Logs and Data from Trenches Across and Near the Green Valley Fault at the Mason Road Site, Fairfield, Solano County, California, 2006–2009

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Introduction

The primary purpose of this report is to provide drafted field logs of exploratory trenches excavated across the Green Valley Fault in 2007 and 2009 that show evidence for four surface-rupturing earthquakes in the past one thousand years. The site location and site detail are shown on sheet 1 (figs. 1 and 2). The trench logs are shown on sheets 1, 2, and 3. We also provide radiocarbon laboratory dates (table 1) used for chronological modeling of the earthquake history. Sheets 4 and 5 show additional data obtained in 2006–2009 to document data obtained in our studies of the long-term geologic slip rate on the Green Valley Fault. However, that effort ultimately did not prove feasible and no slip rate estimate resulted.

Geologic Setting and Fault Mapping

The Green Valley Fault location is identified north and south of the trench site by aerial photo interpretation of its geomorphic expression (Wallace, 1990) and from en echelon cracks caused by fault creep in the asphalt-concrete pavement of Mason Road (sheet 1, fig. 2). The trench site is located in distal alluvial fan deposits that have been offset by right-lateral slip on the fault, which has formed a low scarp and subtle closed depression near trench 07S (fig. 2; below the resolution of the contouring, but fills seasonally with rainwater). Although expression of faulting in trench 07S was almost entirely obscured by highly bioturbated marshy soil deposits, the fault is well resolved at depth by high-resolution seismic imaging (Kimball and others, 2011). Because faulting in trench 07S was in evidence only as a monoclinal warp (in north and south walls) yielding no evidence of individual earthquake ruptures, we logged only the south wall (sheet 3). In contrast, the fault was expressed clearly in trenches N1-N3 (sheet 1, fig. 1 inset; sheet 2) located about

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100 m to the north of trench 07S. Because there is no surface expression of the fault at this site, even in historical aerial photographs, we chose where to trench based on a distinct step in the water table across a distance of only a few meters as observed in cone penetration testing (Bennett and others, 2011) and supplemented by more closely spaced hand augering.

Slip Rate Investigation

The Mason Road site was initially selected because 1896 topographic maps showed a large (400-600-m) right-lateral offset of a minor stream, Hennessey Creek, suggesting that if this offset could be dated then we might obtain a long-term slip rate. The slip rate of the Green Valley Fault has nowhere been determined by local evidence, rather the slip rate has been inferred to be 5 ± 3 mm/yr based on regional assumptions about continuity of observed rates on connected faults to the north and south of the Green Valley Fault (Working Group on California Earthquake Probabilities, 2003, 2008). To determine slip rate, we needed to identify and to date stream sediments associated with initiation of the inferred offset. These sediments were expected to be approximately 100 thousand years old, too old for radiocarbon dating but within the range for optically stimulated luminescence (OSL) dating. During 2006 through 2009, we used cone penetration tests (CPT) and soil borings to characterize the material types and ages within the fan deposits near the fault and the geometry of the subsurface stream channel (for test results see Bennett and others, 2011). Initial results suggested an older stream channel might have been within reach by excavation and so, in 2006, we excavated a pit. This Mason Road Pit 2006 map, logs, and dating results are shown on sheet 4. The OSL dates correspond fairly closely to radiocarbon dates (sheet 4, table 1). The pit was not deep enough to measure the long-term offset that we sought, therefore we used a boring to probe for possible evidence of channel initiation inferred from interpretation of the CPT profile to be at a depth of 12 m (location SNC07 in sheet 1, fig. 2; details of Core SNC07 in sheet 5, and in Bennett and others, 2011). However, the materials at this 12-m depth were not sufficiently old (only about 12,000 years old) to correlate with the large amount of offset inferred from the 1896 map. We also attempted to image buried channel geometry using ground-penetrating radar (Craig and others, 2011), but the results could not adequately resolve channel structures much deeper than about 5-10 m. Kimball and others (2011) used high-resolution seismic refraction techniques that clearly imaged the fault at greater depths, thus suggesting the possibility that we might also be able to identify stream channels at greater depths. Encouragingly, in 2007, surveys east of the fault did indicate a channel at 10-15 m depths, however, in 2009, surveys west of the fault found no matching channel (Craig, 2010). An additional boring at “stake 11” location (sheet 1, fig. 2) was done but we did no additional dating of this buried channel because we had not found any matching offset stream channel deposits west of the fault.

Earthquake Evidence and Trenching Methodology

In 2007, we excavated two cross-fault trenches and three more in 2009 at the site, seeking evidence for paleoearthquakes (sheets 1 and 2) as has been described on another creeping fault in the region, the Hayward Fault (Lienkaemper and others, 2002a, 2010). We identified evidence for a sequence of four ground-rupturing events in the past millennium

(Lienkaemper and others, unpub. data). Earlier ruptures could not be clearly distinguished or dated. The long-axes of trenches N1, N2, and N3 orient perpendicular to the fault; trench N4 is parallel to the fault (fig. 2). Trench N4 was used to show continuity of stratigraphic units. The general stratigraphy is composed of a series of alluvial deposits overlying a marshy, bioturbated silty clay unit (u10). The alluvial deposits are characterized by variation between more silty and sandy units (u20, u40, u60, u80, u100) and more clayey organic units having varying degrees of soil development (u30, u50, u70, u90). 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. Nine pollen samples were taken from trench N1 (m 0.7 in units u80, u90, and u100); however, pollen preservation was poor. The species of non-native pollen, *Erodium cicutarium*, indicative of the earliest historical period (about 1770-1780), was not observed in any of these samples, but the sandy material provided such an oxidative environment that the results are not conclusive.

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References Cited

Bennett, M.J., Noce, T.E., and Lienkaemper, J.J., 2011, Cone penetration tests and soil borings at Mason Road, Green Valley, Solano County, California: U.S. Geological Survey Open-File Report 2011–1281, 52 p.

Craig, M.S., Kimball, Mindy, and Lienkaemper, J.J., 2011, Ground penetrating radar surveying of the Green Valley Fault, San Francisco Bay Area, CA, *in* Knudsen, K., Baldwin, J., Brocher, T., Bürgmann, R., Craig, M., Cushing, D., Hellweg, P., Wiegers, M., and Wong, I., eds., Proceedings of the 3rd Conference on earthquake hazards in the eastern San Francisco Bay area: California Geological Survey Special Report 219, p. 381–390.

Craig, M.S., 2010, Near-surface geophysical imaging of paleochannels for the determination of slip rate at the Green Valley Fault, U.S. Geological Survey, National Earthquake Hazard Reduction Program, Final Technical Report for Award Number G09AP00077, 19 p., accessed February 22, 2011, at *http://earthquake.usgs.gov/research/external/reports/G09AP00077.pdf*

Kimball, M.A., 2005, Seismic refraction on the Green Valley and Hayward Faults, San Francisco Bay Area, CA: California State University, East Bay, Masters Thesis.

Kimball, Mindy, Craig, M.S., and Lienkaemper, J.J., 2011, Using seismic refraction to identify and characterize near-surface expression of active faults in the eastern San Francisco Bay Area, CA, *in* Knudsen, K., Baldwin, J., Brocher, T., Bürgmann, R., Craig, M., Cushing, D., Hellweg, P., Wiegers, M., and Wong, I., eds., Proceedings of the 3rd Conference on earthquake hazards in the eastern San Francisco Bay area: California Geological Survey Special Report 219, p. 369–380.

Lienkaemper, J., Dawson, T., Personius, S., Seitz, G., Reidy, L., and Schwartz, D., 2002a, A record of large earthquakes on the southern Hayward fault for the past 500 years: Bulletin of the Seismological Society of America, v. 92, no. 7, p. 2637–2658.

Lienkaemper, J., Dawson, T., Personius, S., Seitz, G., Reidy, L., and Schwartz, D., 2002b, Logs and data from trenches across the Hayward Fault at Tyson's Lagoon (Tule Pond), Fremont, Alameda County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF–2386, 12 p., 2 plates, accessed February 22, 2011, at *http://pubs.usgs.gov/mf/2002/2386/.*

Lienkaemper, J.J., Williams, P.L., and Guilderson, T.P., 2010, Evidence for a 12th large earthquake on the southern Hayward fault in the past 1900 years: Bulletin of the Seismological Society of America, v. 100, no. 5A, p. 2024–2034.

McFarland, F.S., Lienkaemper, J. J., and Caskey, S.J., 2009, Data from theodolite measurements of creep rates on San Francisco Bay region faults, California, 1979–2009: U.S. Geological Survey Open-File Report 2009–1119, version 1.2 (2011), p. 17, accessed April 5, 2012, at *http://pubs.usgs.gov/of/2009/1119/*.

Prescott, J.R., and Hutton, J.T., 1994, Cosmic ray contribution to dose rates for luminescence and ESR dating; large depths and long-term time variations: Radiation Measurements, v. 23, p. 497–500.

Stuiver, M., and Polach, H., 1977, Discussion; reporting of 14C data: Radiocarbon, v.19, p. 355–363.

U.S. Geological Survey and California Geological Survey, 2006, Quaternary fault and fold database for the United States: U.S. Geological Survey and California Geological Survey, accessed February 22, 2011, at *http://earthquake.usgs.gov/regional/qfaults/*.

Wallace, R.E., 1990, Geomorphic expression, *in* Wallace, R.E., ed., The San Andreas Fault System, California: U.S. Geological Survey Professional Paper 1515, p. 14–58.

Working Group on California Earthquake Probabilities, 2003, Earthquake probabilities in the San Francisco Bay Region; 2002–2031: U.S. Geological Survey Open-File Report 2003–214, accessed February 22, 2011, at *http://pubs.usgs.gov/of/2003/of03-214/.*

Working Group on California Earthquake Probabilities, 2008, The uniform California earthquake rupture forecast, version 2 (UCERF 2): U.S. Geological Survey Open-File Report 2007–1437, February 22, 2011, at *http://pubs.usgs.gov/of/2007/1437/*.

Table 1. Radiocarbon ages.

Sample no.[1]	Material	^{14}C age (yr) BP[2]	Unit no. (u#)	Expos. -Wall[3]	Location (m)	$\partial^{13}C$[4]	Fraction modern	$\partial^{14}C$	Lab. no.[5]
07N24	charcoal	670 ± 30	u100	N1-n	7	-26.1	0.9198 ± 0.0031	-80.2	135766
07N13	charcoal	480 ± 35	u80	N1-n	4	-25	0.9422 ± 0.0036	-57.8	137742
07N14*	charcoal	530 ± 30	u80	N1-n	4	-24.8	0.9360 ± 0.0031	-64.0	135763
07N03	charcoal	1700 ± 60	u80	N1-n	0	-25	0.8088 ± 0.0053	-191.2	137741
07N01	charcoal	2480 ± 270	u80	N1-n	0	-25	0.7342 ± 0.0246	-265.8	137740
07N26	charcoal	800 ± 30	u70	N1-s	9	-25	0.9054 ± 0.0032	-94.6	135767
07N20	charcoal	815 ± 35	u70	N1-n	6	-25	0.9037 ± 0.0036	-96.3	135765
07N29	charcoal	845 ± 35	u70	N1-n	9	-25	0.9002 ± 0.0036	-99.8	135768
07N15a*	charcoal	865 ± 30	u60	N1-n	4	-24.4	0.8982 ± 0.0030	-101.8	135764
07N15b	charcoal	880 ± 30	u60	N1-n	4	-24	0.8961 ± 0.0030	-103.9	135998
N3-2a	charcoal	745 ± 30	u50	N3-n	5	-25	0.9116 ± 0.0033	-88.4	145907
N3-2b	charcoal	865 ± 40	u50	N3-n	5	-25	0.8978 ± 0.0041	-102.2	145912
N3-4	charcoal	1060 ± 30	u50	N3-n	7	-25	0.8766 ± 0.0032	-123.4	145908
07N08b	charcoal	900 ± 35	u40	N1-s	1	-25	0.8941 ± 0.0035	-105.9	135770
07N08a*	charcoal	950 ± 30	u40	N1-s	1	-24.6	0.8885 ± 0.0030	-111.5	135761
07N10*	charcoal	1005 ± 30	u40	N1-n	2	-25.6	0.8826 ± 0.0028	-117.4	135762
N3-1a	charcoal	950 ± 35	fissure in u30	N3-n	5	-25	0.8885 ± 0.0035	-111.5	145906
N3-1b	charcoal	970 ± 35	fissure in u30	N3-n	5	-25	0.8865 ± 0.0035	-113.5	145911
N2-2	bulk	640 ± 180	u30	N2-n	6	-25	0.9230 ± 0.0197	-77.0	145914
N3-5	charcoal	1290 ± 35	u30	N3-n	10	-25	0.8515 ± 0.0035	-148.5	145909
N2-1	charcoal	1015 ± 35	u30	N2-n	6	-25	0.8813 ± 0.0036	-118.7	145910
07N31*	bulk	1810 ± 30	u10	N1-s	2	-25.8	0.7984 ± 0.0027	-201.6	135769
MR07-06a	charcoal	10,905 ± 35	—	SNC7	—	-25	0.2574 ± 0.0011	-742.6	137744
MR07-06b	charcoal	10,970 ± 35	—	SNC7	—	-25	0.2553 ± 0.0011	-744.7	135772
MR07-09a	twig	10,950 ± 35	—	SNC7	—	-25	0.2558 ± 0.0011	-744.2	135773
MR07-09b	bulk	14,015 ± 45	—	SNC7	—	-25	0.1747 ± 0.0009	-825.3	135771
MRP-4	charcoal	840 ± 35	pit-35	06Pit	—	-25	0.9005 ± 0.0036	-99.5	129414
MRP-7	charcoal	950 ± 30	pit-45	06Pit	—	-27.0	0.8887 ± 0.0029	-111.3	129415
MRP-3	charcoal	3085 ± 30	pit-70	06Pit	—	-26.6	0.6813 ± 0.0022	-318.7	129413
MRP-8	bulk	6335 ± 45	pit-80	06Pit	—	-25	0.4543 ± 0.0025	-545.7	129416

[1]a,b,c - indicates a dated split of a sample. Samples marked with * have had a $\partial^{13}C$ split taken to confirm the estimate of -25‰

[2]±1σ-age in radiocarbon years using the Libby half life of 5568 years and following the conventions of Stuiver and Polach (1977)

[3]±Expos., exposure: Trenches N1, N2, N3; 2006 Pit; Core SNC007; -n, north wall; -s, south wall

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

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