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Supplemental Data File

Methods:

1. Infra-Red Stimulated Luminescence dating

IRSL samples were removed from 15cm steel or brass core tubes under low-intensity amber laboratory lighting, and sieved to isolate the 175-200µm grains. After initial HCl treatment, the fraction <2.58 g.cm^{-3} was isolated for each sample using lithium metatungstate (LMT) solution, and treated with 10% hydrofluoric acid (HF) for 10 minutes to remove the outer alpha-irradiated layer. Following rinsing, drying and second sieving, grains >175µm were mounted in Risø single grain holders.

Measurements were performed in a Risø TL-DA-20CD automated reader equipped with an XY single grain attachment. Stimulation used a 150 mW 830 nm IR laser directed through a RG780 filter. After an initial preheat at 250°C for 60 seconds, each grain was stimulated with IR light for 2.5s at 50°C to remove charge most susceptible to fading by localized tunneling (Jain and Ankjærgaard, 2011). Following the first IR stimulation, each grain was again stimulated at 225°C for 2.5s to release the electrons from more stable traps (Buylaert et al., 2009; 2012; Thiel et al., 2011). Luminescence emissions were observed using an EMI 9235QB photomultiplier (PMT) fitted with a BG3 and BG39 filter combination allowing transmission between 340 and 470nm. The dating protocol used a single aliquot regenerative-dose (SAR) approach, incorporating full sensitivity correction measurements using a test dose, a final hot bleach within each SAR cycle using Vishay TSFF 5210 870nm IR diodes for 40s at 290°C, with multiple regenerative dose steps, a zero dose to assess thermal transfer, and a repeat of the first artificial dose point.

Samples displayed consistent behavior, with many grains providing intense IRSL decays at both 50 and 225°C, displaying exponential-plus-linear signal growth with dose. Between 200 and 600 grains were measured for each sample. A significant subset of single grain equivalent dose (D_e) values for each sample was consistent with each other around the minimum D_e, and this value, determined assuming an overdispersion value 15%, was used in age estimation. The alluvial deposits comprising sediments at this site were deposited in a relatively small catchment, reducing the opportunities for zeroing of the IRSL signal used in dating. Single grain analysis can overcome this limitation by selecting only well-bleached grains (Rhodes, 2011) from a widely dispersed population of apparent ages, as was observed for these samples. Grain selection is performed by including only those with the lowest apparent age values and rejecting higher values, within expected statistical limits. Some statistical variation in measured age between individual grains is expected, owing to measurement precision limitations imposed by counting statistics, and additional dispersion (over-dispersion) is caused by a range of factors such as variations in dose rates to individual grains. An over-dispersion value of 15% was used here, based on experience from quartz OSL (Rhodes et al., 2010), and because this value has been demonstrated to provide consistent single grain post-IR IRSL age estimates for K-feldspar at other sites in California and elsewhere (Rhodes, in press).

Fading assessment was made of each grain using delay times of several days, though very little laboratory fading was observed, and fading was assumed to be absent for the post-IR IRSL signal from these samples. IRSL results are consistent with a radiocarbon age from a charcoal sample collected at 13.51 m depth in borehole DY-4 (Figure 7). Specifically, this charcoal sample (DY-C7) yielded a calibrated age of 6964-7223 yb2015. This sample, which comes from the basal part of Unit G, is ~1,000 years younger than the unmodeled 7930 ± 530 IRSL age (Dy-OSL-1/5) from the top of underlying Unit H, and is ~2,000 years older than overlying IRSL samples from near the top of Unit G (unmodeled age of 4790 ± 350 [Dy-OSL-4/3] and 5020 ± 310 [Dy-OSL-1/4] yb2015).

2. Seismic reflection data

The two N-S seismic reflection profiles were acquired across the Ventura fault scarp beneath Brookshire Road in eastern Ventura (1.06 km long profile) and Day Road in the city (2.24 km long profile; Figure 1 and Supplementary figure S1). The best image of the folding above the fault tip is provided by the Brookshire Road seismic reflection profile. The Brookshire profile began at the intersection of South Brookshire Road and Woodland Street, 263 m south of Telegraph Road. The profile continued north across Telegraph Road, turned right for 14 m, then continued north though a yard and onto North Brookshire Road. At the north end of Brookshire Road the profile crossed Kearny Street and extended onto private property for 35 m. The entire profile was collected along the east side of the roads. This profile likely provided the best imaging because it was acquired on a straight road with almost no traffic, on an older fan that contains more consolidated strata than in the younger fans beneath the other profiles.

The 2.24-km-long Day Road profile extended 0.6 km into the VAA and extended about 1.75 km south of the slope break at the base of the hills formed by the VAA (Supplementary figure S1). The profile begins 0.6 km into the VAA along the paved road through Arroyo Verde Park. The profile extends south along heavily-used Day Road, across the incised valley on the north side of Aurora Drive, and then follows Bucknell Avenue south to its intersection with

Lafayette Street. The profile was acquired along Day Road despite the heavy traffic noise because an alternative route that allowed for the combination of both the seismic profile and boreholes in close proximity on a young alluvial fan was not available. The heavy traffic noise along Day Road degraded the image quality, but the profile nonetheless defines a synclinal axial surface separating south-dipping reflector segments on the north half of the profile from relatively flat reflector segments to the south.

Both of the profiles were collected using a trailer-mounted mini-vibrator as a source. Source and geophone spacing were 4 m for all profiles, with each the vibrator sweeping a 20 to 160 Hz, 14-second sweep at each shot point. A 16-second listening time resulted in a 2-sec correlated shot record. Depending on the amount of ambient noise, between 1 and 4 vibrator sweeps were recorded at each source point and later summed during processing.

The data were recorded using a 144-channel cabled recording system, although there were generally only 120 channels being recorded at one time, with the other 24 channels being moved to prepare for the next line segment in the roll-along. After every 24 sourcepoints, the recording channels were incremented by 24 channels, resulting in 24-station increments in the receiver spread location. Data were recorded in SEG2 format with a 1-msec sample rate. The effectiveness of the imaging varied by the depth of the water table, the amount of traffic noise, the consolidation of strata being imaged and the straightness of the road.

Data were processed using the Seismic Unix system from the Colorado School of Mines. The processing followed a standard seisimic reflection processing sequence consisting of:

-Automatic Gain Control (AGC) (1-sec window)
-Geometry definition
-Common Midpoint (CMP) sort
-elevation static corrections to datum near average line elevation
-bandpass filter (20-32-140-160 trapezoidal filter)
-Prediction Error filter (Deconvolution); gap = 0.012 sec, filter length=0.2 sec

-trace gain to increase amplitudes with time (A=A*t)
-Automatic Gain Control (AGC) (0.2 sec window)
-trace equalization (equalizes RMS amplitudes of the traces)
-bottom mute to remove surface waves (distance=-600,-8,8,600 times=1.80,0,0,1.80)
-Multiple iterations of:
    -velocity analyses
    -normal moveout correction with stretch mute (130%)
    -residual statics analyses
-bandpass filter (16-24-90-120 Hz trapezoidal filter)
-CMP stack
-migration using f-k (frequency wavenumber) algorithm

Both seismic profiles revealed a section of south-dipping beds separated from sub-horizontal strata by a synclinal axial surface. The Brookshire Avenue profile provided us with the clearest seismic image to a depth of ~500 m. A well-defined, north-dipping active synclinal axial surface can be traced from the tipline of the fault at a depth of approximately 230 meters below sea level to the surface (Figure 5). The south-dipping strata between the synclinal and anticlinal axial surfaces extends to the surface at a prominent, south-facing fold scarp lying approximately 500 meters south of the topographic range front. This scarp defines the surface expression of deformation associated with the most recent folding events on the underlying thrust ramp.

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