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PHOTOMOSAICS AND LOGS OF TRENCHES ON THE SAN ANDREAS FAULT, THOUSAND PALMS OASIS, CALIFORNIA

By
Thomas E. Fumal, William T. Frost, Christopher Garvin, John C. Hamilton, Monique Jaasma and Michael J. Rymer

INTRODUCTION

We present photomosaics and logs of the walls of trenches excavated for a paleoseismic study at Thousand Palms Oasis (Fig. 1). The site is located on the Mission Creek strand of the San Andreas fault zone, one of two major active strands of the fault in the Indio Hills along the northeast margin of the Coachella Valley (Fig. 2). The Coachella Valley section is the most poorly understood major part of the San Andreas fault with regard to slip rate and timing of past large-magnitude earthquakes, and therefore earthquake hazard. No large earthquakes have occurred for more than three centuries, the longest elapsed time for any part of the southern San Andreas fault. In spite of this, the Working Group on California Earthquake Probabilities (1995) assigned the lowest 30-year conditional probability on the southern San Andreas fault to the Coachella Valley. Models of the behavior of this part of the fault, however, have been based on very limited geologic data.

The Thousand Palms Oasis is an attractive location for paleoseismic study primarily because of the well-bedded late Holocene sedimentary deposits with abundant layers of organic matter for radiocarbon dating necessary to constrain the timing of large prehistoric earthquakes. Previous attempts to develop a chronology of paleoearthquakes for the region have been hindered by the scarcity of in-situ 14C-dateable material for age control in this desert environment. Also, the fault in the vicinity of Thousand Palms Oasis consists of a single trace that is well expressed, both geomorphically and as a vegetation lineament (Figs. 2, 3). Results of our investigations are discussed in Fumal et al. (2002) and indicate that four and probably five surface-rupturing earthquakes occurred along this part of the fault during the past 1200 years. The average recurrence time for these earthquakes is 215 ± 25 years, although interevent times may have been as short as a few decades or as long as 400 years. Thus, although the elapsed time since the most recent earthquake, about 320 years, is about 50% longer than the average recurrence time, it is not necessarily unprecedented.

THE THOUSAND PALMS OASIS SITE

Methodology

Our paleoseismic site is located in an active wash area between two groves of native California fan palms (*Washingtonia filifera*) (Fig. 3). This area is sparsely vegetated with predominantly inkweed (*Suaeda torreyana ramosissima*) and arrowweed (Pluchea sericea). We excavated 8 trenches perpendicular to the fault and 7 trenches parallel to the fault (Fig. 4), in order to resolve slip and evidence for individual surface-rupturing earthquakes. The depth of the trenches was limited to less than 3 meters because of a shallow water table on the northeast side of the fault.

Trenches were excavated during two field seasons. The initial trenches, T1 and T2, were logged with traditional hand-drawing methods. During the second year, portions of the walls of these trenches, and the walls of all subsequent trenches, were photo-logged (note composite nature of T1 and T2 logs). For this technique, a 1m-by-0.5m rail and string grid was constructed on the trench walls and each 1m by 0.5m rectangle was photographed with a 35mm film camera fitted with a 20mm rectilinear lens. The camera was mounted on a "French-o-matic", a frame constructed of aluminum tubing that acts to keep the film plane parallel to and and equidistant from the trench wall for each photo (Fig. 5). Logging was done on mylar over prints of the photos. Later, the photos were digitized, rectified to the measured string and rail grid visible on each photo, and mosaiced together. Field linework was then transfered to the photomosaics.

Structure

The fault appears to project as a nearly straight, continuous trace from an exposure in Trench 14, excavated at the base of the hill southeast of the site, to outcrops northwest of the oasis (Fig. 3). Other trenches, however, revealed that this is not the case in the near-surface sediments. Faulting is expressed in Trenches 1, 2, 7, and 9 as a relatively simple zone less than 1 m wide, although in Trench 2 there are several older traces about 4-5 m northeast of the main zone. Faulting was not observed, however, in Trench 1A, which was not logged, nor in Trench 11, which together span a zone about 36 m wide across the projection of the fault. Also, faulting was not observed in fault-perpendicular trenches in the southeastern part of the site (Trenches 8 and 13). The deposits in these areas are 500–1000 years old and should have been offset by 2–3 earthquakes. Because the observed fault traces are parallel to the overall trend of the fault zone rather than at an angle to it as the individual segments of an en echelon zone would be, we infer the site is located within a small stepover in the fault. Because of the lack of faulting in the northwest and southeast portions of the site, logs of Trenches 6, 8, 11, 12, and 13 are not shown.

Stratigraphy

We exposed six major channels of different ages that have been eroded and filled during the past approximately 1600 years. We name the channels I–VI, with Channel I the oldest. Deposits within individual channels are indicated with colored tints on the stratigraphic column (Figure 6) and photomosaics/logs. These channels are sub-parallel and are oriented at high angles to the fault. The sedimentary fill in each channel is characterized by a basal coarse-grained gravel deposit overlain by layers of fluvial and eolian silty sand and clay interbedded with thin organic-rich layers. The channeling results in complex stratigraphic relationships with subtle unconformities exposed in fault-perpendicular trenches. Commonly, individual beds are no longer physically continuous across the site. For this reason, we have not identified individual clastic layers on the trench logs. We have, however, named distinctive organic layers. Deposition at the site has been relatively rapid, about 0.5 m/100 years.

We exposed a composite section greater than 8 m thick with more than 40 individual layers, half of which contain abundant organic matter. The organic material in these layers, which range from a few millimeters to about 20 cm thick, primarily consists of fine charcoal. We interpret these charcoal-rich layers to be the result of local fires within the oasis. California fan palm oases produce heavy accumulations of fuel and are adapted to frequent fires due to both human activity and natural causes (Vogl and McMargue, 1966). The abundance of charcoal-rich layers makes possible relatively high-resolution dating of the sedimentary deposits and paleoearthquakes.

We obtained 80 AMS 14C determinations from samples of charcoal, extracted humic acids, and rootlets from 57 samples from 20

Acknowledgements

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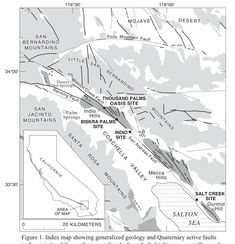


Figure 1. Index map showing generalized geology and Quaternary active faults in the vicinity of the southernmost San Andreas fault. Light gray, crystalline rock; dark gray, stratified late Cenozoic deposits; white, Quaternary alluvium. Location of paleoseismic sites indicated with black dots.

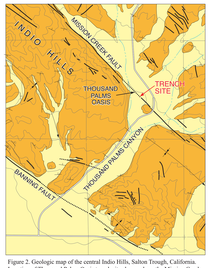


Figure 2. Geologic map of the central Indio Hills, Salton Trough, California. Location of Thousand Palms Oasis trench site shown along the Mission Creek strand of the San Andreas fault. Orange, mid-late Pleistocene alluvium; yellow, late Pelistocene–Holocene alluvium. Geology by M.J. Rymer.

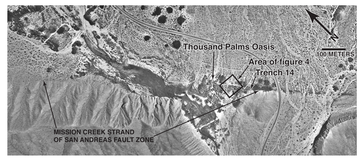


Figure 3. Aerial view of Thousand Palms Oasis and vicinity showing location of the paleoseismic site (box). Note expression of the Mission Creek strand of the San Andreas fault as a geomorphic break in slope (left of oasis) and as vegetation lineament (right of oasis). Location of Trench 14 that exposed the fault at the base of the hill southeast of the site is indicated.

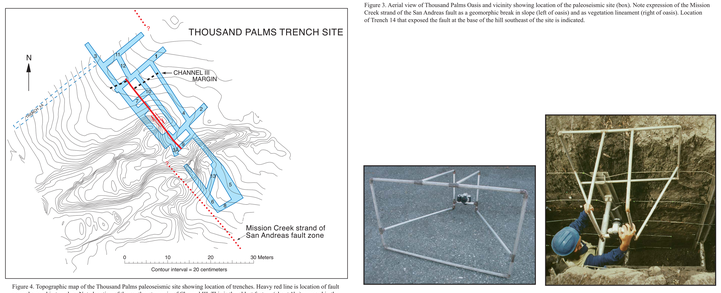


Figure 4. Topographic map of the Thousand Palms paleoseismic site showing location of trenches. Heavy red line is location of fault zone observed in trenches. Note location of the southeast margin of Channel III. This is the oldest feature (about 1ka) exposed in the trenches that can be matched across the fault. It is offset 2.0 ± 0.5 m.

Figure 5. The Trench-o-matic. 35mm-film camera fitted with 20mm rectilinear lens is used to take photos of 1m by 0.5m portions of the trench stratigraphic column.

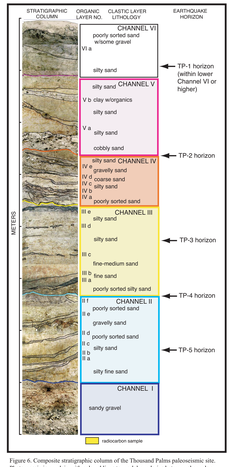
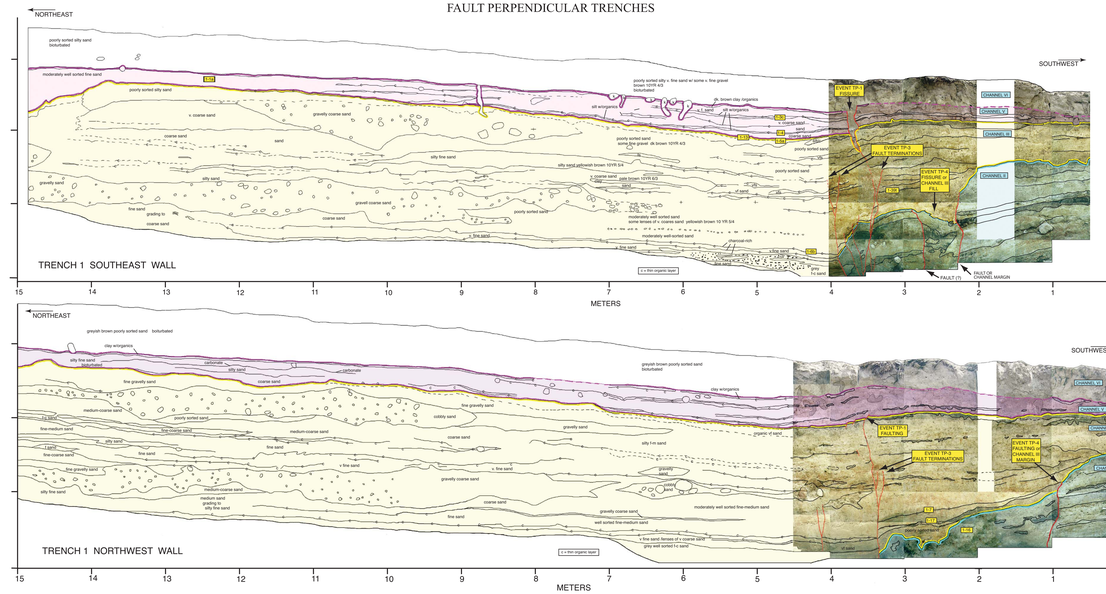
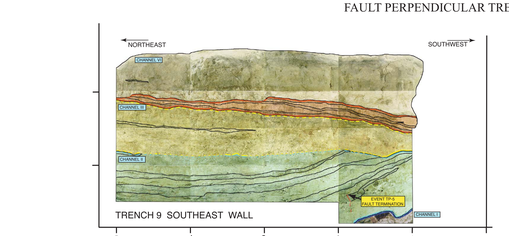
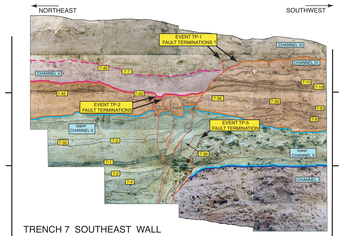
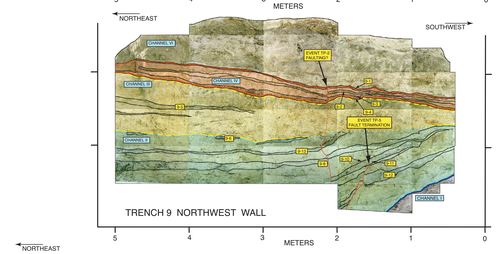
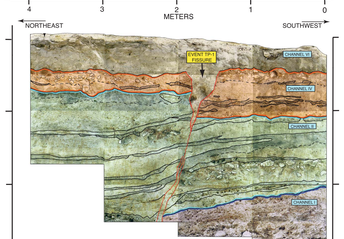
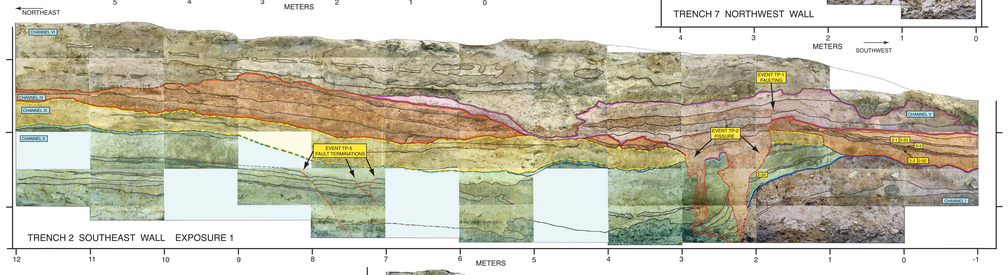
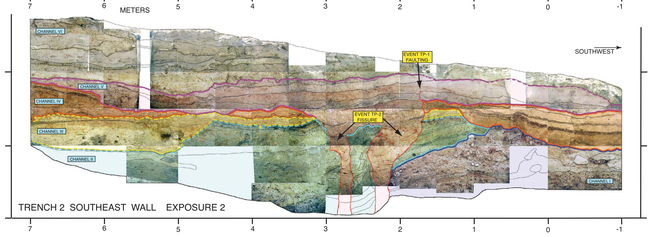
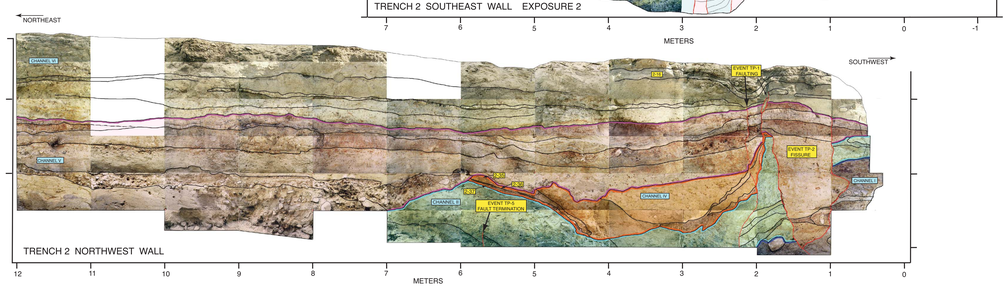


Figure 6. Composite stratigraphic column of the Thousand Palms paleoseismic site. Photomosaic is overlain with colored lines to mark boundaries between channels on this and following figures. Black lines delineate lithologic units within channels. Unit numbers for organic layers and lithologic descriptions for interbedded clastic units are shown in color-coded boxes. Arrows indicate locations of earthquake horizons.

TABLE 1 RADIOCARBON DATES

LAB #	SAMPLE #	UNIT	MATERIAL	^{14}C AGE	^{13}C VALUE
AA 17729	T1-1A	VI	charcoal	715 ± 35	-21.7
AA 17738	T2-3S	VI	charcoal	1185 ± 70	-24.
AA 17734	T1-3C	Vb	soil/charcoal	355 ± 55	-26.6
AA 21918	T10-2	Vb	soil/charcoal	285 ± 45	-25.886
AA 17735	T1-3D	Va	soil/charcoal	1015 ± 60	-25.5
AA 21905	T5-3	Va	soil/charcoal	945 ± 45	-25.719
CAMS 63505	T7-40	Va	soil/charcoal	480 ± 40	-25*
CAMS 63506	T7-40	Va	humics	420 ± 50	-26*
AA 21917	T10-1	Va	soil/charcoal	310 ± 45	-26.241
CAMS 63507	T7-41	IVe	soil/charcoal	360 ± 40	-25*
CAMS 63508	T7-43	IVd	humics	860 ± 50	-25*
AA 21910	T9-1	IVd	soil/charcoal	505 ± 40	-26.433
CAMS 53956	T2-33	IVd	soil/charcoal	460 ± 50	-25*
CAMS 53951	T2-33	IVd	humics	350 ± 60	-25*
AA 21911	T9-2	IVd	soil/charcoal	1005 ± 45	-25.987
CAMS 63509	T7-45	IVd	humics	400 ± 50	-25*
AA 21911	T9-2	IVd	soil/charcoal	660 ± 45	-26.062
CAMS 53958	T9-2	IVd	soil/charcoal	460 ± 60	-25*
CAMS 53953	T9-2	IVd	humics	310 ± 50	-29*
CAMS 53954	T9-3	IVd	charcoal	1015 ± 60	
AA 17731	T2-1	IVd	soil/charcoal	850 ± 65	-27.5
AA 21893	T2-35	IVd	soil/charcoal	520 ± 45	-26.528
AA 21920	T10-6	IVd	soil/charcoal	520 ± 45	-26.450
AA 21908	T7-10	IVc	soil/charcoal	515 ± 45	-26.941
CAMS 63510	T7-46	IVc	soil/charcoal	1015 ± 45	-25*
CAMS 63444	T7-36	IVb	charcoal	580 ± 40	-25*
CAMS 64147	T7-36	IVb	charcoal/humics	410 ± 40	-28*
CAMS 63505	T7-39	IVb	soil/charcoal	560 ± 40	-25*
CAMS 64143	T7-39	IVb	humics	430 ± 40	-28*
AA 21912	T9-1	IVb	soil/charcoal	1015 ± 45	-26.782
AA 21913	T9-1	IVb	soil/charcoal	680 ± 45	-26.282
CAMS 53960	T9-3	IVb	roots	180 ± 50	
AA 17732	T2-2	IVb	soil/charcoal	695 ± 35	-27.4
AA 17733	T2-4	IVb	soil/charcoal	950 ± 65	-26.8
CAMS 63511	T7-47	IVb	soil/charcoal	1015 ± 45	-25*
CAMS 53950	T2-30	IVb	humics	460 ± 60	-25*
AA 21895	T2-37	IVb	soil/charcoal	525 ± 45	-26.801
AA 21894	T2-36	IVb	soil/charcoal	560 ± 45	-27.055
AA 21906	T7-8	IVa	soil/charcoal	510 ± 45	-25.723
CAMS 53949	T9-4	IVa	humics	510 ± 50	-25*
CAMS 53961	T9-4	IVa	humics	580 ± 50	-29*
CAMS 53962	T9-5	IVa	Post-Modern		
AA 21900	T5-5	IV	soil/charcoal	520 ± 45	-25.168
CAMS 53954	T1-13	IIIa-upper	soil/charcoal	600 ± 50	-25*
AA 17730	T1-5A	IIIa-lower	soil/charcoal	695 ± 60	-25.3
AA 21907	T9-5	IIId	soil/charcoal	795 ± 45	-26.754
CAMS 63512	T7-50up	IIIc	soil/charcoal	1015 ± 45	-25*
CAMS 63504	T1-39up	IIIc	charcoal	850 ± 50	-25*
AA 17736	T1-6B	IIIb	soil/charcoal	1075 ± 70	-26.8
AA 17737	T1-7	IIIb	soil/charcoal	1050 ± 130	-25.7
AA 21897	T1-17	IIIa	soil/charcoal	920 ± 45	-26.10
CAMS 54961	T9-12	IIIa	soil/charcoal	1210 ± 50	-25*
CAMS 54964	T9-13	IIIa	soil/charcoal	1210 ± 50	-25*
CAMS 54966	T9-13	IIIa	humics	1060 ± 50	-29*
AA 21905	T7-3	IIId	soil/charcoal	1530 ± 50	-25.931
CAMS 63501	T7-35	IIId	soil/charcoal	1300 ± 50	-25*
CAMS 63502	T7-35	IIId	humics	1280 ± 50	-29*
CAMS 63502	T7-35	IIId	charcoal	1310 ± 40	-25*
CAMS 64146	T7-35	IIId	charcoal/humics	1130 ± 40	-28*
CAMS 54963	T9-8	IIId	soil/charcoal	1290 ± 50	-25*
CAMS 54145	T9-8	IIId	humics	1080 ± 50	-29*
CAMS 63503	T7-37	IIIa	soil/charcoal	1290 ± 50	-25.910
AA 21904	T5-1	IIIa	soil/charcoal	1405 ± 45	-25.910
AA 21915	T9-11	IIIc	soil/charcoal	1330 ± 45	-26.044
CAMS 53963	T9-11	IIIc	roots modern		
AA 21914	T9-10	IIIc	soil/charcoal	1535 ± 45	-26.743
CAMS 54965	T9-10	IIIc	humics	1360 ± 50	
AA 21902	T7-2	IIIb	soil/charcoal	1395 ± 50	-26.284
AA 21916	T9-12	IIIb	soil/charcoal	1530 ± 45	-26.059
CAMS 53964	T9-12	IIIb	roots	480 ± 80	
AA 21896	T5-3	IIIb	soil/charcoal	1170 ± 45	-26.484
CAMS 63513	T7-51	IIIb	soil/charcoal	1290 ± 50	-25*
CAMS 53952	T2-34	IIIb	humics	1280 ± 50	-29*
AA 21904	T7-4	IIa	soil/charcoal	1235 ± 55	-26.023
CAMS 63865	T7-58	IIa	soil/charcoal	2280 ± 50	-25*
CAMS 63845	T7-58	IIa	humics	1130 ± 40	-28*
AA 21899	T5-4	IIa	soil/charcoal	1385 ± 45	-25.980
AA 21898	T5-1	IIa	soil/charcoal	1465 ± 45	-25.123
AA 21897	T5-2	IIa	soil/charcoal	1485 ± 45	-27.176
AA 21891	T1-16	I	soil/charcoal	1670 ± 50	-26.188