**Text S2. Terrestrial Cosmogenic Nuclide Geochronology Methods**
The concentration of a cosmogenic nuclide in a sample exposed at or beneath an unstable geomorphic surface is given by:

$$N_m(Z,t,\epsilon) = S_{el} S_T S_s \sum_q \frac{J_q}{\epsilon/(\Lambda)_q + \lambda_m} \left[ \exp\left(-\frac{Z_0 - \epsilon t}{(\Lambda)_q}\right) - \exp\left(-\lambda_m t - \frac{Z_0}{(\Lambda)_q}\right) + N_{inh} \right]$$

where N(Z,t,$\epsilon$) is the concentration of a cosmogenic nuclide at depth Z, time t, and erosion rate $\epsilon$. $S_{el}$, $S_T$, and $S_s$ are the scaling factors for elevation/latitude, topographic obstruction of the cosmic ray flux, and surface coverage (e.g., snow, sand), respectively. $\lambda_m$ is the decay constant of the nuclide of interest, e is the erosion rate of the exposed surface, $J_q$ and $(\Lambda)_q$ are the production terms and attenuation lengths for the four principal production reactions: fast neutron (spallation) reactions, epithermal neutron absorption, thermal neutron absorption, and muon-induced reactions. The production terms and corresponding attenuation lengths are specified by equations 3.83 to 3.90 in Gosse and Phillips [2001]. $N_{inh}$ is the inherited cosmogenic nuclide inventory, in other words, the cosmogenic nuclide concentration incorporated in the material at the time of deposition. In alluvial sediments, such as those investigated in this study, this inherited component usually arises from exposure to cosmic rays during weathering at the primary outcrop and transport to the site of deposition.

**AM 2.1 Cosmogenic Nuclide Depth Profiles**
The distinction between the in situ and inherited components in a depth profile can be accomplished because the inherited signature should be relatively uniform through a depth profile in any single depositional unit that has experienced steady tectonic and climatic forcing over the duration of deposition. On the other hand, the in situ component should vary with a characteristic quasi–exponential decrease in concentration with depth. The rate at which nuclide production decreases is a function of the density of the material through which the cosmic rays are passing. In general, production rates decrease by 1/e for every approximately 160 g/cm$^2$ increase in depth. This absorption length is equivalent to about 80 cm in arid-zone fans. Therefore, by approximately 2 m depth, production of cosmogenic nuclides is negligible [Hancock et al., 1999; Gosse and Phillips, 2001]. By using the deep samples to estimate the inherited component, the exposure age and erosion rate can be determined by fitting the measured depth profile to the production equation. In this study, we use the cosmogenic nuclides $^{10}$Be from surface samples and $^{36}$Cl from depth profiles to determine the age of the Q2c surface at Red Wall and Big Dip Canyons.

Amalgamating clasts with variable individual cosmic-ray–exposure histories allows the average exposure age of the deposit to be determined assuming the inherited component is the same at each depth interval. Previous studies have shown that  150 clasts are necessary in order to average out irregularities in clast exposure histories and ensure repeatability of age determinations [Phillips et al., 2003].

**AM 2.2 Chlorine-36**

The depth profile modeling treats the upper boundary (the soil surface) as a dynamic surface. This is because the air-soil interface is subject to erosion and/or aggradation especially during changes in climate [Bull, 1991]. The Red Wall and Big Dip Canyon fans are formed by a combination of debris flows and sheet-wash events where after deposition, pedogenesis becomes the dominant process, with clasts remaining at the surface resting on a cumulic soil [Denny, 1965; Wells et al., 1985; Wells et al., 1995; McFadden et al., 1998; Birkeland, 1999; Blair, 2000]. The presence of the A horizon indicates that the Q2c surfaces are not eroding [Dohrenwend et al., 1986].

Net surface aggradation or erosion can be estimated on the basis of soil property measurements and geological observations. Secondary accumulation products add to the original soil mass, thereby reducing the relative concentration of original sand and gravel. The Q2c surface in Death Valley is often characterized by aeolian silt and clay that has infiltrated to at least a meter depth [Machette et al., in review]. Addition of silt and clay leads to a net aggradation and results in volumetric expansion of the soil profile. However, in places, minor erosion of the Av horizon has occurred and the surface is distinguished by low amplitude undulations. In such cases, both aggradation and surface erosion may have occurred. Although erosion is an active process on the Q2c surface, among others, we selected depth profile sampling sites away from active arroyos and beneath flat, undisturbed surfaces.

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