High-Resolution Slip Rate for the Southern San Andreas Fault at Salt Creek, Salton Trough, California

Thomas K. Rockwell[1], Katherine M. Scharer,[2] Patrick Williams,[1] Nathan Brown,[3] William C. Buckley[1], Paula, M. Figueiredo[4], Andrea Fabbrizzi[1]

[1]San Diego State University, [2]US Geological Survey, [3]University of Texas, Arlington, [4]University of Lisbon, Portugal

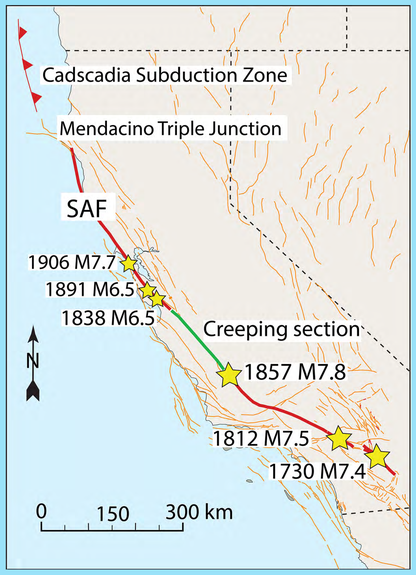
Abstract

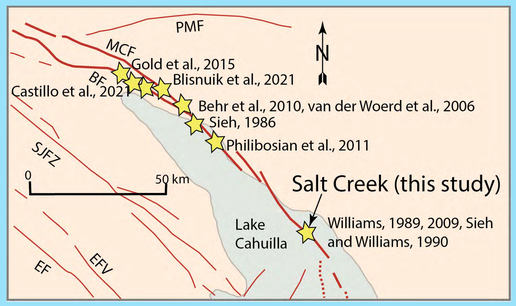
We present a new geologic slip rate determined for the southernmost San Andreas Fault (sSAF) within a relatively linear fault segment situated adjacent to the modern-day Salton Sea about 16 km from the southern end of the fault. This is the first Holocene slip rate that encompasses the entire fault zone in the Salton Trough. The closest published Pleistocene-to-present long-term slip rates are 60 km north of the southern terminus of the sSAF, in the Indio Hills, where the fault is multistranded, resulting in a twofold uncertainty in slip rates (12–27 mm/yr). New work at Salt Creek, between Bombay Beach and North Shore on the eastern side of the Salton Sea, has resolved a buried channel margin offset about 53 m by the fault. We combine previous exposures with two new trench exposures to reduce the full estimated displacement uncertainty to about ±1 m.

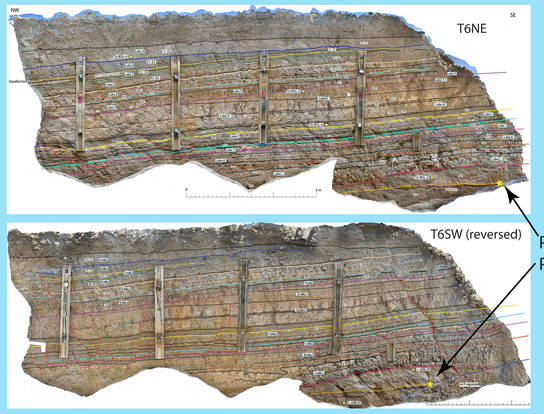
To constrain the age of the offset, we dated three samples of detrital charcoal from the fluvial sand unit used as the piercing point, which yielded calibrated ages of 3.52±0.05, 3.47±0.08, and 3.45±0.04 ka. The Salt Creek catchment includes an archeological site (Dos Palmas Preserve oasis), which was repeatedly occupied during the lowstands of ancient Lake Cahuilla, potentially introducing an inherited age bias in the charcoal. As a result, the dated charcoal samples provide maximum ages for the host strata, resulting in a minimum slip rate when applied to the offset channel margin. We apply an offset of 53±1m since <3.45±0.05 ka to resolve a minimum late-Holocene slip rate of ~15–16 mm/yr on the channel, slightly lower than the observed geodetic rate of ~18 mm/yr. To obtain an age unaffected by charcoal inheritance, we acquired new Post-IR Infrared Stimulated Luminescence ages that directly dates the Salt Creek fluvial sand used as a piercing point. The youngest and stratigraphically highest sample yielded a n age of 2.61±0.29 ka. Applying an offset of 53±1 m yields a slip rate of 20.3+3/-2.4 mm/yr. Off-fault deformation is not quantified nor does the rate account for the current open interval of nearly 300 years suggesting that this higher rate may also be a minimum. These results highlight the importance of applying multiple dating techniques to resolve slip rates and timing of past earthquakes, especially when using detrital charcoal derived from archeological sites. An open question is whether the sSAF will release all of the accumulated strain in a single large event with as much as 6 meters of slip.

Motivation

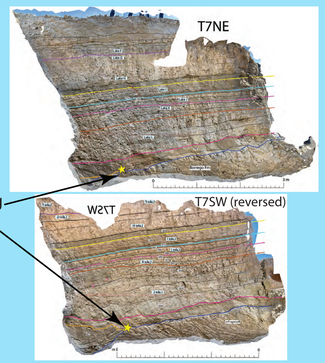
The open interval on the San Andreas fault is twice as long as the average recurrence interval for the past 1200 years. The slip rate estimates for the SAF in the Salton Trough have a factor of 2.5 uncertainty. Our new work places much tighter contraints on the amount of potential accumulated displacement that may be released in the next large southern San Andreas event.

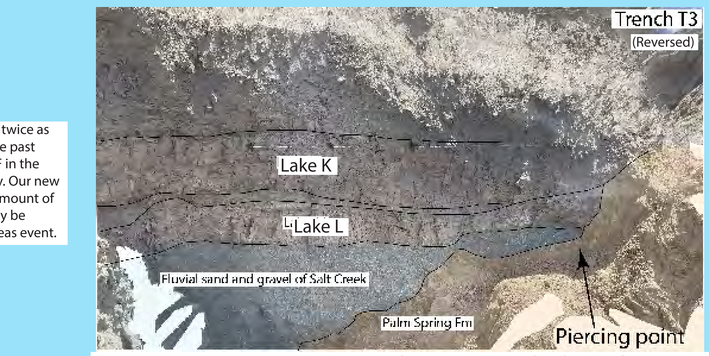




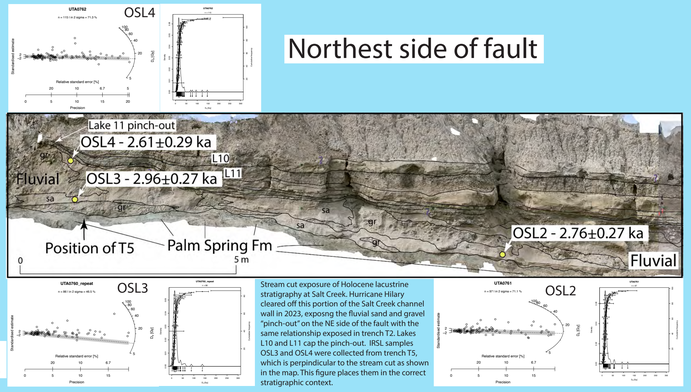


SW side of the fault





The piercing point, exposed in multiple trenchette faces, on the NE side of the fault. The fluvial sand and gravel cut into Plio-Quaternary Palm Spring Formation and is capped by lacustrine strata of Lake L.



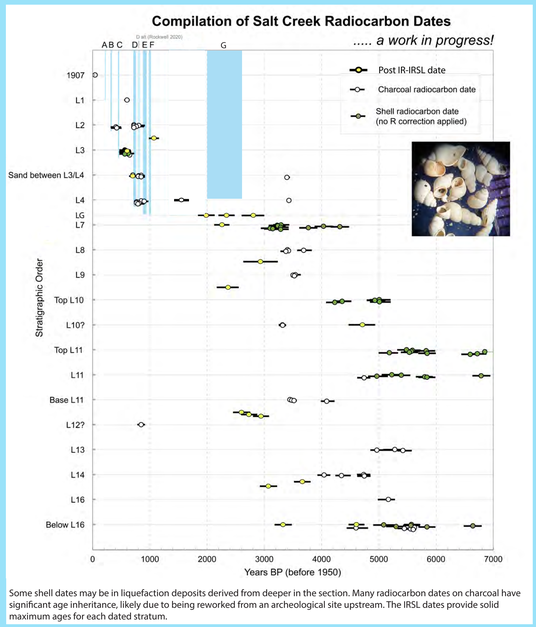
Northest side of fault

Stream cut exposure of Holocene lacustrine stratigraphy at Salt Creek. Hurricane Hilary cleared off this portion of the Salt Creek channel wall in 2023, exposng the fluvial sand and gravel "pinch-out" on the NE side of the fault with the same relationship exposed in trench T2. Lakes L10 and L11 cap the pinch-out. IRSL samples OSL3 and OSL4 were collected from trench T5, which is perpindicular to the stream cut as shown in the map. This figure places them in the correct stratigraphic context.

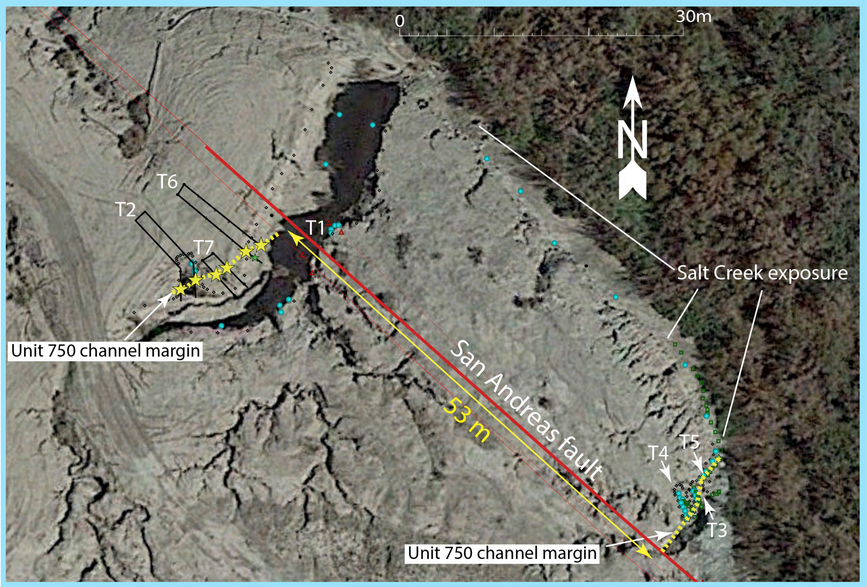
Table 1. New single-grain Post IR-IRSL dates for Salt Creek stratigraphic units

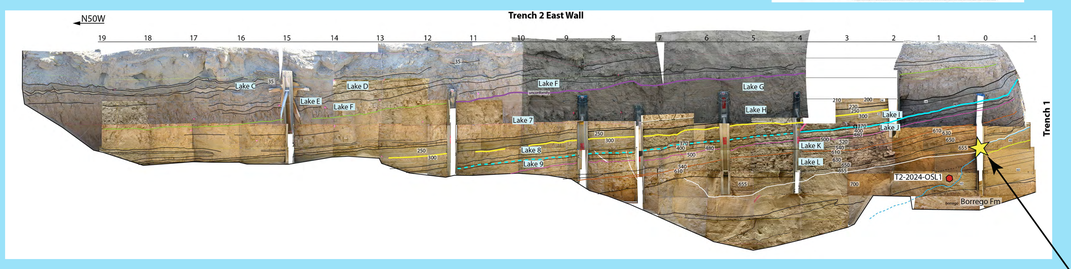
Field code	Lab code	U (ppm)	Th (ppm)	K (wt.%)	Rb (ppm)	Water content (%)	Depth (m)	Geologic dose rate (Gy/ka)	Overdispersion (%)	Grains accepted	Grains measured	Equivalent dose (Gy)	SG pIRIR225 age (ka)*	C14 age	Strat. Context	CE/BCE age
SC-23 L7A	UTA0771	2.23	11.1	2.2	75.7	1.37	2.20	4.466 ± 0.148	50	27	300	5.03 ± 0.85	1.13 ± 0.19	0.4	L2/3 colluvium	895
SC-23 L9A	UTA0773	2.24	9.9	2.3	80.8	0.48	0.65	4.550 ± 0.150	64	49	300	2.73 ± 0.46	0.60 ± 0.10	0.5	L3	1425
SC-23 L8A	UTA0772	2.12	10.4	2.2	78.4	0.79	1.90	4.411 ± 0.147	60	62	300	3.14 ± 0.48	0.71 ± 0.11	0.7	L3/4	1315
SC25 upper	UTA0777	1.67	7.5	2.3	79.0	0.82	0.45	4.197 ± 0.144	32	60	300	9.80 ± 1.09	2.34 ± 0.27	2-2.2	Lake G	-315
SC-23 L4A	UTA0768	1.85	9.0	2.3	74.8	1.04	1.17	4.326 ± 0.146	44	74	300	8.52 ± 1.16	1.97 ± 0.28	2-2.2	Lake G	55
SC25 lower	UTA0776	1.45	7.3	2.2	74.2	0.69	0.98	3.997 ± 0.140	32	40	300	11.22 ± 1.52	2.81 ± 0.39	2-2.2	Lake G	-785
SC-23 L3A	UTA0767	2.41	11.0	2.2	87.8	0.80	2.18	4.535 ± 0.149	40	83	300	10.14 ± 1.13	2.24 ± 0.26	~2.2	L7a/7b	-215
SC-23 L11	UTA0775	2.10	8.5	2.8	95.4	0.65	1.81	4.857 ± 0.161	48	18	300	14.26 ± 2.86	2.94 ± 0.60	2-3 ka	L8/9	-915
SC-23 L2A	UTA0766	2.14	7.4	2.6	89.5	1.32	2.52	4.535 ± 0.153	100	86	300	10.78 ± 1.74	2.38 ± 0.39	2-3 ka	L9/10	-355
SC-23 L1A	UTA0765	2.13	7.6	2.5	91.2	1.33	2.82	4.445 ± 0.150	100	75	300	21.04 ± 1.89	4.74 ± 0.46	2-3 ka	liquefaction ejecta?	-2715
SC-23 L10	UTA0774**	2.42	7.8	2.5	119.0	2.40	3.63	4.483 ± 0.150				±	±	2.5-3	L11/12	
OSL5	UTA0763	2.54	9.0	2.5	95.7	0.64	3.00	4.700 ± 0.155	41	125	600	14.94 ± 0.65	3.18 ± 0.17	2.5-3	unk. Location	-1155
OSL4	UTA0762	2.47	9.0	2.5	93.6	0.80	2.00	4.691 ± 0.154	27	84	300	12.25 ± 1.31	2.61 ± 0.29	2.5-3	L11/12 (PP)	-585
OSL2	UTA0760	2.35	8.9	2.4	93.1	0.78	3.10	4.532 ± 0.151	40	125	600	12.49 ± 1.15	2.76 ± 0.27	2.5-3.2	below PP	-735
OSL3	UTA0761	2.17	8.0	2.4	90.2	0.90	2.00	4.423 ± 0.149	34	146	600	13.09 ± 1.10	2.96 ± 0.27	2.5-3.2	below PP	-935
OSL1	UTA0759	1.98	10.6	1.9	105.0	0.92	2.65	4.076 ± 0.139	29	192	600	14.87 ± 1.07	3.65 ± 0.29	2.5-3	L15/16 colluvium	-1625
SC-23 L5A	UTA0769	2.66	10.0	2.1	85.0	0.96	1.15	4.438 ± 0.147	28	80	300	13.50 ± 1.23	3.04 ± 0.30	3-5 ka	L15/16	-1015
SC-23 L6A	UTA0770	2.38	9.5	2.3	79.3	0.54	1.89	4.521 ± 0.150	30	47	300	15.09 ± 1.18	3.34 ± 0.28	3-5 ka	below L16	-1315
OSL6	UTA0764	2.46	10.4	2.3	83.6	0.77	2.03	4.603 ± 0.151	77	98	300	21.23 ± 0.96	4.61 ± 0.26	3-5 ka	below L16	-2585

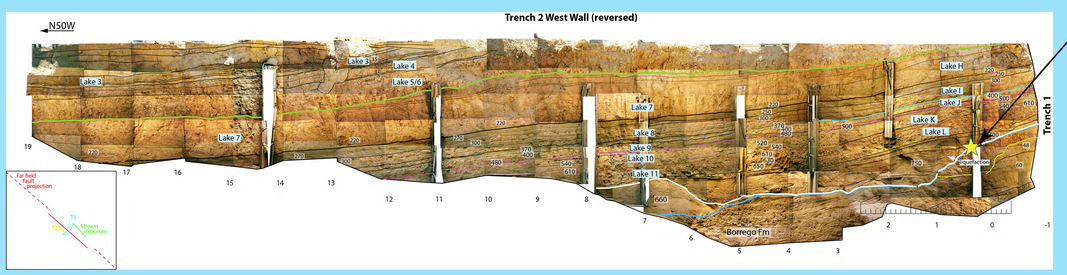
9 additional Post IR-IRSL dates are pending



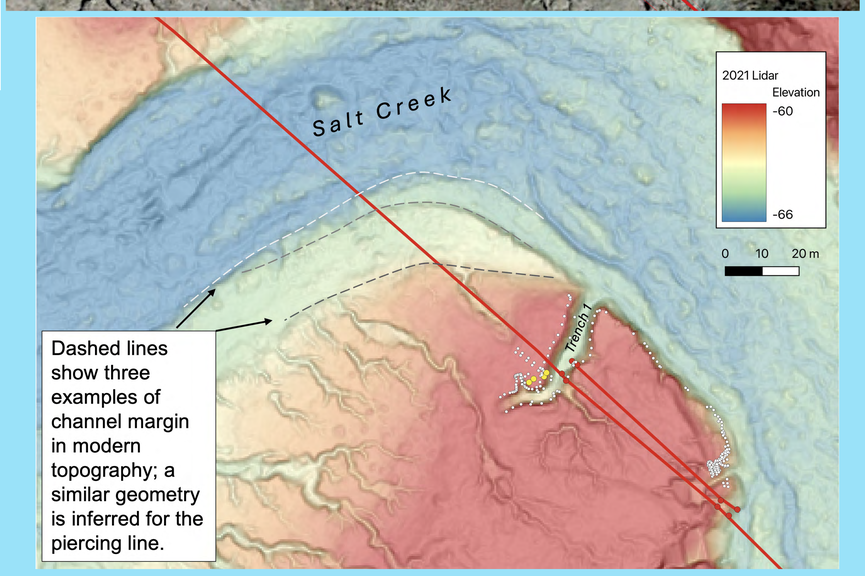
Some shell dates may be in liquefaction deposits derived from deeper in the section. Many radiocarbon dates on charcoal have significant age inheritance, likely due to being reworked from an archeological site upstream. The IRSL dates provide solid maximum ages for each dated stratum.





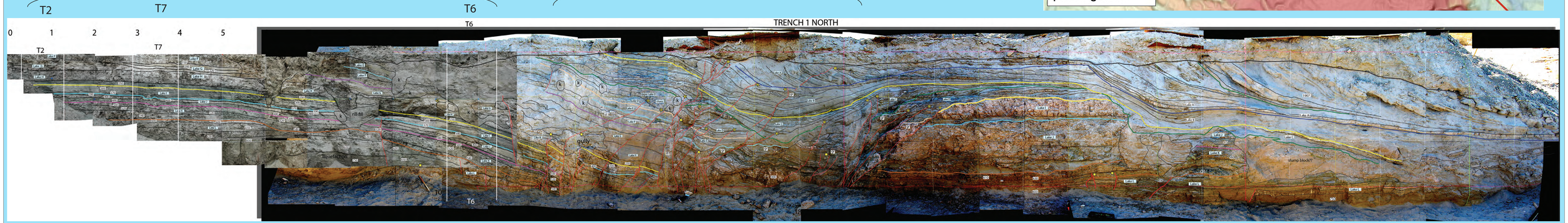


Piercing Point



Fault-parallel trenches on the SW side of the main fault zone

Main Fault Zone



North face of the main trench, T1, which is a cleared off arroyo face. Note that the "trench" is curvilinear (see map)