 1975, Preliminary map showing known and suspected active faults in Idaho: U.S. Geological Survey Open-File Report 75-278, 71 p. pamphlet, 1 sheet, scale 1:500,000.

Compilation form for historical surface faulting

HISTORICAL SURFACE FAULTING

Name of earthquake

Comments:

Affected structure(s), segment(s), or section numbers

Date

Magnitude or intensity

Comments:

Moment magnitude or seismic moment

Comments:

Location of epicenter

Comments:

Depth of epicenter

Comments:

Sense of movement T R D S N

Comments:

Dip

Comments:

Maximum slip at surface

Comments:

Geophysical average slip

Comments:

Length of surface rupture Determined from GIS data

Comments:

REFERENCES

Example of data for historical surface faulting earthquake

HISTORICAL SURFACE FAULTING

Name of earthquake Borah Peak earthquake
Comments:

Affected structure(s), segment(s), or section numbers 601C; 601B; 601g; 604b

Date 10/28/1983

Magnitude or intensity $M_S = 7.3$
Comments: (Dewey, 1987)

Moment magnitude or seismic moment $M_o = 2.9 \times 10^{26}$ dyne-cm
Comments: Seismically derived moment is less than that derived geodetically ($M_o = 3.2 \times 10^{26}$ dyne-cm) by Stein and Barrientos (1984). Sum of scalar moments was 2.86×10^{26} dyne-cm, but 3.5 weeks of aftershocks contributed to only 6% to the total seismic moment (Smith and others, 1985).

Location of epicenter 43.974° N; 113.916° W
Comments: (Dewey, 1987). Epicenter was about 15 km south-southwest of termination of recognized surface faulting(Doser and Smith, 1985). Rupture propagated up and unilaterally to northwest, contrary to eyewitness report in Wallace (1984).

Depth of epicenter 14-16 km
Comments: Dewey(1985; 1987) reported 14 km, whereas 15-16 km was reported by Doser and Smith (1985).

Sense of movement **NS**
Comments: Crone and others (1987) report about 17% of slip component was sinistral at the surface, which agrees with small component of sinistral slip inferred from fault plane solution (Doser and Smith, 1985).

Dip 45°-62° SW
Comments: Subsurface dip of fault from variety of sources; see Richins and others (1987) for details.

Maximum slip at surface 2.7 m
Comments: Maximum is net vertical throw; average vertical throw along entire rupture 0.8 m; average vertical throw along Thousand Springs segment (601C) 1.1 m, 58% of length of rupture on Thousand Springs segment had scarps that exceeded 1 m in throw; left-lateral component was approximately 17% of vertical (Crone and others, 1985; 1987). Some individual scarps are nearly 5 m high (Crone and Haller, 1991), but were associated with grabens and local backtilting.

Geophysical average slip 1.4-2.1 m
Comments: Preferred model for geodetic data (Barrientos and others, 1987) indicates 2.1 m of slip at southern end of rupture and 1.4 m of slip at the northern end of rupture on a single planar fault dipping 49° SW with dimensions of 26 km long by 18 km (south end) to 8 km (north end) wide. Calculations based on the seismic moment suggest 1.4 m of slip (Doser and Smith, 1985).

Length of surface rupture Determined from GIS data
Comments: 36.4 ± 3.1 km reported by Crone and others (1987); length is not sum of trace lengths of various parts of rupture but is a straight-line length. They believe that the 20.8-km-long rupture on Thousand Springs segment (601C) represents the primary rupture and the 7.9-km-long rupture on Warm Spring segment (601B) and 14.2 km on the nearby Willow Creek hills strand (601g) and Lone Pine fault (604b) are a secondary result of triggered slip. Geodetic data (Barrientos and others, 1987) support this interpretation.

REFERENCES

Barrientos, S.E., Stein, R.S., and Ward, S.N., 1987, Comparison of the 1959 Hebgen Lake, Montana and the 1983 Borah Peak, Idaho, earthquakes from geodetic observations: Bulletin of the Seismological Society of America, v. 77, p. 784-808.

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