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Geological slip rate estimate for the Calico Fault at Newberry Springs, California: new age constraints from optically stimulated luminescence dating

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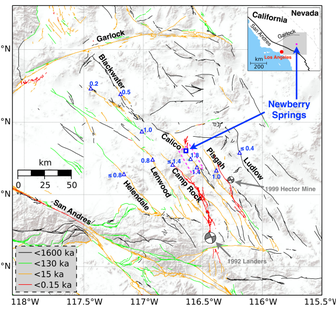
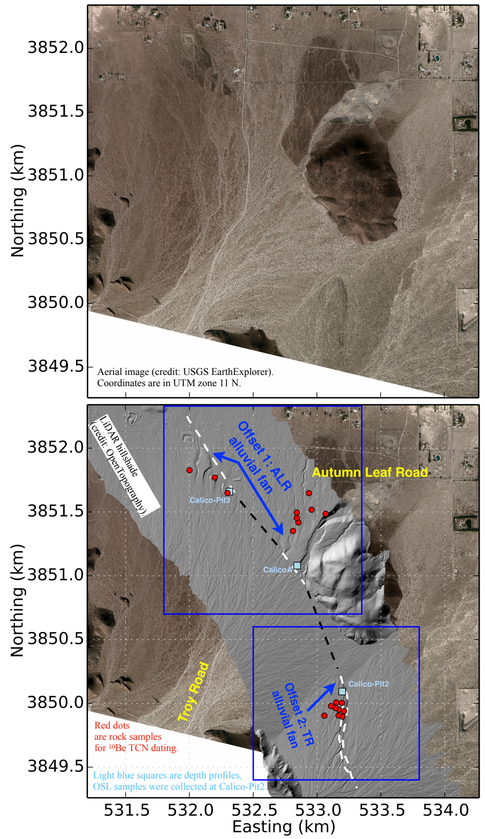
Abstract:

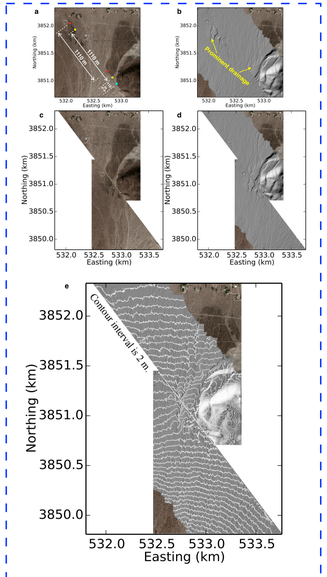
- Two alluvial fans offset by the Calico Fault at Newberry Springs California were dated by ^{10}Be terrestrial cosmogenic nuclide (TCN) methods to estimate slip-rates.
- For the younger fan, TCN results were inconclusive, but soil development and correlation with regional chronostratigraphy suggests a Holocene to latest Pleistocene age for the fan surface.
- Optically stimulated luminescence (OSL) yields ages from 5.8±0.4 (75 cm depth) to 5.0±0.4 ka (33 cm depth), consistent with a slip rate that is higher than previous estimates for the Calico Fault in the Eastern California Shear Zone.

Fault map from USGS and California Geological Survey.
Blue numbers are fault slip rates.

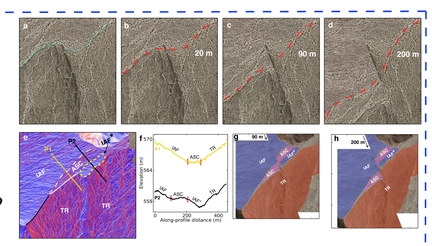


Alluvial fan morphology interpretation and displacements



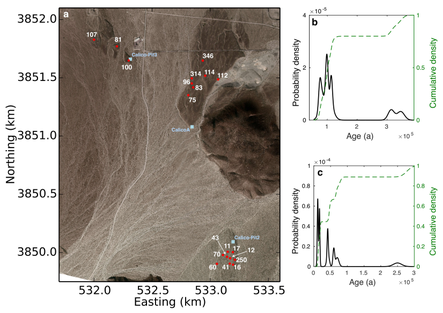


ALR alluvial fan displacement estimate: 1110±110 m.

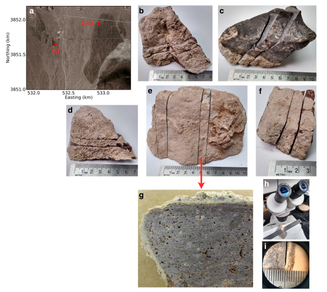


TR alluvial fan displacement estimate: <200 m.
But how much (200/90/20/…) ?
Further studies are needed.

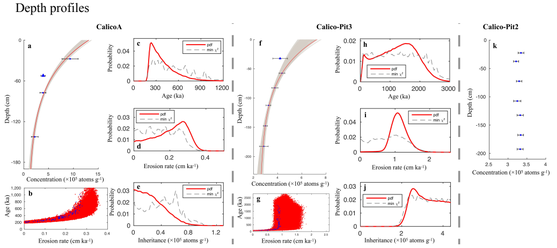
Rock sample ages from ^{10}Be TCN dating



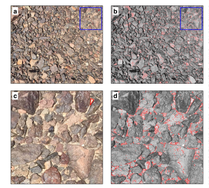
Carbonate rind thickness measurements for the ALR alluvial fan



Depth profiles



Estimate of pebble coverage percentage for the ALR alluvial fan (this case 97%)



^{10}Be TCN dating, cross correlation with soil chronostratigraphy and slip rate

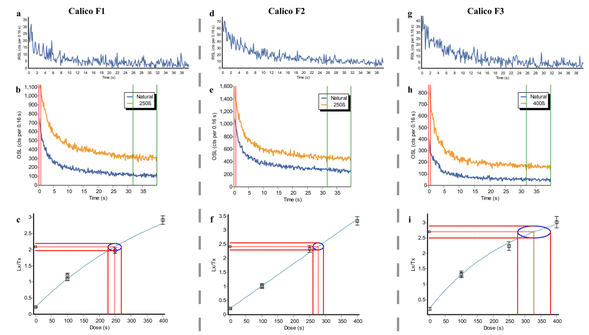
1) ALR alluvial fan: boulders exposure ages yield an oldest age of 346±24 ka. Depth profiles show obvious exponential decrease with depth, but present a broad range of ages. The cross-correlation with the surface pavement (pebble coverage percentage and varnish), carbonate rind thickness and soil chronostartigraphy, support an age of 346±24 ka as the preferred age, resulting in a 3.2±0.4 mm/yr for Calico Fault slip rate.

2) TR alluvial fan: boulders present a wide range of exposure ages (11-250 ka), and inheritance saturation is shown in the depth profile. Based on the four boulders with youngest apparent ages we estimate the weighted mean and two standard deviations, and obtained 14.0±5.8 ka for the age surface. In addition, soil here is poorly development, with absence of carbonate layer, suggesting a Holocene to late Pleistocene age. Surface pavement is poorly developed as well.

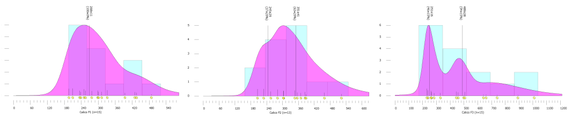
To improve TR alluvial fan age constrain, we collected several OSL samples from TR alluvial fan deposit exposed at Calico-Pit2, to provide the age of deposition, that should be older than the age surface.

Samples collected from Calico-Pit2 for OSL dating.

OSL dating



ISRL test for feldspar (top); typical OSL shine down curves (middle); regenerative curves (bottom) and for each dated sample.



Equivalent doses for each sample, plotted as histograms (number of aliquots) and probability against equivalent dose (Gy). Samples Calico F1 and F2 present a lower dispersion.

1) Quartz grains were extracted from the sediment and IRSL tested, before measurements.
2) Samples Calico F1 and F2 present a lower dispersion than Calico F3, which are interpreted as better "bleached" sediments than the upper sample, Calico F3.
3) Ages range from 5.8±0.4 (75 cm depth) to 5.0±0.4 ka (33 cm depth). This suggests a surface age younger than 5 ka.
4) OSL age estimate may be underestimating the sediment age due to several circumstances such as low OSL sensitivity and poor quartz characteristics, high dose rates, as it has been recognized by previous studies (e.g. Owen et al., 2007; Lawson et al., 2012). Other luminescence techniques should be tested, in parallel.

Summary table of OSL dating results from extracted from sediment, sample locations, radioisotopes concentrations, moisture contents, total dose-rates, D_E estimates and optical ages. More detail in Xie et al. (2018).

Sample number	Location (°N/°W)	Altitude (m asl)	Depth (cm)	U (ppm)	Th (ppm)	K (%)	Rb (ppm)	Cosmic (Gy/ka)	Dose-rate (Gy/ka)	n_t	n	Dispersion D_E (%)	Average equivalent dose (Gy)	OSL Age (ka)
Calico F1	34.7925/116.6371	596	75	2.5	14.5	2.8	110	0.21±0.02	4.395±0.24	24	15	19	25.46±1.0	5.8±0.4
Calico F2	34.7925/116.6371	596	55	2.1	14.1	3.0	118	0.22±0.02	4.447±0.25	24	13	21	23.27±2.7	5.2±0.7
Calico F3	34.7925/116.6371	596	33	2.3	14.9	3.1	120	0.22±0.02	4.731±0.26	32	15	40	23.84±1.5	**5.0±0.4**

Conclusions:

1) OSL dating yields a Holocene age for the TR alluvial fan, and the fan upper sediments were deposited in a short period of time; this is consistent with the absence of an exponential decrease in Calico-Pit2 TCN depth profile.
2) For the younger alluvial fan, such as TR, TCN inheritance can change the apparent ages of ^{10}Be TCN significantly, and should be justified in estimating the true exposure age. Despite the fact that these quartz characteristics may contribute to underestimating the age, the difference between 5 ka and 14 ka (TCN exposure age estimate) could be partially due to inheritance.
3) The cross-correlation of TCN, OSL dating and soil chronology lead us to infer a TR age range from 5±0.4 to 14.0±5.8 ka, consistent with the soil chronology and proposed ages for regional alluvial fan generation by Miller et al. (2010).
4) Our data highlight the challenges in determining an exposure age using TCN ^{10}Be for the TR alluvial fan, and perhaps for other young fans in similar environment. OSL results are less sensitive to these factors (especially inheritance) and may provide a more robust age estimate.
5) Although the complexity of the TR alluvial fan prevents us to estimate a robust displacement, the young OSL age suggests a faster slip rate than previous studies.

References

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Hidy et al. (2010) A geologically constrained Monte Carlo approach to modeling exposure ages from profiles of cosmogenic nuclides: An example from Lees Ferry, Arizona. *Geochem. Geophy. Geosy.*
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