**SUPPLEMENTARY MATERIAL**

*Details of sample preparation*

Benzene for liquid scintillation counting (LSC) was prepared from cellulose as follows: 1. Combustion to CO2 in a stream of O2 gas; 2. Removal of S- and Cl-bearing impurities in bubble traps containing AgNO3, acidified KMnO4 and chromic acid/H2SO4 solutions; 3. Cryogenic separation of water from CO2; 4. Reaction of CO2 with molten Li at 500°C, to give Li2C2, followed by cooling and hydrolysis yielding C2H2 gas. 5. Chemical purification of C2H2 gas using concentrated H3PO4 solution; 6. Trimerization of C2H2 to C6H6 on a catalyst containing Cr6+ on a substrate of silica and alumina.  All of these operations were carried out using vacuum lines and vessels reserved for this project. A split of the CO2was reserved for measurement of δ13C following step 3. Benzene was stripped from the catalyst beads at 70-90°C, then frozen into a cold trap at the temperature of dry ice. The vapor above the solid benzene was pumped for 30 minutes to ensure removal of any radon gas. The benzene was collected and weighed. Ideally, 7-8 g of benzene was obtained.

For LSC, 7.02 ± 0.02 g of benzene was mixed with 0.0958 ± 0.0002 g of butyl-PBD scintillant in a counting vial. Counting of 6000 to 8000 minutes in 100 minute intervals provided the desired precision for full-size samples. Smaller samples were “diluted” to 7.3 g with high-purity benzene containing 0 percent modern carbon, and the mixing ratio was determined gravimetrically. The mixture was prepared for counting as for full-size samples, and the counting time was extended in order to obtain the required precision.

A single LKB Quantulus 1220® spectrophotometer with excellent long-term stability characteristics was used for all LSC measurements. The two photomultiplier tubes in the counter were balanced by determining the dependence of the spectral quench parameter of the external standard (SQP(E)) factor (the counter channel below which 95% of the energy spectrum of detected pulses is encountered) on applied high voltage, and selecting a pair of voltages that gave the same value of SQP(E) in each tube. Counter stability was verified by 1. Checking the photomulitplier tube high voltages every few weeks; 2. Measurement, every 15-20 unknowns, of the IAEA standard Oxalic acid I which was prepared according to the numbered steps above, but using different vacuum lines and vessels; and 3. Measurement of background, every 15-20 unknowns, using the same high-purity benzene that was used for sample dilution. Calibration was carried out using international standard Oxalic Acid I.

Counting vials of two different types were employed. For AD 1064 to 1200, borosilicate scintillation vials, selected for uniform optical quality, were used. The vials were equipped with metal screw-caps with teflon liners and an indium-foil seal against the glass. They were cleaned with chromic acid, followed by DI water and benzene rinses. For the remaining samples, silica glass vials equipped with metal plugs and a compression seals using Chemraz® O-rings. Cleaning steps included rinses with ethanol and water, ultrasonication with chromic acid, and subsequent rinses with DI water, ethanol and benzene. The plugs and O-rings were rinsed with benzene between runs. Table S1 shows counting characteristics, which differed between the borosilicate and silica vials. Despite the lower efficiency of the silica vials, their background was so low that their use led to a superior figure of merit. High background measurements were obtained occasionally from the borosilicate vials, but never from the silica vials. This suggested a difficulty with the cleaning technique applied to the borosilicate vials.

Quench corrections (McCormac 1992) were applied to data measured in borosilicate vials. The quench correction adjusts for changes in the energy of detected pulses as a result of small variations in the chemical composition of the benzene from sample to sample; effectively, such changes can shift the energy spectrum of counts relative to the fixed counting window. The quench correction for a sample is determined by way of the factor SQP(E) by irradiating the vial from an external radium source. The technique cannot be applied to silica glass because it causes slow-decaying luminescence in the glass. The absence of a quench correction might be expected to introduce a random error into the post-1200 data set. In fact, most of those data (post 1230) show less scatter than can be seen as outliers in the data set for AD 1100-1200.

*References*

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**SUPPLEMENTARY FIGURE CAPTIONS**

Supplementary Fig. S1: A-F: Sequential panels showing details of the Tucson Δ14C time series.

Supplementary Fig. S2: A. Comparison of the Tucson δ13C time series with temperature residuals determined from tree-ring width at tree-line sites of the southern Sierra Nevada, within 100 km of the Big Stump Grove (Graumlich 1993; Scuderi 1993). Also shown are periods of general wetter and drier climate (Graumlich 1993). The corresponding changes in δ13C in the Tucson time series are the opposite of those predicted in the literature (Dieffendorf et al. 2010). B. Temperature residuals (ΔT) from Graumlich (1993) plotted against δ13C from the Tucson dataset, showing no significant correlation.



Fig. S1



Fig. S2