Additional isochron burial dating of late Pleistocene alluvial surfaces to constrain long-term San Andreas fault slip rates

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Technical Report

Objectives:

This project focuses on better constraining the age of the Mid-Late Pleistocene Fw2 surface at Whitewater Wash, deformed between the Banning and Garnet Hill strands of the San Andreas Fault (SAF) in the San Gorgonio Pass (SGP), southern California. This will be accomplished using the robust ^{10}Be/^{26}Al isochron burial dating technique (Balco and Rovey, 2008; Granger, 2014) and the unique capabilities of the Purdue Rare Isotope Measurement Laboratory (PRIME Lab). It builds on previous SCEC-funded research at the site by PI Lifton and R. Heermance of CSU Northridge (SCEC award #15135) that applied the same techniques to the buried Fw1 paleosol at the site and derived the first directly determined numerical age for that Fw1 surface in the region – 420 ± 90 ka (Lifton et al., 2016). The success of the isochron burial dating method in constraining the Fw1 surface burial age suggests one can also further constrain the effects of deflation on age estimates for the overlying Fw2 surface. The widespread occurrence of that upper surface and correlative fanglomerates in the SGP and northern Coachella Valley region, and their offset along SAF strands make them a key target for geochronological study to constrain long-term SAF slip rates. Although incised locally, the top of the Fw2 fanglomerate is typically planar, suggesting it is an intact remnant of a more regional geomorphic surface, or perhaps represents separate fans of the same vintage.

Surface dating can be complicated by post-depositional degradation and/or inflation, particularly in this very windy environment where eolian input and abrasion is likely. There is nearby evidence of surface deflation of ~0.75 m on an ~50 ka fan surface near Indio, CA (~40 km southeast of the Whitewater River), that led to exposure age interpretations that were >20% too low (Behr et al., 2010; Van der Woerd et al., 2006). Moreover, there is evidence of wind abrasion of boulders in the form of ventifacts on Holocene surfaces in Millard Canyon to the west, suggesting that both boulders and the surfaces may be lowering simultaneously. The fact that the area is home to one of California's largest wind-farms is no coincidence, and wind deflation provides a probable mechanism for surface lowering.

It is not clear whether in situ ^{10}Be concentrations measured in boulders from the Whitewater and Mission Creek Fans by Owen et al. (2014) have been affected significantly by eolian erosion of the boulder surfaces. It perhaps more likely that eolian deflation of the fanglomerate surface and corresponding exhumation of surficial cobbles and boulders could lead to decreased ^{10}Be concentrations. Boulder exhumation would tend to increase scatter in a set of exposure ages, as surface deflation gradually exposes clasts from deeper in the deposit over time. Indeed, the Fw2 surface of Owen et al. (2014) shows such scatter, with ages of individual boulders differing by up to ca. 50 ky. This effect was also invoked by Behr et al. (2010) for a correlative surface at the Biskra Palms site near Indio.

While the Fw1 burial age is robust, any corresponding estimate of Fw2 surface age based on that must rely on uncertain assumptions of fanglomerate sedimentation rates over >70 m of deposition beneath the upper surface. By determining isochron burial ages at shallower depths below the upper surface, one can more closely constrain the age of the Fw2 surface and assess potential effects of deflation/exhumation when compared to surface results such as those of Owen et al. (2014). At depths greater than ca. 5-6 m or so (dependent on overlying bulk density), surficial production from high-energy neutrons is negligible due to an exponential decrease with depth. Rather, any post-burial production arises from deeply penetrating cosmic-ray particles known as muons that only weakly interact with matter. These weak muon interactions also decrease approximately exponentially with depth, but over a characteristic length scale that is typically more than an order of magnitude longer than that of the high-energy neutrons. As such, at those depths post-burial production by muons is insensitive to deflation or inflation of the surface for all but the most rapid deflationary rates (counter-indicated by the presence of a thick, well-developed surficial soil). Furthermore, the advantage of the isochron burial dating method is that the resulting age only requires that each of the samples analyzed has undergone the same post-burial history (section 4.0 below) – any post-burial production changes are accounted for in the calculation systematics. This study comprises analysis of up to 10 samples collected in September 2016 for $^{26}Al/^{10}Be$ isochron burial dating from the terrace riser approximately 8-10 m beneath the Fw2 surface along the Whitewater River to assess surface deflationary effects.

Methods:

Field work was completed in September 2016. PI Lifton was assisted by Doug Yule and his MS student Brittany Huerta (both from CSU Northridge) during collection. Eleven quartz-bearing cobbles were collected from a horizon approximately 8-10 m below the Fw2 surface. Purdue MS student Sarah Sams is currently processing the samples at PRIME Lab. Processing was delayed because funding delays associated with the transition from SCEC4 to SCEC5 affected student recruitment and subsequent availability. Samples were individually photographed, crushed, and sieved to separate the 250-500 μm size fraction at PRIME Lab at Purdue University for quartz purification and chemical processing. Quartz was isolated following standard procedures modified from Kohl and Nishiizumi (1992). Be and Al are being isolated from selected samples using standard procedures (Ochs and Ivy-Ochs, 1997) and will be analyzed by AMS for ^{10}Be and ^{26}Al, respectively. $^{10}Be/^{9}Be$ ratios will be normalized to the material 07KNSTD (2.85×10^{-12}, using a ^{10}Be half-life of 1.39×10^{6} yr) (Nishiizumi et al., 2007; Chmeleff et al., 2010; Korschinek et al., 2010). $^{26}Al/^{27}Al$ ratios will be measured relative to standard KNSTD prepared by Nishiizumi (2004) (4.694×10^{-12}, using a ^{26}Al half-life of 7.05×10^{5} yr). The total number of atoms in process blanks will be subtracted from measured sample concentrations.

Results:

Results of these analyses are pending, and expected in time for the SCEC 2018 meeting. The suite of AMS results from each paleosol will be analyzed in terms of burial age using the isochron techniques of Granger (2014). This method relies on a spread in concentrations of ^{10}Be and ^{26}Al at the start of the burial time period. Should the results from the horizon have concentrations too low or clustered too closely to yield a reliable isochron, we will attempt to apply the approach used in another SCEC-funded project (#16066 to Burgette, Lifton, and Scharer). In that study, cobbles from a horizon buried ca. 8 m below the surficial soil of an alluvial deposit (potentially correlative to Fw2) at two sites on Gould Mesa, north of the Jet Propulsion Laboratory in Pasadena, CA, yielded uniformly low concentrations of ^{10}Be and ^{26}Al, preventing a robust isochron. We thus interpreted those samples in terms of a minimum exposure age based on the dominant muon production at that depth, and derived a value from the two sites of ca. 170 ± 32 ka.

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