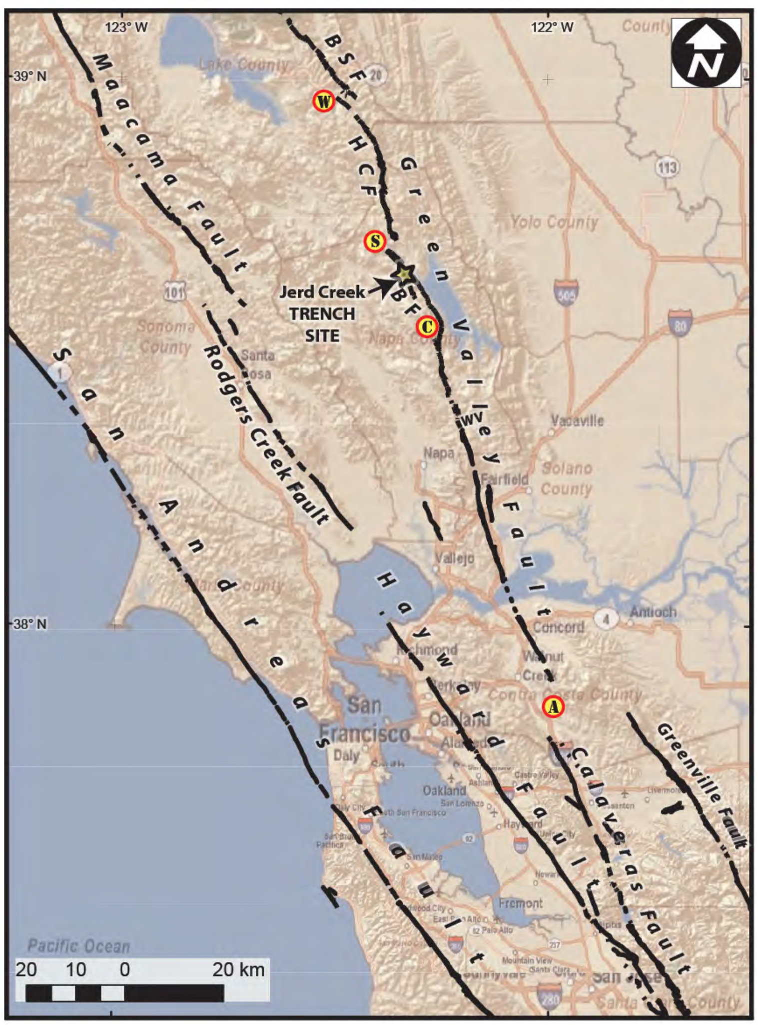
Prepared in cooperation with the U.S. Bureau of Reclamation

Logs and Data from Trenches Across the Berryessa Fault at the Jerd Creek Site, Northeastern Napa County, California, 2011–2012



Open-File Report 2014–1033

U.S. Department of the Interior
U.S. Geological Survey

COVER: Map showing location of Jerd Creek trench site (star) on the Berryessa Fault (BF). Figure by James J. Lienkaemper.

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Pamphlet to accompany

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By James J. Lienkaemper,[1] Carla M. Rosa,[1] Ian J. Cappelle,[1,2] Evan M. Wolf,[1,3] Nichole E. Knepprath,[1,4] Lucille A. Piety,[5] Sarah A. Derouin,[5] Liam M. Reidy,[6] Joanna L. Redwine,[5] and Robert R. Sickler[1]

Introduction

The primary purpose of this report is to provide drafted field logs of exploratory trenches excavated across the Berryessa Fault section of the northern Green Valley Fault (Lienkaemper, 2012; Lienkaemper and others, 2013) in 2011 and 2012 that show evidence for at least one surface-rupturing earthquake in the past few centuries. The site location and site detail are shown on sheet 1 (figs. 1 and 2). The trench logs are shown on sheets 1, 2, 3 and 4. We also provide radiocarbon ages (table 1) used for chronological modeling of the earthquake history and a field description of a soil profile in one trench (appendix). A formal report based on these logs and data is in preparation.

Geologic Setting and Fault Mapping

The approximate location of the west trace of the Berryessa Fault, a northern section of the Green Valley Fault, is identified in the vicinity of the trench site primarily by aerial photo interpretation of its geomorphic expression (Lienkaemper, 2012) and more precisely at the site from its exposure in trenches. The trench site (sheet 1, figs. 1 and 2) lies in an alluviated valley formed by the dextral fault offset of Jerd Creek, and primarily comprises residual soils and colluvium at the valley margins, and within the valley, alluvial fan, stream and debris flow deposits of late Pleistocene and Holocene age. Except for the most recent colluvial deposits (unit A, <0.5 ka), all of these materials have been displaced by right-lateral slip on the fault. The main fault trace is expressed by a low scarp, composed of shallow bedrock with a <1-m veneer of colluvium, and a subtle depression near trench JC11S (sheet 1, fig. 2), The sense of vertical separation on the fault revealed by trenching was highly variable, and thus not uniformily consistent with this feature, suggesting that strike slip motion here is strongly dominant over any local vertical component of slip.

Our detailed stratigraphic interpretation of the most recent geologic section in the site is confined primarily to the locations of four trenches less than 2 m deep, only one of which crossed most of the valley. From this limited basis, it appears that the northeast margin of the valley, adjacent to the main trace of the fault, contains mainly debris flow layers originating generally from the north. Clasts in these flows range from rounded gravel to cobbles of mostly andesitic composition reworked from the Cache Formation (Wagner, 1975; Graymer and others, 2007) that is exposed at the north end of the valley, and with a few 1–2 m angular andesite boulders of ~1.4 Ma from a local unit of the Clear Lake Volcanics (Donnelly-Nolan and others, 1981). This unit caps the ridge upslope of the site to the northeast and

[1] U.S. Geological Survey
[2] University of Texas, El Paso
[3] University of California, Los Angeles
[4] Xstrata Mt. Isa Mines, Queensland, Austrailia
[5] U.S. Bureau of Reclamation
[6] University of California, Berkeley

comformably overlies the Cache Formation (Wagner, 1975). Some late Pleistocene (pre-23 ka) debris flow deposition extended as far as the center of this valley, but the two most recent (<1 ka) flows at our site did not extend as far (trench JC11S, sheet 2). The southwest side of the valley where we trenched (trench JC11S) is dominated by more recent channel and flood deposits of Jerd Creek. The position of the main fault trace and interaction with the faulting appears to be a major factor in controlling the depositional style and extent of these deposits. Additional descriptions of some local stratigraphic units continues below in the context of evidence of faulting and identification of paleoearthquake horizons.

Earthquake Evidence, Trenching Methodology and Near-fault Stratigraphy

We excavated two trenches in 2011 and two more in 2012, seeking evidence for paleoearthquakes as has been described on other creeping faults in the region (Lienkaemper and others, 2002, 2010, 2013). It is currently unknown whether fault creep occurs at this location, because we have only monitored for creep at this site for one year (McFarland and others, 2014). We identified evidence for at least one ground-rupturing event having occurred in the past millennium, best expressed in trench JC12S (sheet 3), followed by JC12N (sheet 4) and in JC11N (sheet 1). Earlier individual surface ruptures were not distinguishable with certainty. Detailed interpretive descriptions of the evidence for and age of earthquakes will be presented in a later publication.

The methodology used in logging the trenches is described in Lienkaemper and others (2002b). Logging was done on high-resolution, ortho-rectified photo mosaics of the trench walls. Raw radiocarbon ages are shown in table 1 below. Liam Reidy analyzed nine pollen samples taken from trenches JC12N (J1–J4), JC11N (J5), and JC12S (J6–J9); however, pollen preservation was generally poor. Only one sample (J1, JC12N-northwall m11, that is, located near meter 11 on sheet 4) contained non-native pollen of the species, Erodium cicutarium, indicative of the earliest historical period—approximately the time of European settlement (ca. 1776)—however, it may have arrived up to a few decades later in parts of the northern San Francisco Bay area (Reidy, 2001; Byrne and Reidy, 2005).

East of the main fault trace, and within the active strands of the main fault zone, lies a weathered shale that is part of the Franciscan Complex (Wagner, 1975) of Cretaceous age (Graymer and others, 2007) that is mapped as occurring on both sides of the fault at this location, overthrust by serpentinite. Although serpentinite crops out on the northwest margins of the valley, it was not observed in situ in our trenches. Weathering of the shale produced sedentary soils, but in many of our exposures, two late Holocene age (< 1 ka) debris flows (units C and B) have scoured away most of this older soil. The trajectory of these flows encounters the fault zone at a low oblique angle and in the valley flows nearly parallel to it. The youngest 0–1 m thick debris flow (unit B), observed in all of our trenches, is the most useful for documenting the occurrence and age of the most recent earthquake on this fault. Unit B is overlain by unit A, a mixed facies of colluvium and alluvium, and much of it disturbed by bioturbation. The lower part of unit A is dominantly colluvium with abundant shale fragments; and, a younger, 0–1 m thick part of unit A, displays greater alluvial-fan depositional character with fewer shale fragments. The oldest unit we encountered below unit B, the “lower debris flow” unit (LDF), is an undifferentiated unit primarily of debris flow origin, that appears to be heterogeneous, with few easily identifiable internal contacts that are laterally traceable for more than a few meters. In various places within the LDF we find localized indications of buried soil horizons, minor alluvial packages and colluvial deposition—especially near the northeast margin adjacent to the bedrock. Our longest trench (JC11S), which extended about half way across the south end of the valley, ended to the west in two alluvial units of Jerd Creek that overlie the LDF and appear to be of latest Pleistocene age or younger based on one 23 ka radiocarbon age in the lower of these units. On the north wall, minor faulting has broken these alluvial units and may reach the base of the modern soil, a lateral equivalent to unit B, but containing few clasts.

Evidence for faulting was not observed in the younger alluvial unit on the south wall where this unit is much more bioturbated.

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Table 1. Radiocarbon ages.

Sample no.[1]	Mtl[2]	^{14}C age (yr) BP[3]	Unit	Expos. –Wall[4]	∂^{13}C[5]	Fraction modern	∂^{14}C	Lab. no.[6]
JC12N-01*	c	140 ± 30	Channel -st	12N-n-11	-25	0.9827 ± 0.0034	-17.3 ± 3.5	159377
JC12N-05*	c	145 ± 40	Channel -gv	12N-n-11	-25	0.9821 ± 0.0042	-17.9 ± 4.3	159378
JC12S-17	exo	Modern	A	12S-s-5	-25	1.1673 ± 0.0043	167.3 ± 4.4	159380
JC12S-24	c	880 ± 35	A	12S-s-8	-25	0.8960 ± 0.0035	-104.0 ± 3.5	159381
JC11N-18	c	1005 ± 30	A-upper	11N-n-3	-28.1	0.8825 ± 0.0031	-117.5 ± 3.2	157723
JC11N-19*	bsc	1550 ± 25	A-upper	11N-n-3	-25.6	0.8245 ± 0.0022	-175.5 ± 2.3	154677
JC11N-17	bsc	3935 ± 35	A-lower	11N-n-2	-25	0.6126 ± 0.0024	-387.4 ± 2.5	154676
JC11N-16	c	4585 ± 25	A-lower	11N-n-2	-27.9	0.5651 ± 0.0016	-434.9 ± 1.7	157724
JC12S-02	c	5900 ± 140	A	12S-n-2	-25	0.4795 ± 0.0080	-520.5 ± 8.1	159379
JC11S-13*	c	440 ± 30	B	11S-s-4	-25	0.9465 ± 0.0034	-53.5 ± 3.4	154675
JC11S-10A*	bsc	675 ± 30	B	11S-n-30	-25.8	0.9196 ± 0.0030	-80.4 ± 3.1	154674
JC11N-07*	c	950 ± 25	B	11N-n-9	-28.6	0.8887 ± 0.0026	-111.3 ± 2.7	154672
JC12S-18*	c	950 ± 30	B	12S-s-5	-25	0.8886 ± 0.0032	-111.4 ± 3.2	159470
JC11N-01A	c	1780 ± 25	B	11N-n-4	-29.2	0.8015 ± 0.0020	-198.5 ± 2.0	157725
JC11N-09*	c	1975 ± 30	B	11N-s-9	-28.6	0.7819 ± 0.0029	-218.0 ± 2.5	154673
JC12N-12a*	c	2585 ± 30	B	12N-n-1	-25	0.7248 ± 0.0025	-275.2 ± 2.6	159382
JC12N-12c*	c	2610 ± 30	B	12N-n-1	-25	0.7224 ± 0.0025	-277.6 ± 2.6	159383
JC12N-12b	c	2605 ± 35	B	12N-n-1	-25	0.7230 ± 0.0028	-277.0 ± 2.9	159386
JC12N-12b2	c	2640 ± 30	B	12N-s-0	-25	0.7197 ± 0.0026	-280.3 ± 2.6	159514
JC12N-12b1	c	2675 ± 40	B	12N-s-0	-25	0.7167 ± 0.0032	-283.4 ± 3.2	159478
JC12N-13	c	2725 ± 40	B	12N-s-1	-25	0.7121 ± 0.0034	-287.9 ± 3.4	159468
JC11N-01B*	bsc	3865 ± 35	B	11N-s-4	-26.0	0.6182 ± 0.0026	-381.8 ± 2.6	154670
JC12S-13	c	5360 ± 60	B	12S-s-2	-25	0.5133 ± 0.0035	-486.7 ± 3.5	159469
JC12S-20	c	10625 ± 50	B	12S-s-6	-25	0.2665 ± 0.0015	-733.5 ± 1.5	159471
JC12N-02	c	675 ± 35	C	12N-n-11	-25	0.9195 ± 0.0035	-80.5 ± 3.5	159472
JC12N-19	c	1605 ± 40	C	12N-s-8	-25	0.8187 ± 0.0036	-181.3 ± 3.6	159475
JC12N-07	c	2000 ± 35	C	12N-n-11	-25	0.7798 ± 0.0032	-220.2 ± 3.2	159474
JC12N-03	c	2295 ± 50	C	12N-n-10	-25	0.7516 ± 0.0043	-248.4 ± 4.3	159473
JC12N-03rep	c	3010 ± 70	C	12N-n-10	-25	0.6874 ± 0.0052	-312.6 ± 5.2	159477
JC11N-03	CO_3	1975 ± 30	OGG	11N-n-5	-12	0.7819 ± 0.0028	-218.1 ± 2.9	154671
JC11S-12	c	23530 ± 80	AL1	11S-n-28	-23.6	0.0534 ± 0.0005	-946.6 ± 0.5	157726

[1]a,b,c - indicates a dated split of a sample; A,B - indicates different material sampled at same position (e.g., bulk vs. charcoal). Samples marked with * have had a ∂^{13}C split taken to confirm the estimate of -25‰

[2]Mtl - .-material dated: c, charcoal; bsc, bulk soil carbon; exo, insect exoskeleton; CO_3, bulk groundwater carbonate

[3]±1σ-age in radiocarbon years using the Libby half life of 5568 years and following the conventions of Stuiver and Polach (1977)

[4]±Expos., exposure: Trenches JC11N, JC11S, JC12N, JC12S; -n, north wall; -s, south wall; nearest meter on log

[5]∂^{13}C values are the assumed values according to Stuiver and Polach (1977) when given without decimal places.

[6]All ages obtained by AMS analysis at Center for Accelerator Mass Spectrometry (CAMS), Lawrence Livermore National Laboratory, Livermore, California

Appendix

A field description of soil properties was made in trench JC11S at m1 on the north wall (sheet 1). The file is named “Appendix_JerdCreekSoil.pdf” and can be downloaded from: http://pubs.usgs.gov/of/2014/1033/.