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Quaternary Fault and Fold Database of the United States

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South Granite Mountains fault system, Ferris Mountains section (Class A) No. 779d

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Synopsis	**General:** This 125-km-long, west-northwest trending, north-dipping fault system is located along the north margin of a low chain of anomalous west-northwest-trending mountain ranges within the Wyoming Basin province of central Wyoming. Two episodes of movement have been documented on the fault system. The first was near the end of the Eocene when the Granite Mountains (to the north) were uplifted at least 3 km, and during the Pliocene to Quaternary when the fault system was reactivated in the opposite sense (down-to-the-north) resulting in subsidence of the previously uplifted Precambrian-cored Sweetwater Arch. Part of this subsidence was accommodated by the Split Rock syncline [778], which lies north of the South Granite Mountains fault system. There has been a thorough reconnaissance of the fault system and detailed paleoseismic investigations at two locations along its middle portion. This study revealed clear

	evidence for Quaternary deformation on the three central faults (sections) of the system, but Quaternary deformation has not been proven for the distal sections (Class B structures). Pleistocene to Holocene displacement was found in the Green Mountain and Ferris Mountains areas, and minor Quaternary displacement was found in the Muddy Gap area. However, all five sections are considered to be of potential Quaternary age because of the prevalence of lineaments, springs, alignment of vegetation and fault scarps. Trenching has shown that a displacement of about 0.5 m (net vertical) is typical of the average surface-rupturing event on the Ferris Mountains section of the fault system. In addition, using reported average to maximum displacement ratios for historic faulting events, they proposed that the active (late Quaternary) sections of the South Granite Mountains fault system might have a maximum surface faulting event of 1–1.5 m displacement. **Sections:** This fault has 5 sections. Geomatrix Consultants (1988 #2980) defined five segments (herein considered as sections) for the South Granite Mountains fault system. From west to east, these are the Crooks Mountain [779a], Green Mountains [779b], Muddy Gap [779c], Ferris Mountains [779d] and Seminoe Mountains [779e] sections. Quaternary movement (Class A structures) has been documented in the Green Mountain area, along the Ferris Mountains, and in the Muddy Gap area. As such, only these three sections are described in detail; the Crooks Mountain (779a) and Seminoe Mountains [779e] sections are considered to be of Class B (potential Quaternary) structures, pending further investigations.
Name comments	**General:** Named for its location south of the Granite Mountains. However, the fault is in fact much closer to the mountain chain formed by the Green, Ferris, and Seminoe Mountains, which it borders on their north sides. The fault system is defined by Geomatrix Consultants (1988 #2980) as having five sections; the western end of the system is near Alkali Creek on the western end of the Crook Mountains and the eastern end is at Saylor Creek, north of Horseshoe Ridge at the eastern end of the Seminoe Mountains. **Section:** Named for the fault's proximity to the Ferris Mountains. This section of the fault extends roughly 18 km long in a west-northwest direction along the north margin of the Ferris Mountains, from Cherry Creek on the west to Sand Creek Canyon on the east (Geomatrix Consultants, 1988 #2980). This section

	coincides with the eastern end of the Ferris Mountains, whereas the western end corresponds with a distinct change in the trend of the mountain front. **Fault ID:** Referred to as normal fault 3 on figure 2-1 of Geomatrix Consultants (1988 #2973) and fault 242 of Witkind (1975 #819).
County(s) and State(s)	CARBON COUNTY, WYOMING
Physiographic province(s)	WYOMING BASIN
Reliability of location	Poor Compiled at 1:250,000 scale. *Comments:* Trace based on map of entire fault system (fig. 3-1) at about 1:330,000 scale by Geomatrix Consultants (1988 #2980) with modifications based on Geomatrix Consultants (1988 #2980) 1:250,000 scale map (plate 2). This modified trace was transferred to 1:250,000-scale map with topographic-base, and then digitized. The 1:330,000 scale trace is a generalization from Love and others (1979 #3470) and Love and Christiansen (1985 #2287). The fault is shown in generalized fashion at 1:500,000 scale by Witkind (1975 #819) and Geomatrix Consultants (1988 #2980), and at 1:1,000,000 scale by Case and others (1997 #3449). A detailed (1:100,000 scale) map of the fault section is included in fig. 3-2 by Geomatrix Consultants (1988 #2980).
Geologic setting	The South Granite Mountains fault system trends west-northwest along the northern flanks a chain of low mountain ranges comprised of Crooks Mountain (on the west), the Green Mountains, Ferris Mountains, and Seminoe Mountains (on the east). The fault system forms the southern margin of the Sweetwater Arch, a west-northwest-trending asymmetric Laramide-age anticline consisting of a steeply dipping southern limb and a gently dipping northern limb (Love, 1970 #3445). The central to western portion of the arch is comprised of Precambrian granitic knobs that protrude above Miocene to Pliocene sediment. The southern limb is comprised of the South Granite Mountains. After being buried by conglomerate in the Eocene, the arch started to subside via structural downwarping along the Split Mountain syncline and by normal displacement along the North and South Granite Mountain fault systems. Subsidence continued

	into the Pliocene, but Quaternary movement has only been documented on portions of the South Granite Mountains fault system. The system's east-west orientation and normal sense of movement are consistent with the north-south extensional stress regime proposed for the Wyoming foreland by Zoback and Zoback (1980 #176)(1980).
Length (km)	This section is 18 km of a total fault length of 133 km.
Average strike	N68°W (for section) versus N72°W (for whole fault)
Sense of movement	Normal *Comments:* Down to the north in Pliocene to Quaternary time; in Eocene, movement was in opposite (down-to-the-south) sense (Love, 1970 #3445). Love (1970 #3445) suggested a minimum post-Miocene displacement of 650 m for the fault system.
Dip Direction	N *Comments:* Appears to dip steeply (Love, 1970 #3445).
Paleoseismology studies	Site 779-2 Cherry Creek area. Three trenches (CC-1, CC-2, and CC-3) were excavated in the Cherry Creek area by Geomatrix Consultants (1988 #2980). Trench CC-1 penetrated the surface of unit Q2c and showed >1.9 m of surface displacement of the relict soil that has formed on uneroded remnants of Q2c (40–90 ka). However, the number of events and amounts of displacement could not be determined. About 1.6 m of displacement is recorded for three events. Trench CC-2 penetrated surface Q3c (15–40 ka) and showed about 1.0 m of vertical displacement from two discrete surface faulting events, for an average of 0.5 m per event. Trench CC-3 was excavated across the unfaulted surface of unit Q4c mainly to provide evidence for the minimum time of most recent faulting. Geomatrix Consultants (1988 #2980) concluded that a displacement of about 0.5 m (net vertical) is typical of the average surface rupturing event on the Ferris Mountains section of the fault system. In addition, using reported average to maximum displacement ratios for historic faulting events, they proposed that the active (late Quaternary) sections of the South Granite Mountains fault system might have a maximum surface faulting event of 1–1.5 m displacement.

Geomorphic expression	Along the eastern part of the section, the expression of the fault is one of discontinuous aligned springs and associated vegetation lineaments. Along the western part of the section, the fault is expressed as nearly continuous fault scarps for about 13 km. These fault scarps face north and have vertical surface displacements of about 1–6 m and associated heights of 3–13 m. The scarps are formed on several different-aged geomorphic surfaces that Geomatrix Consultants (1988 #2980) was unable to confidently correlate to other regions. Along this western part of the section, the following three study areas were studied in detail by Geomatrix Consultants (1988 #2980). A) Cherry Creek (west end of section). This area, characterized by nearly continuous alignment of north-facing scarp, was selected for detailed fault investigations (including trenching, Site 779-2). The faults cut at least three different-aged geomorphic surfaces. The oldest surface (Q1c) has about 4.3 m of displacement, a scarp height of 9.2 m and a 23° maximum slope angle; surface Q2c has about 1.4 m of displacement, a scarp height of 3.8 m and a 23° maximum slope angle; and surface Q3c has scarps with 0.4–1 m of displacement and 13–15° maximum slope angles on relatively steep alluvial-fan surfaces. The youngest mapped surface (Q4c) is not deformed. No estimates of fault timing were made from these data, but the data show conclusively that the fault has had recurrent activity in middle to late Quaternary time. B) Pete Creek (west part of section, 6 km west of C). At least three different-aged geomorphic surfaces are displaced by the fault. Two distinct strands of the fault were mapped, and although the relative timing of movement on these traces is uncertain, both exhibit morphology indicative of late Quaternary faulting. The youngest mapped surface (Q4p) is not deformed. C) East Arkansas Creek (east one-third of section). At least three different-aged geomorphic surfaces are displaced by the fault. The oldest surface (Q1a) has a composite scarp with about 6 m of net displacement and a maximum scarp-slope angle of 13.5°. The youngest mapped surface (Q4a) is not deformed.
Age of faulted surficial deposits	Although undated, Geomatrix Consultants (1988 #2980) made a four-fold subdivision of surficial units at the study areas. On the basis of soil development and comparisons with dated sequences elsewhere in the Rocky Mountains province, unit Q2c was

	estimated at 40–90 ka, unit Q3c at 15–40 ka, and the unfaulted unit Q4c at 2–7 ka.
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* This estimate of timing comes from Site 779-2, trench CC-2, where two faulting events have occurred in the past 15–40 k.y. Geomatrix Consultants (1988 #2980) found no displacement of the surface of Q4c, which is considered to be have stabilized between 2 and 7 ka. Thus, they concluded that the two most recent faulting events occurred before 2–7 ka and after 40 ka. Although considered to be late Quaternary (<130 ka) by Geomatrix Consultants (1988 #2980), on the basis of suggested recurrence intervals (8–30 ka for the late Quaternary), we characterize the most recent event as latest Pleistocene or Holocene for this database.
Recurrence interval	8–20 k.y., <40 ka; 13–30 k.y., <90 ka *Comments:* Using surface age estimates, Geomatrix Consultants (1988 #2980) calculated the recurrence of 0.5 m surface-rupturing events on the Ferris Mountains section. Their basic data are three surface faulting events since deposition of unit Q2c (40–90 ka), two surface faulting events since deposition of unit Q3c (15–40 ka), and no surface faulting events since deposition of unit Q4c (2–7 ka). Their estimates of recurrence since 40 ka were 8–20 k.y., whereas for the past 90 k.y. they estimated 13–30 k.y. Geomatrix Consultants (1988 #2980) assigned recurrence intervals of >5.1 k.y. to >16 k.y. for a Ms 6.5–6.75 earthquake using a moment-rate approach and two possible fault widths (depths).
Slip-rate category	Less than 0.2 mm/yr *Comments:* Geomatrix Consultants (1988 #2980) calculated slip rates based on displacements and estimated ages of surfaces in the Cherry Creek study area. This data is summarized in their Table 6-3 (note, the geomorphic surfaces shown in this table are mislabeled). Their rates range from a minimum of 0.02–0.03 to a maximum of 0.05–0.08 mm/yr. They concluded that the average net slip rate on the section is probably less than or equal to 0.1 mm/yr. Thus, we placed this section in the <0.2 mm/yr slip-rate

	category.
Date and Compiler(s)	1999 Michael N. Machette, U.S. Geological Survey, Retired
References	#3449 Case, J.C., Larsen, L.L., Boyd, C.S., and Cannia, J.C., 1997, Earthquake epicenters and suspected active faults with surficial expression in Wyoming: Geological Survey of Wyoming Preliminary Hazards Report 97-1, 1 sheet, scale 1:1,000,000. #2973 Geomatrix Consultants, Inc., 1988, Northwestern Wind River Basin seismotectonic evaluation: Technical report to U.S. Department of Interior, Bureau of Reclamation, Denver, under Contract 6-CS-81-07310, 116 p., 3 pls. #2980 Geomatrix Consultants, Inc., 1988, Wyoming Basin geomorphic province seismotectonic evaluation: Technical report to U.S. Department of Interior, Bureau of Reclamation, Denver, under Contract 6-CS-81-07310, 167 p., 2 pls. #3445 Love, J.D., 1970, Cenozoic geology of the Granite Mountain area, central Wyoming: U.S. Geological Survey Professional Paper 495-C, 154 p., 10 pls. #2287 Love, J.D., and Christiansen, A.C., 1985, Geologic map of Wyoming: State Geologic Map, 3 sheets, scale 1:500,000. #3470 Love, J.D., Christiansen, A.C., Earle, J.L., and Jones, R.W., 1979, Preliminary geologic map of the Casper 1° x 2° quadrangle central Wyoming: U.S. Geological Survey Open-File Report 79-961, 13 p., 1 pl., scale 1:250,000. #819 Witkind, I.J., 1975, Preliminary map showing known and suspected active faults in Wyoming: U.S. Geological Survey Open-File Report 75-279, 35 p. pamphlet, 1 sheet, scale 1:500,000. #176 Zoback, M.L., and Zoback, M., 1980, State of stress in the conterminous United States: Journal of Geophysical Research, v. 85, no. B11, p. 6113-6156.