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Genoa fault (Class A) No. 1285

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Synopsis	This long, continuous and conspicuous range-front fault bounds the precipitous east front of Carson Range from near Highway 50 east of Spooner Summit in Nevada and extends southward along west edge of Jacks and Carson Valleys, across Nevada-California border near mouth of Fay Canyon, along the west edge of Diamond and Pleasant Valleys in California. Although it has been considered to mark approximate boundary between Basin and Range province and Cascade-Sierra Mountains province, some researchers include this fault in western Basin and Range province. The Carson Range in this area and apparently Carson Valley are west-tilted structural blocks. Even though the fault has been discussed in smaller pieces by several investigators, what we know of the timing of events and the slip rate of the fault does not indicate notable differences along strike. Therefore we provide a single record for this fault. Detailed trench studies, limited scarp profiles, reconnaissance photogeologic mapping, and large-scale

	photogeologic and surficial geologic mapping of the fault are the sources of data.
Name comments	This fault has been called a number of different names in the literature primarily due to differing interpretations. We follow the name that Ramelli (1999 #3636) cites for this part of a much longer system of faults that bound the northern Sierra Nevada. Faults along the Carson Range have been called the Carson Range fault system (dePolo, 1998 #2845; Ramelli and others, 1999 #3636); however, we have described each of them in separate records [i.e., 1647, 1648 1652, 1653, 1654]. Also referred to as part of the Sierra Nevada frontal fault zone (i.e., the Northern Sierra Nevada fault zone of Ramelli, 1994 #2573, southern part of Sierra Nevada frontal fault zone of Bell 1981 #2875) and as the Carson Valley fault (e.g., Clark and others, 1984 #2876). Faults were mapped by Russell (1887 #2590), Lawson (1912 #140), Moore (1961 #2879), Slemmons (1966, unpublished Walker Lake 1:250,000-scale map; 1968, unpublished Reno 1:250,000-scale map), Pease (1979 #2566; 1979 #2560; 1980 #2880), Bell (1981 #2875), Dohrenwend (1982 #2481; 1982 #2870), Stewart and others (1982 #2873), Armin and John (1983 #2874), Armin and others (1984 #5873), Smith (1984 #5874), Clark and others (1984 #2876), Ramelli and others (1994 #2573; 1999 #3636), and Ramelli (1997 #2579) along east front of Carson Range from near Highway 50 east of Spooner Summit in Nevada southward across the Nevada-California border near mouth of Fay Canyon to Silver Creek. **Fault ID:** The southern part of this zone in California was referred to as fault 128 by Jennings (1994 #2878). Refers to faults R14G and R14H and includes southern part of fault R14D of dePolo (1998 #2845).
County(s) and State(s)	DOUGLAS COUNTY, NEVADA
Physiographic province(s)	CASCADE-SIERRA MOUNTAINS
Reliability of location	Good Compiled at 1:100,000 scale. *Comments:* Locations chiefly based on 1:100,000-scale map of Ramelli and others (1994 #2573); mapping based on photogeologic analysis of conventional and low-sun-angle aerial

	photography and field studies of key locations.
Geologic setting	This long, continuous and conspicuous range-front fault bounds precipitous east front of Carson Range from near Highway 50 east of Spooner Summit in Nevada southward across Nevada-California border near mouth of Fay Canyon to Silver Creek in California (Lawson, 1912 #140; Moore, 1961 #2879; Pease, 1979 #2566; 1979 #2560; 1980 #2880; Bell, 1981 #2875; Smith, 1981 #4863; Dohrenwend, 1982 #2481; 1982 #2870; Stewart and others, 1982 #2873; Armin and John, 1983 #2874; Clark and others, 1984 #2876; Ramelli and others, 1994 #2573). Even though the fault has been considered to mark approximate boundary between Basin and Range province and Cascade-Sierra Mountains province, some researchers (e.g., Stewart, 1978 #2866; Ramelli and others, 1999 #3636) include it, the Carson Range, and the Tahoe basin within the Basin and Range province. The Carson Range is, and Carson Valley appears to be, west-tilted structural blocks (Stewart, 1978 #2866) that may have split from the main Sierra Nevada block during the Plio-Quaternary, possibly in past 2.5 to 3 Ma (Birkeland, 1963 #3622). More than 2,000 m of throw across the fault is indicated near Genoa by 1,500 m of range-front relief and some 500 to 1,000 m of adjacent basin fill (Maurer, 1985 #146; Ramelli and others, 1999 #3636). Fault is commonly associated with the other principle structures bounding the Carson Range in this area (faults 1647, 1648, 1652, 1653, and 1654). Lawson (1912 #140) may have been the first to divide the fault into sections based on appearance of youthful fault scarps, and geometric and geomorphic expression of range front, but he concluded that single earthquake produced the faults scarps that he observed . More recently, Ramelli and others (1994 #2573; 1999 #3636) discussed four parts of the fault, the Jacks Valley, Carson Valley, Diamond Valley, and Sierra sections, to provide geographic perspective not to suggest behavioral differences.
Length (km)	24 km.
Average strike	N12°W
Sense of movement	Normal *Comments:* Normal sense of movement based on Russell (1887 #2590), Lawson (1912 #140), Moore (1961 #2879), Dohrenwend (1982 #2481; 1982 #2870), Stewart and others (1982 #2873), Hayes (1985 #2508), and Ramelli and others (1994 #2573; 1999

	#3636). Slemmons (1975 #5995) reported that right-lateral displacement accounted for about 20 percent of the net displacement on fault at a location south of Genoa. Lateral movement is supported by Vadurro (1993 #5994) who interpreted an earlier phase of dextral shear on northwest-striking planes followed by normal slip on north-south planes that characterizes the recent movement on the fault.
Dip	55° E. to 90° *Comments:* Faults dipping 65° E. to vertical (Ramelli and others, 1994 #2573) in alluvial-fan deposits were exposed in a trench at west edge of Jacks Valley between Water and James Canyons (site 1285-1). Pease (1979 #2566) reported dips of 58–61° E. at an unspecified location on the Genoa fault. A fault exposed in a trench near Walleys Hot Springs (1285-2) dips from 58–65° in alluvial-fan and terrace deposits and on nearby bedrock fault plane exposed in quarry. Fault exposed in a trench about 4 km to the south (1285-3) displace alluvial-fan and scarp colluvium and dip 55–70° E. (Ramelli and others, 1994 #2573; 1999 #3636).
Paleoseismology studies	Site 1285-1, Jacks Valley site: Ramelli and others (1994 #2573) excavated a trench at west edge of Jacks Valley between Water and James canyon across the face and lower part of a steep scarp more than 6 m high. The scarp represents 4.6±0.4 m vertical separation and 5.7±0.6 m dip-slip displacement; the trench did not cross scarp crest because of the size and steepness of the scarp. The trench exposed an eastward-dipping sequence of alluvial-fan deposits, including at least 15 layers of disseminated charcoal (Ramelli and others, 1999 #3636), and an approximately 12-m-wide fault zone. The principal fault traces dip 65° E. and the sum of discrete down-to-the-east displacements in the zone is 3.2±0.5 m of dip-slip or 2.9±0.5 m of vertical displacement. An additional about 2.5 m of deformation at the site appears to be represented by warping of near-surface deposits. These data were interpreted to represent a single faulting event with 5-6 m of vertical displacement. Site 1285-2, near Walleys Hot Springs (their Walleys site): Ramelli and others (1994 #2573; 1999 #3636) excavated a trench into a 10-m-high scarp on an inset terrace that was removed from the modern channel flow by the two most recent faulting events; size and steepness of scarp precluded excavating across its crest. The trench exposed alluvial-fan deposits overlying and faulted

	against granitic bedrock. A 58° E.-dipping fault was also exposed and a minor antithetic fault was suggested by apparent downdropping of a soil horizon and by aligned clasts. An adjacent topographic profile suggests that the scarp represents 6.1±0.4 m of vertical separation and 8.2±0.6 m of dip-slip displacement. The thickness of the colluvial wedges indicates that the most recent event resulted in slightly greater dip-slip; about 4.5 m and 3.7 m, respectively. Striations on fault plane and striations and mullions on bedrock fault plane exposed in nearby quarry exhibit pure dip-slip movement (Ramelli and others, 1994 #2573; 1999 #3636). Site 1285-3, Sturgis site: Ramelli and others (1994 #2573; 1999 #3636) excavated a trench into a 6-m-high scarp at mouth of Corsser Creek on the Sturgis Ranch, about 4 km south of the trench near Walleys Hot Springs (site 1285-2). The trench exposed alluvial-fan deposits, containing several layers of disseminated charcoal, overlain by scarp colluvium. Two principal faults were exposed near base of scarp that have variable dips ranging from 55–70 °E., averaging about 65°. They interpreted the stratigraphic relationships exposed by the trench to indicate that two events having a cumulative displacement of 5.0 to 6.5 m produced the scarp, which agrees well with two adjacent scarp profiles that indicate 6.0 and 6.4 m of dip-slip displacement. Site 1285-4 Fay-Luther trench site (Ramelli and Bell, 2011 #7776). A prominent fault scarp about 20 m high crosses a broad Pleistocene surface at the mouth of Fay Canyon; the trenches are located about 1 km north of the canyon. Trench FL1 crossed a 4-m-high scarp, and trench FL2 crossed a 2-m-high scarp. Seven uncalibrated C14 ages range from 620 to 2245 yr BP are from FL1 and nine uncalibrated C14 ages (320–6110 yr BP) are used to constrain the timing of two coseismic surface ruptures. The penultimate event is younger than about 1740 yr; the most recent event occurred less than about 390.
Geomorphic expression	The northern 8 km of the fault (referred to as the Jacks Valley section by Ramelli and others, 1999 #3636) is marked by prominent east front of Carson Range, which exhibits fault facets and a nearly continuous well-defined scarp on late Holocene colluvial and locally on alluvial-fan deposits (Pease, 1979 #2566; 1979 #2560; 1980 #2880; Bell, 1981 #2875; Stewart and others, 1982 #2873; Armin and John, 1983 #2874; Bell, 1984 #105; Ramelli and others, 1994 #2573; 1999 #3636). Pease (1979 #2566) reported that along the valley edge the fault was also

	marked by stream knickpoints and that it extends northward from the valley as an ill-defined scarp on granitic bedrock. The 18 km long part of the fault along the Carson Valley contains the most prominent geomophology along the fault zone. The range front is steep, with 1200 to 1500 m of relief, and marked by prominent rilled fault facets (Ramelli and others, 1994 #2573; 1999 #3636). Fresh appearing scarps were noted along this section more than a century ago by Russell (1887 #2590) and later studied by Lawson (1912 #140), who reported fresh, little degraded scarps at and near angle of repose believed to be near-historical in age. One of the most distinctive features of this part of the fault is a single, large, very well-defined, east-facing scarp with a few to several meters high extending along entire length near Genoa. Ramelli and others (1994 #2573; 1999 #3636) reported a scarp on late Holocene alluvial-fan deposits near Walleys Hot Springs that represents 6.1±0.4 m of cumulative vertical separation for the two most recent events. Nearby, they measured 5.6 m of vertical separation across a scarp on colluvium, believed to represent the same two events and 18.3 m of vertical separation across a scarp on an older terrace deposits. The Carson River flows near western edge of Carson Valley, suggesting recent westward tilting of the valley floor (Moore, 1969 #5872; Slemmons, 1975 #5995). dePolo (1998 #2845) reports a maximum preferred basal fault facet height of 354 m (329-378 m), the second largest in his data set from Nevad a nd 244 m (219-268 m) along this fault. To the south, fault scarps cross a flight of outwash terraces along Carson River near Woodfords, California, that progressively increase in height (3–14 m) from the lowest faulted terrace to the highest (Ramelli and others, 1994 #2573). Detailed topographic cross-profiles across the scarp on a 150 (+9/-12) ka deposit are vertically offset 59 (+21/-9), 42 (+20/-10), and 66 (+23/-8) m and two profiles across a 20.7±1.1 ka deposit are vertically offset 10 (+5/-2) and 9 (+4/-1) m (Rood and others, 2011 #7775). In addition, faults are marked by distributed scarps on Diamond Valley (Clark and others, 1984 #2876; Ramelli and others, 1994 #2573; 1999 #3636). Movement on the southernmost extension of the Genoa fault is highly distributed and adjacent to small intermontane valleys and in the Sierra Nevada Block (Ramelli and others, 1999 #3636).
Age of faulted	latest Holocene; upper Pleistocene. There is general agreement

surficial deposits	that the fault displaces Holocene hillslope and alluvial-fan deposits (e.g. Bell, 1981 #2875; 1984 #105), that may be as young as a few hundreds of years old (e.g., Lawson, 1912 #140; Pease, 1979 #2566; 1979 #2560; Ramelli and others, 1994 #2573; 1999 #3636). Holocene alluvial-fan and terrace deposits and latest Pleistocene (latest Tioga) glacial-fluvial outwash terrace deposits are offset near West Fork of Carson River (Clark and others, 1984 #2876; Ramelli and others, 1994 #2573; 1999 #3636).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* In general, most of the information from several locations along the fault indicates a Holocene time for the most recent event as shown by the age of faulted alluvial-fan and terrace deposits (Bell, 1981 #2875; Bell, 1984 #105; Clark and others, 1984 #2876; Ramelli and others, 1994 #2573; Dohrenwend and others, 1996 #2846; 1999 #3636). Radiocarbon dates from trench (site 1285-1) confirm this and further suggest the most recent event is young (0.58±0.11 ka to 0.52±0.12 ka, Ramelli and others, 1999 #3636). Other radiocarbon dates on charcoal bracket the most recent event between 1.37±0.12 ka and 0.58±0.12 ka (Ramelli and others, 1999 #3636), or late Holocene.
Recurrence interval	1.5-2 ka (<2.7 ka); 3-4 ka (12 ka) *Comments:* Ramelli and others (1999 #3636) reported an interseismic interval of 1.5 to 2 ka between the most recent event and the penultimate event, which is interpreted from trench studies on the Carson Valley section. The interval is determined from radiocarbon dates on charcoal that bracket the most recent event between 1.37±0.12 ka and 0.58±0.12 ka and the penultimate event between 2.3±0.11 ka and 1.97±0.11 ka; an earlier event is only constrained to have occurred before 3.1±1.6 ka (Ramelli and others, 1999 #3636). Pease (1979 #2566) proposed a recurrence interval of 3 to 4 ka, based three to four events in past 12 ka interpreted from profiles of beveled scarps and soil-chronology. Further south, Bevels and slope angles on fault scarps, and progressively higher scarps on each of four outwash terraces (less than or equal to 10-13 k.y.) suggest three or four large (3 m each, average) surface faulting events (Ramelli and others, 1994 #2573).

Slip-rate category	Between 1.0 and 5.0 mm/yr *Comments:* No rates of deformation have been reported based on the most recent trenching of the southern Genoa fault (Ramelli and Bell, 2011 #7776), but the single-event vertical displacement rates could be quite different between the two trenches. Geomorphic mapping, surveying, and ^{10}Be surface exposure dating of glacial surfaces suggest the mean vertical displacement rate (0.4+0.3/-0.1 mm/yr) has remained relatively stable in the past 20 k.y. and 150 k.y. near Woodfords (Rood and others, 2011 #7775). Individual rates with uncertainty for the Tahoe outwash terrace (150 + 9/-12 ka) are 0.4(+0.2/-0.1), 0.3±0.1, and 0.4(+0.2/-0.1) mm/yr, and for the Tioga outwash terrace (20.7±1.1 ka) are 0.5(+0.2/-0.1) and 0.4(+0.2/-0.1) mm/yr; furthermore, the authors document the vertical displacement rate during the interval between the two glacial periods is 0.4±0.1 mm/yr. Ramelli and others (1999 #3636) report a vertical displacement rate of about 5 mm/yr based on averaging displacements associated with the two most recent events (about 10 m in past 2 ka), which are interpreted to have ruptured most of the fault. However; they believe that this rate significantly overestimates the average Holocene rate, instead they suggest 2–3 mm/yr, based the average per-event displacement for these events and the interseismic interval between the two events (1.5–2 k.y.) is a better estimate of Holocene activity. Scarps from 7–13 m high (Pease, 1979 #2566) on alluvial-fan deposits thought to be 4 ka (based on nearby ages from Ramelli and others, 1994 #2573) yield similar vertical rates, and Clark and others (1984 #2876) estimated a preferred vertical displacement rate of a 1.0 mm/yr (0.7–1.6 mm/yr) from 9- to 16-m-high fault scarp on a late Tioga (10–13 k.y.) outwash terrace.
Date and Compiler(s)	2011 Thomas L. Sawyer, Piedmont Geosciences, Inc. Kenneth Adams, Piedmont Geosciences, Inc. Kathleen M. Haller, U.S. Geological Survey
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