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Meers fault, southeastern section (Class A) No. 1031b

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Synopsis	**General:** Fault originally mapped in about the late 1930s, and scarp was considered to be an erosionally exhumed fault-line scarp. The scarp, formed on late Quaternary deposits, was first recognized by M. Charles Gilbert in the early 1980's during field studies of the igneous rocks exposed in the nearby Wichita Mountains (Gilbert, 1983 #671; 1983 #672). Paleoseismic studies of the fault indicate a temporal clustering of events in the late Quaternary. These studies have established the occurrence of two well-dated, late Holocene events, and a preceding event that occurred middle Pleistocene time or earlier. **Sections:** This fault has 2 sections. The two sections described here are based on the distinctly different surficial expression of the fault along each section. A conspicuous, continuous Holocene scarp is present along a 26-km-long section of the fault, but low-

	sun angle photography suggests that the Holocene rupture along this section may be as much as 37 km long (Ramelli and others, 1987 #668; Ramelli and Slemmons, 1990 #665). This 26- or possibly 37-km-long section is considered as section 1031b in this compilation. A poorly studied section is located northwest of section 1031b, and is referred to as section 1031a in this compilation. Knowledge and information on this northwesterly section is based solely on work by Cetin (1990 #658; 1992 #674). The actual length and details of the subsurface extent of the Meers fault are not well known, but subsurface (Harlton, 1951 #670; 1963 #667) and magnetic (Jones-Cecil and Crone, 1989 #663; Jones-Cecil, 1995 #673) data show that the fault extends for tens of kilometers to the northwest and southeast of the Quaternary scarp (section b). Other sections of the fault may exist at depth that are not expressed in Quaternary deposits.
Name comments	**General:** Originally named the Thomas fault by Harlton (1951 #670). It was renamed the Meers Valley fault on the 1954 version of the Oklahoma Geologic map (Harlton, 1963 #667), but subsequent common usage has shortened the name to the Meers fault. The sections of the fault discussed here extend from near Sugar Creek on the northwest to near Beef Creek (tributary of East Cache Creek) on the southeast. **Section:** Fault has not been formally divided into sections or segments, although only part of the entire fault has a Quaternary scarp. Therefore, in most discussions of the region's Quaternary tectonics, the Meers fault usually refers to this section of the fault that has a Quaternary scarp, in contrast to the subsurface Meers fault which is much longer than the fault scarp. The part of the fault discussed in this section extends from the northern boundary of Comanche County southeastward to near Beef Creek, which is a tributary of East Cache Creek. **Fault ID:** Decription of the Meers fault was originally assigned a Structure Number of 1020 in the compilation of Crone and Wheeler (2000 #4359), but subsequently, the Structure Number was changed to 1031.
County(s) and State(s)	COMANCHE COUNTY, OKLAHOMA
Physiographic province(s)	CENTRAL LOWLAND
Reliability of	Good

location	Compiled at 1:50,000 scale. *Comments:* The northwestern 26-km-long part of this section, from the northern boundary of Comanche County to about 1.5 km southwest of Richards Spur, has a prominent scarp that is very obvious, especially on low-sun-angle photography (Ramelli and others, 1987 #668). Southeastward from the Richards Spur area, discontinuous, more subtle scarps increase the total length of this section to 37 km (Ramelli and Slemmons, 1990 #665); these subtle scarps have not been carefully checked in the field because they are in an artillery range of the U.S. Army Fort Sill. The location of the 26-km-long section is based on A.J. Crone's mapping of the scarp using 1:18,000-scale aerial photographs and transferring its location to 1:50,000-scale topographic maps. The location of the subtle scarps is based on a 1:160,000-scale map shown as figure 5 of Ramelli and others (1987 #668).
Geologic setting	The fault is one of at least four west- to northwest-trending faults that form the Frontal Wichita fault system (Harlton, 1951 #670; 1963 #667; 1972 #666), which is the boundary between the Paleozoic sedimentary rocks in the Anadarko basin to the northeast and the Cambrian intrusive and extrusive igneous rocks that comprise the Wichita Mountains to the southwest. Faults in the frontal fault system have a cumulative down-to-the-northeast throw of as much as 10 km. In contrast, the Quaternary scarp indicates a down-to-the-south-west sense of throw on the fault. Uncertain amounts of lateral slip have probably occurred on many faults in the frontal fault system; estimates range from a few kilometers to as much as 120 km. The location and trend of the fault system were probably controlled by zones of crustal weakness that developed during formation of the Southern Oklahoma aulacogen in latest Precambrian to Early Cambrian time.
Length (km)	This section is 35 km of a total fault length of 54 km.
Average strike	N63°W (for section) versus N°64W (for whole fault)
Sense of movement	Left lateral *Comments:* Estimates of the ratio of sinistral to vertical displacement vary from approximately 1.3:1 (Kelson and Swan, 1990 #659) to >5:1 (Crone and Luza, 1990 #661). A ratio of 2:1 is probably a good general estimate. Reverse sense of movement is based on northeasterly dip in the shallow subsurface, however, at

	depth, the fault probably dips to the southwest. The very linear trace of the fault suggests that it has a near-vertical dip in the shallow subsurface.
Dip	40° SW.–76° NE. *Comments:* Dips are 40° SW–76° NE. Drill-hole and seismic-reflection data indicate that the major faults in the frontal fault system dip at moderate angles to the southwest. At depth, the Meers fault has a moderate dip (about 40°) to the southwest (McConnell, 1989 #660). In the shallow subsurface, near-vertical to northeasterly dips are common (Crone and Luza, 1990 #661; Miller and others, 1990 #664). The northeasterly to vertical dips in the shallow subsurface may be the result of steepening and refraction of the fault as it approaches the surface.
Paleoseismology studies	Detailed studies have been conducted at five locations along this section. Starting from the northwest, site 1031b-1 is named the "Valley site" of Kelson and Swan (1990 #659) and Swan and others (written commun. 1993 #675) where a 1.5-m-high scarp is formed on Holocene alluvium. The vertical displacement from brittle deformation at this site is estimated to be about 1.8 m, and the total vertical deformation from both faulting and folding is estimated to be about 3.6 m. Their best estimate of sinistral displacement is about 9 m. A 21-m-long trench at this site exposed stratigraphic evidence of two late Holocene faulting events; the age of the older event is bracketed between 2000 and 2900 years ago, and the younger event occurred 800–1600 years ago. At site 1031b-2, the "Northwestern Ponded Alluvium" site of Kelson and Swan (1990 #659) and Swan and others (written commun. 1993 #675), a small northeastward-flowing drainage has deposited alluvium against an uphill-facing scarp. A network of seven trenches at this site indicate about 1.8 m of vertical and 3.1 m of sinistral displacement in a channel thalweg. The trenches exposed two fault-related colluvial wedges; radiocarbon dating of stratigraphic units in the trenches indicates that the older event occurred sometime before 1700 years ago and the younger event probably occurred about 1050 years ago. Site 1031b-3 corresponds to the "Ponded Alluvium" sites of

Crone and Luza (1990 #661) and the "Southeastern Ponded-Alluvium" site of Kelson and Swan (1990 #659) and Swan and others (written commun. 1993 #675). Here, Holocene movement on the fault has created a 1.1-m-high, uphill-facing scarp on Post Oak Conglomerate that has disrupted the gradient of several small drainages and ponded alluvium against the scarp. Crone and Luza (1990 #661), Kelson and Swan (1990 #659) and Swan and others (written commun. 1993 #675) excavated a network of trenches parallel to and across the scarp. Studies of these trenches yield estimates of vertical displacement that range from 0.7 m to 2.7 m and estimates of sinistral displacement that range from 3.4 to 5.0 m. Scarp-derived colluvial wedges indicate two late Holocene faulting events. The older event preceded deposition of a colluvial-wedge deposit that yielded a radiocarbon age of 3400 yr B.P. The most recent event immediately preceded deposition of a younger colluvial wedge that yielded a radiocarbon age of 1050 yr B.P.

The Canyon Creek site (1031b-4) is discussed by Luza and others (1987 #544), Luza and others (1987 #669), Crone and Luza (1990 #661), Kelson and Swan (1990 #659), and Swan and others (written commun. 1993 #675). Two trenches at this site were excavated in Hennessey Shale and Quaternary alluvium. The trenches did not find convincing stratigraphic evidence of multiple Holocene faulting events; the absence of this evidence may be related to the abundant ductile deformation in the shale, which minimized the likelihood of a surface-rupturing earthquake forming a scarp with a discrete free face. Without a free face, faulting-related colluvial wedges never formed to leave a record of multiple rupturing events. Based on the similar size of the scarp here with the measured vertical offsets at sites in the Post Oak Conglomerate terrain (sites 1031b-1, 1031b-2, 1031b-3), the two Holocene events recorded elsewhere along this section likely ruptured the fault at this site. These trenches did yield an estimate of 1100–1300 yr B.P for the age of the most recent event. At this site, scarp profiles on Holocene deposits and on middle (?) Pleistocene deposits indicate a similar amount of vertical displacement (5.1–5.4 m; Kelson and Swan, 1990 #659; Swan and others, written commun. 1993 #675) on both deposits. These data suggest that, prior to the two late Holocene events, no surface ruptures had occurred extending back to at least middle Pleistocene time.

Site 1031b-5 is the "Browns Creek" site of Madole (1988 #662).

	Natural exposures along the creek reveal fault-related fan alluvium that is at least 1.4 m thick adjacent to the fault. Radiocarbon dating brackets the age of the fan alluvium to be less that 1,360 ±100 years old and greater than 470 ±150 years old.
Geomorphic expression	This section has a prominent, continuous, linear scarp for 26 km and to the southeast, an additional 9 km of subtle, discontinuous, arcuate scarps. The linear part of the scarp strikes N. 60° W. The scarp is formed on two lithologically different Permian-age rock types. The northwestern part of the scarp is formed on the Post Oak Conglomerate, which is a well-indurated, resistant limestone-pebble conglomerate in a calcareous matrix. Eastward from about 2 km west of Canyon Creek, the scarp is formed on the Hennessey Shale, which is much less resistant to erosion. In the Post Oak terrain, the scarp is very prominent and sharp, whereas in the Hennessey terrain, it is more subdued but still obvious on conventional and low-sun-angle aerial photography and on the ground. The 9-km-long subtle scarps at the eastern end of this section are not obvious on conventional aerial photography; their existence was recognized from low-sun-angle photography (Ramelli and others, 1987 #668).
Age of faulted surficial deposits	late Holocene (Luza and others, 1987 #544; 1987 #669; Ramelli and others, 1987 #668; Madole, 1988 #662; Crone and Luza, 1990 #661; Kelson and Swan, 1990 #659; Swan and others, written commun. 1993 #675).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Two late Holocene events are documented—one between 1,100–1,300 yrs ago (Luza and others, 1987 #669; Luza and others, 1987 #544; Madole, 1988 #662; Crone and Luza, 1990 #661; Kelson and Swan, 1990 #659), and a preceding event between 2,000-2,900 yrs ago (Kelson and Swan, 1990 #659; Swan and others, written commun. 1993 #675). The discontinuous scarps east of the prominent linear scarp are unstudied but are presumed to be Holocene in age.
Recurrence interval	0.6-1.7 k.y. (<2.9 ka) *Comments:* The recurrence interval is based on timing of the two

	documented Holocene events. However, it is difficult to assign a conventional recurrence interval because the available data suggest temporal clustering of events. Stratigraphic evidence of pre-Holocene faulting events is lacking. Topographic profiles of scarps formed on Pleistocene deposits show that the Pleistocene deposits are vertically offset about the same amount as the Holocene deposits (Crone and Luza, 1990 #661; Kelson and Swan, 1990 #659). Based on the degree of soil development on these deposits, they are thought to be middle Pleistocene in age (on the order of 130–790 ka) (Madole, 1988 #662). These relations indicate that the middle Pleistocene deposits have only been deformed by the late Holocene events. Therefore, prior to the two late Holocene events, no surface faulting events have occurred for 100 k.y. or more.
Slip-rate category	Less than 0.2 mm/yr *Comments:* There are no known published slip rates for this section of the Meers fault, probably because slip rate is difficult to determine because geologic evidence indicates temporal clustering of events-the two late Holocene events occurred about 700–1,800 years apart and any older events are more than about 130 ky. The only geologic constraints on the time of the surface deformation that preceded these two Holocene events is that it occurred more than 100 k.y. earlier and possibly many hundreds of thousands of years earlier. Based on the time interval between the two late Holocene events, the late Holocene slip rate would be about 0.9–4.9 mm/yr, but these must be viewed as a maximum value. The time between the late Holocene events is 700–1,800 years based on the estimated ages of these events (1,100–1,300 and 2,000–2,900 yrs ago, respectively). The only slip-per-event data available for the Holocene events are based on measuring the total slip for the two late Holocene events and dividing the value by 2, which yields slip-per-event estimates as small as 1.6 m and as large as 3.4 m (Kelson and Swan, 1990 #659; Swan and others, written commun. 1993 #675). The 3.4 m-per-event value was determined at site 1031b-4 where only the vertical component of slip was measured. These ranges of inter-event times and slip-per-event yield a short-term Holocene slip rate of 0.9–4.9 mm/yr (1.6 m in 1,800 yr and 3.4 m in 700 yr); however, the values probably have very large uncertainties. Geological evidence indicates that the short term, Holocene slip rate is anomalously high compared to the fault's long-term behavior. The cumulative net slip in Quaternary deposits is on the order of 3.9–5.9 m (Kelson and Swan, 1990 #659; Swan and others, written commun. 1993 #675).

	If these total slip values are divided by 100,000 years (the minimum estimated age of the Quaternary deposits), then the maximum long-term slip rates are 0.039–0.059 mm/yr. If the Quaternary deposits are actually older, then the calculated slip rates decrease accordingly. The measurements of lateral and vertical displacement along the fault presented by Ramelli and others (1987 #668) and Ramelli and Slemmons (1990 #665) permit another estimate of a long-term slip rate. These authors note a location near the center of the scarp where the lateral slip may be about 20 m, and the scarp is slightly less than 5 m high. These values suggest a net slip of about 20.6 m. The age of the scarp at this location is unknown, but it is formed in the highly resistant Post Oak Conglomerate. Thus, the scarp could be hundreds of thousands of years old. If we use a conservative estimate of 200,000 years for the age of the scarp in resistant bedrock, then the long-term slip rate is 0.1 mm/yr; if the bedrock scarp is 500,000 years old, then the slip rate is 0.04 mm/yr. The conclusion is clear—the long-term slip rate for this section of the Meers fault is very likely a small fraction of a millimeter per year, and the short-term rate, which is computed using the time interval between the two late Holocene events, indicates an anomalously high rate of fault slip. Thus we assign the Meers fault a slip-rate category of less than 0.2 mm/yr because this value probably reflects the long-term rate of displacements on the fault.
Date and Compiler(s)	1994 Anthony J. Crone, U.S. Geological Survey, Emeritus
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