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East Cache fault zone, southern section (Class A) No. 2352c

Last Review Date: 2016-02-11

Compiled in cooperation with the Utah Geological Survey

citation for this record: **Black, B.D., Hylland, M.D., Haller, K.M., and Hecker, S., compilers, 2016, Fault number 2352c, East Cache fault zone, southern section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, https://earthquakes.usgs.gov/hazards/qfaults, accessed 12/14/2020 02:57 PM.**

Synopsis	**General:** Normal fault zone that separates Cache Valley from the Bear River Range to the east. The fault zone is at the boundary between the Basin and Range and the Middle Rocky Mountains physiographic provinces. The East Cache fault zone is one of several north-trending, northeast stepping, late Quaternary, normal faults that lie between the Wasatch fault zone in Utah and the Teton fault in Wyoming. **Sections:** This fault has 3 sections. Informally named sections

	defined here follow McCalpin (1987 #4999; 1994 #4414). McCalpin (1994 #4414) describes physiographic sections because the faulting history cannot be constrained well enough to define seismogenic segments. The sections are differentiated based on fault zone complexity, tectonic geomorphology, and expression of surface fault scarps . Bailey (1927 #5186) alludes to the same sectioning of the fault based on gross differences in the range-front morphology. The central section of the fault is the most active in the latest Quaternary; the northern and southern sections are less active and show evidence of only middle to late Pleistocene activity. The morphology of faceted spurs along the range front suggests that the boundary between the northern and central sections has shifted southward several kilometers during the middle to late Quaternary, probably along with development of a younger, western fault strand in the northern section (McCalpin, 1994 #4414; 1989 #4999). Similarities in the structure of faceted spurs and the absence of a gravity-defined boundary between the central and southern sections suggest that they may have behaved as a single 44-km-long seismogenic section during much of the late Cenozoic. However, the last two events on the East Cache fault zone were limited to the 20-km-long central section, leading McCalpin (1994 #4414; 1989 #4999) to suggest that paleoearthquake magnitudes were in the range of 6.6 to 7.1. The south end of the southern section abuts the northeast-trending James Peak fault [2378].
Name comments	**General:** Early workers in the area referred to this fault as the Bear River Range fault (Bailey, 1927 #5187; 1927 #5186) and Bear River fault (Peterson, 1936 #5184). More recent studies use the name East Cache fault or East Cache fault zone. Fault extends from east of Preston, Idaho, southward to its intersection with the James Peak fault [2378] southeast of Avon, Utah. **Section:** Informal section names and are as defined by McCalpin (1994 #4414); this section extends from Blacksmith Fork Canyon southward to the James Peak fault (McCalpin, 1987 #4999; 1994 #4414). McCalpin (1987 #4999) also identified this as segment C; however, even in this paper he does not suggest that these are necessarily seismogenic segments. Oaks and others (1999 #5157) identify the western strand as the "Paradise fault" and the central strand as the "McKenzie Flat fault". **Fault ID:** Refers to fault number 11-3 (East Cache fault zone, southern segment) of Hecker (1993 #642).
County(s) and	

County(s) and State(s)	CACHE COUNTY, UTAH
Physiographic province(s)	MIDDLE ROCKY MOUNTAINS
Reliability of location	Poor Compiled at 1:50,000 scale. *Comments:* Location of faults from 1:50,000-scale mapping of McCalpin (1989 #760). Poor designation is because the fault is poorly expressed; therefore, it is approximately located in original mapping.
Geologic setting	Generally north-trending range-front normal fault along the western base of the Bear River Range in eastern Cache Valley. The East Cache fault zone and opposing West Cache fault zone [2521] bound an intermontane graben forming Cache Valley (McCalpin, 1987 #4999). Faulting here probably had begun by at least late Eocene to early Oligocene (Brummer and Evans, 1989 #5185; Brummer and McCalpin, 1995 #4394). Oaks and others (1999 #5157) indicate that the vertical throw across the southern part of the East Cache fault zone is 7,750 m. Evans (1991 #4425) estimates net slip ranges from 2.7 km near the Idaho border to 8.1 km in southern Cache Valley; he indicates that in central Cache Valley, net slip is about 4.5–6.4 km. Brummer (1989 #5185) indicates that total net vertical offset is on the order of 2.7–3.0 km. Earlier estimates by Zoback (1983 #213) indicate that total late Cenozoic slip is 3.4–4.5 km. Faulting has resulted in a pronounced escarpment rising 1000 m above Cache Valley.
Length (km)	This section is 22 km of a total fault length of 79 km.
Average strike	N4°W (for section) versus N1°W (for whole fault)
Sense of movement	Normal
Dip	45–60°W *Comments:* All of the strands dip to the west following the mapping of McCalpin (1989 #760). However Oaks and others (1999 #5157) indicate that the central strand is down to the east. Seismic reflection data indicate the fault dips 65–70° near the ground surface and shallows to 50° at depth (Evans, 1991 #4425). Additional interpretations of seismic reflection data indicate the fault dips at 60° near the surface, flattening at depth to 45–55°

	between 3.5 and 4.0 km (Smith and Bruhn, 1984 #4561), and probably cuts the Sevier-age Paris thrust (Evans and Oaks, 1990 #4411). Evans and McCalpin (2012 #7323) report that the fault exposed in the eastern trench dips 45° W. and flattens to 40° near the bottom of the approximately 4-m-deep exposure.
Paleoseismology studies	Site 2352-3. Evans and McCalpin (2012 #7323) reports the findings of four trenches excavated across the principle faults of the southern East Cache fault near Paradise, Utah. Only the eastern trench shows evidence of faulting and the location is reported here. The trench exposed a normal fault separating Paleozoic dolostone and a more than 3 m of Quaternary section that did not contain colluvial-wedge deposits; the upper part of the loess deposit yielded optically stimulated luminescence (OSL) ages of 58.8±4.5 ka and 62.5±5.0 ka in proper stratigraphic order. Evans and McCalpin (2012 #7323) speculate, "Even though no young faulting was exposed in this trench, it is possible that faulting…is younger than 59–63 ka on the main fault".
Geomorphic expression	McCalpin (1994 #4414) describes the fault as having three subparallel traces, similar to the northern section. However, along this part of the fault, the rangefront strand appears to be the most active as expressed in the low saddles that cross the heads of pre-Bonneville fans. High rates of Cenozoic displacement is recognized (Evans and Oaks, 1996 #7324; Oaks and others, 2005 #7325) along this part of the fault. The expression of faulting along the central and western strands is subtler and can be characterized as an alignment of low hills and stream channels. Evans and McCalpin (2012 #7323) conclude the western strand does not demonstrate recent surface rupture and is a bedrock fault juxtaposing different stratigraphic horizons of Salt Lake Group or does not exist at all. No evidence of faulting was exposed in two trenches of the central strand and the scarp may be erosional not tectonic (Evans and McCalpin (2012 #7323). McCalpin (1992 #4423) documents the presence of a fault scarp near Paradise Dry Canyon that has a height of 15.8 m and a surface offset of 10 m. There are no fault scarps on latest Quaternary or younger deposits along this section. McCalpin (1992 #4423) does indicate however that observed displacement in young deposits are probably due to near surface deformation.
Age of faulted surficial	Most of the fault traces are poorly expressed along this section. Mapping by McCalpin (1989 #760) shows that the westernmost

deposits	strand is generally buried, with a couple of scarps on Tertiary sedimentary rocks. The central strand has expression on Tertiary sediments and in middle Pleistocene alluvium. The eastern trace of the fault generally follows the bedrock-alluvium contact with discontinuous scarps on middle Pleistocene alluvium.
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* McCalpin (1992 #4423) suggests that faulting occurred between 26 and 46 ka. However, and earlier report states the most recent event occurred between 25 and 44 ka based on constraining thermoluminescence ages (McCalpin, 1987 #4999). Using data from McCalpin and Forman (1991 #299), Mason (1992 #463) suggests the most recent event occurred 36±18 thousand years ago. In a more recent study, Evans and McCalpin (2012 #7323) interpret the absence of scarp-derived colluvium in a trench across the western trace to indicate that the latest movement on this fault plane is older than the Bonneville lake cycle and younger than 59–63 ka
Recurrence interval	15–30 k.y. (<150 ka–1 Ma) *Comments:* McCalpin (1987 #4999; 1992 #4423) suggests a preferred recurrence interval for this section of 15–30 k.y. for the past 150 k.y. to 1 m.y. He bases this calculation on assuming that the 10 m of surface offset is the product of 0.5–1.5 m/event displacements. This yields 7–20 events since the deposition of the middle Pleistocene fan alluvium, which he assigns an age of 150 k.y.–1 m.y. The resulting recurrence interval is 7.5–143 k.y. Using data from McCalpin and Forman (1991 #299), Mason (1992 #463) suggests an average recurrence time of at least 35±17 k.y. Evans and McCalpin (2012 #7323) suggest that their conclusion of one surface rupture younger than 59–63 ka but older than the Bonneville lake cycle, the elapsed time since the most recent large earthquake is at least 26 k.y.
Slip-rate category	Less than 0.2 mm/yr *Comments:* McCalpin (1987 #4999) indicates that the middle to late Quaternary vertical displacement rate is 0.07 mm/yr based on 10 m of offset of a pre-Bonneville surface. Evans and McCalpin (2012 #7323) concur that the rate of mid-late Quaternary

	deformation is slow; they incorrectly identify their vertical-displacement rate of 0.01 to 0.03 mm/yr as representing a closed-interval rate whereas it is based on displacement in the most recent event and the elapse time since. Longer-term slip (?)(rates are provided by Evans (1991 #4425). He indicates that post-17-Ma slip (?) rates are considerably higher (0.47–0.8 mm/yr), and post Miocene (23 Ma) vertical displacement rate is about 0.35 mm/yr (Evans and McCalpin, 2012 #7323) presumably based on (Evans and Oaks, 1996 #7324; Oaks and others., 2005 #7325).
Date and Compiler(s)	2016 Bill D. Black, Utah Geological Survey Michael D. Hylland, Utah Geological Survey Kathleen M. Haller, U.S. Geological Survey Suzanne Hecker, U.S. Geological Survey
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