Supplementary Information

Inferring the timing of abandonment of aggraded alluvial surfaces dated with cosmogenic nuclides

Mitch K. D'Arcy[1,2], Taylor F. Schildgen[2,1], Jens M. Turowski[2], Pedro DiNezio[3]

[1]Institute of Geosciences, University of Potsdam, Karl-Liebknecht-Strasse 24/25, 14476 Potsdam, Germany
[2]GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany
[3]Institute for Geophysics, Jackson School of Geosciences, University of Texas at Austin, J.J. Pickle Research Campus, Building 196 10100 Burnet Road (R2200), Austin, TX 78758, USA

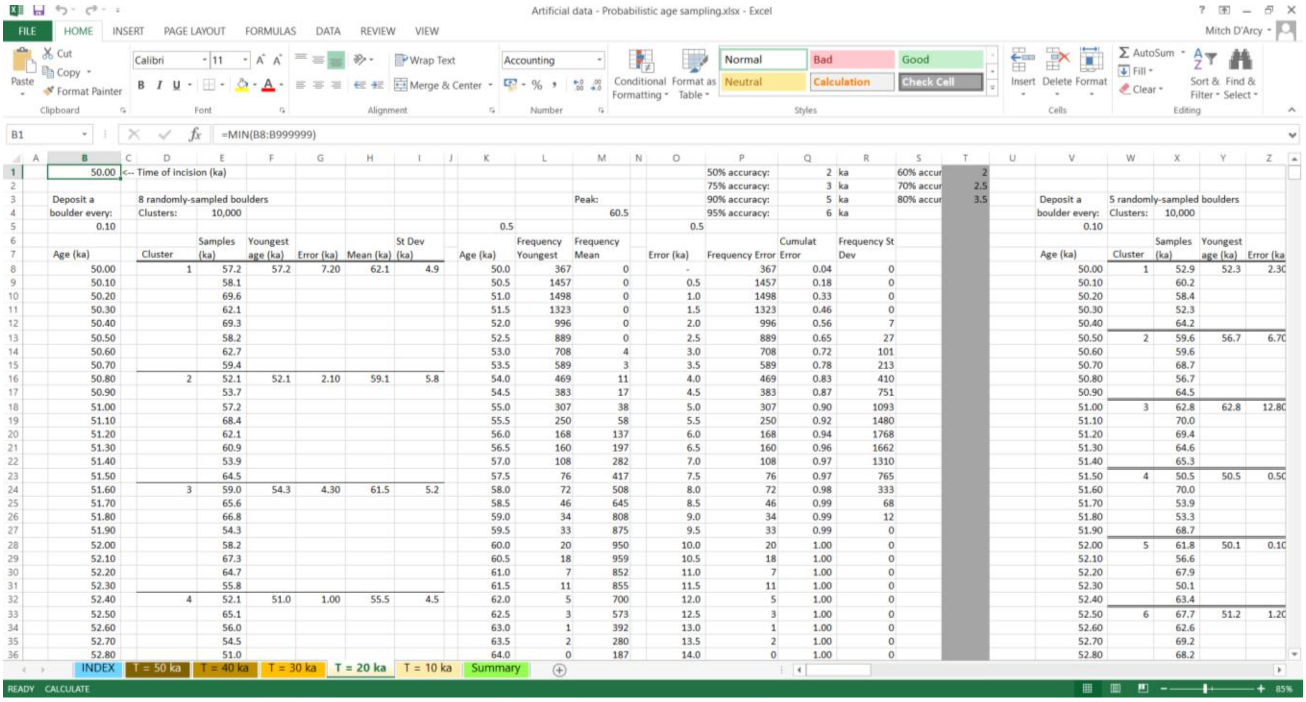
Correspondence to: Mitch K. D'Arcy (mdarcy@uni-potsdam.de)

1. Read-Me for the Excel spreadsheet, "Artificial Data – Probabilistic Age Sampling"

This spreadsheet contains the artificial data used to generate figures 3-6 in the main article. The spreadsheet includes 5 data tabs, each for a value of the duration of deposition, *T*, equal to 10, 20, 30, 40, and 50 kyr.

Note: This file contains millions of calculating cells, so it is recommended to set the spreadsheet to calculate manually. This can be chosen from the 'Calculation Options' drop-down in the Formulas tab.

In each sheet, column B contains a discrete list of 'selectable' surface ages. Columns D-I contain 10,000 clusters of 8 randomly-selected surface ages, i.e., $n = 8$. For each cluster of ages, the youngest age, mean age, and standard deviation of ages is calculated (columns F, H, I), and the error between the youngest age and the true end of surface activity (column G). In Columns K-R, frequency distributions are constructed for the youngest sampled age, the mean sampled age, and the error between a_{min} and the end of surface activity (i.e., τ as defined in our study). In cells P1-T4, example percentiles of τ are extracted. This sampling of column B is repeated again for different values of n in the remaining columns, up to column FN. A total of 10,000 surface age clusters are extracted for every unique value of n.



The ‘Summary’ tab contains 5 data tables that link into the T = 10-50 kyr tabs, and summarise the results of the artificial data.

Table 1: Duration of τ for variable n and T = 30 kyr. These data are used to generate Fig. 3 in the main article.

Table 2: Duration of τ for variable n and T. These data are used to generate Fig. 4 in the main article.

Table 3: Duration of τ_0 for variable T.

Table 4: Value of k for variable P.

Table 5: Value of τ_0 for variable P. The data in tables 3-5 are used to generate Fig. 5 in the main article.

2. Read-Me for the Matlab code, “ProbabilisticSamplingFans”

This Matlab tool allows the user to enter surface age constraints obtained from a particular surface, and output a probability distribution of abandonment ages that are generated using our artificial-data approach.

2.1. User-Defined Values

`iterate`

This parameter appears on line 44 and defines the number of artificial sampling campaigns to be iterated, i.e., how many random sets of n ages are collected from within the timespan T, from which cumulative distributions of τ are derived. The default number of iterations is 10,000 and we recommend this as a minimum. A larger number of iterations produces a smoother distribution of τ but takes longer to run and does not change the outcome.

`n`

This parameter appears on line 47 and defines the number of surface ages obtained. The default example is set to the Q4 surface from the Laguna Salada fans, for which `n` is equal to 5 ages.

`amin`

This parameter appears on line 48 and defines the youngest sample age from the dataset (in unit years). The default example is set to the Q4 surface from the Laguna Salada fans, for which `amin` is equal to 14,400 years.

`sigma`

This parameter appears on line 49 and defines the uncertainty on the youngest sample age from the dataset (in unit years). The default example is set to the Q4 surface from the Laguna Salada fans, for which `sigma` is equal to 1100 years.

`amax`

This parameter appears on line 50 and defines the oldest sample age from the dataset (in unit years). The default example is set to the Q4 surface from the Laguna Salada fans, for which `amax` is equal to 32,100 years.

`q_param, r_param, s_param`

These parameters appear on lines 54-56 and are used to derive the duration of deposition, *T*, from the difference between `amax` and `amin`, i.e., Eq. 6 in the main paper. These parameters are empirical coefficients with default values set to their averages as derived from the artificial-data analyses (see section 4.2 of the main article). For testing the effects of uncertainty on *T*, the $\pm 1\sigma$ values of these parameters can be entered instead (given in section 4.2 of the main article).

`test_range_lower`

This parameter appears on line 60 and allows the user to set the lower bound of a time range of interest, within which the overall probability of surface abandonment will be evaluated (in unit years). The default example is set to the end of the Younger Dryas, for which `test_range_lower` is 11,700 years.

`test_range_upper`

This parameter appears on line 61 and allows the user to set the upper bound of a time range of interest, within which the overall probability of surface abandonment will be evaluated (in unit years). The default example is set to the beginning of the Younger Dryas, for which `test_range_upper` is 12,900 years.

2.2. Calculation of duration of deposition, *T*

The code derives the value of *T* from `amax`, `amin`, `q_param`, `r_param`, and `s_param`, using Eq. 6 in the main article. This equation appears at line 67. For testing purposes, the option is available to deactivate this equation and instead specify a known duration of surface deposition, *T*, if desired (line 70).

The parameter `end_dep` allows the user to impose an end time of deposition, if desired (in unit years). This appears at line 71. If the end time of deposition is not known (as will be the case for most natural surfaces), this should be set to the default value of 0.

2.3. Outputs

The Matlab code generates artificial-data for the specified user-defined values, which are presented in 4 figures.

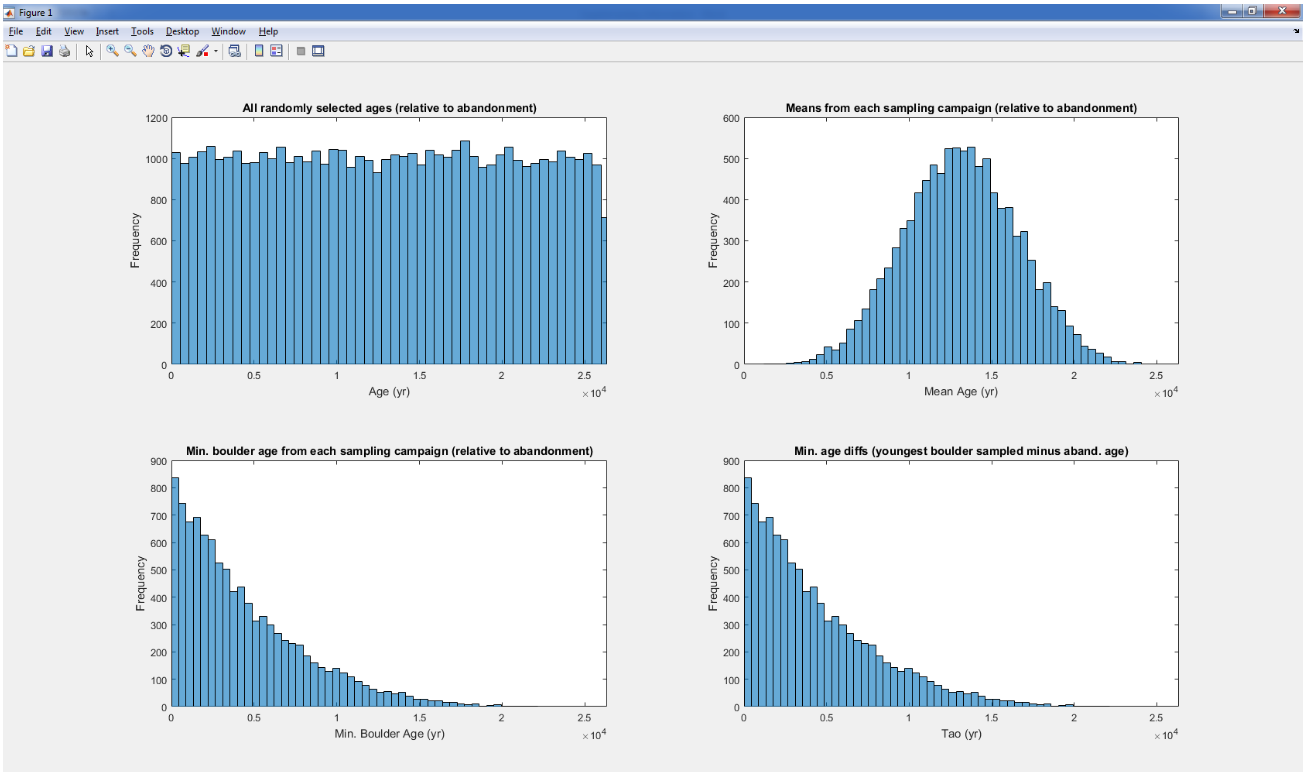


Fig. 1. This figure shows histograms of the artificial data generated for the specified scenario. The code generates artificial data for a surface with the parameters prescribed by the user-defined values above. The top-left plot shows the frequency of all ages obtained from timespan T, relative to the timing of abandonment. The top-right plot shows the frequency distribution of mean surface ages calculated from each sampled cluster of ages. The lower-left plot shows the frequency distribution of minimum age obtained, relative to the timing of abandonment. The lower-right plot shows the frequency distribution of τ.

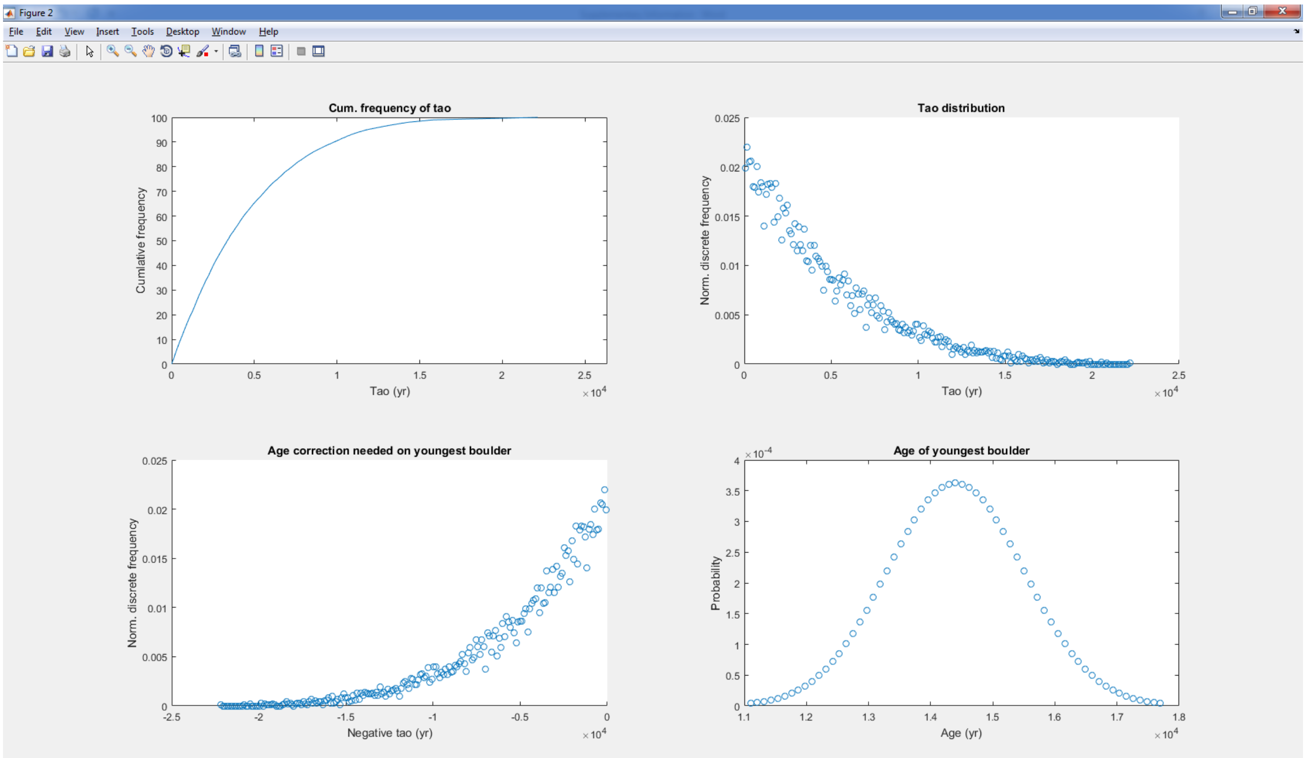


Fig. 2. This figure presents the artificial data normalised by the number of iterations performed. The upper-left plot shows the cumulative frequency distribution of τ for the specified scenario. The upper-right plot shows the normalised discrete frequency distribution of τ values. The lower-left plot shows these values converted into the age correction needed on the youngest sampled age in each cluster, in order to coincide with the timing of abandonment. The lower-right plot shows a probability distribution representing the value of a_{min}. The default setting is to treat the youngest boulder age as having a normally-distributed 3σ uncertainty.

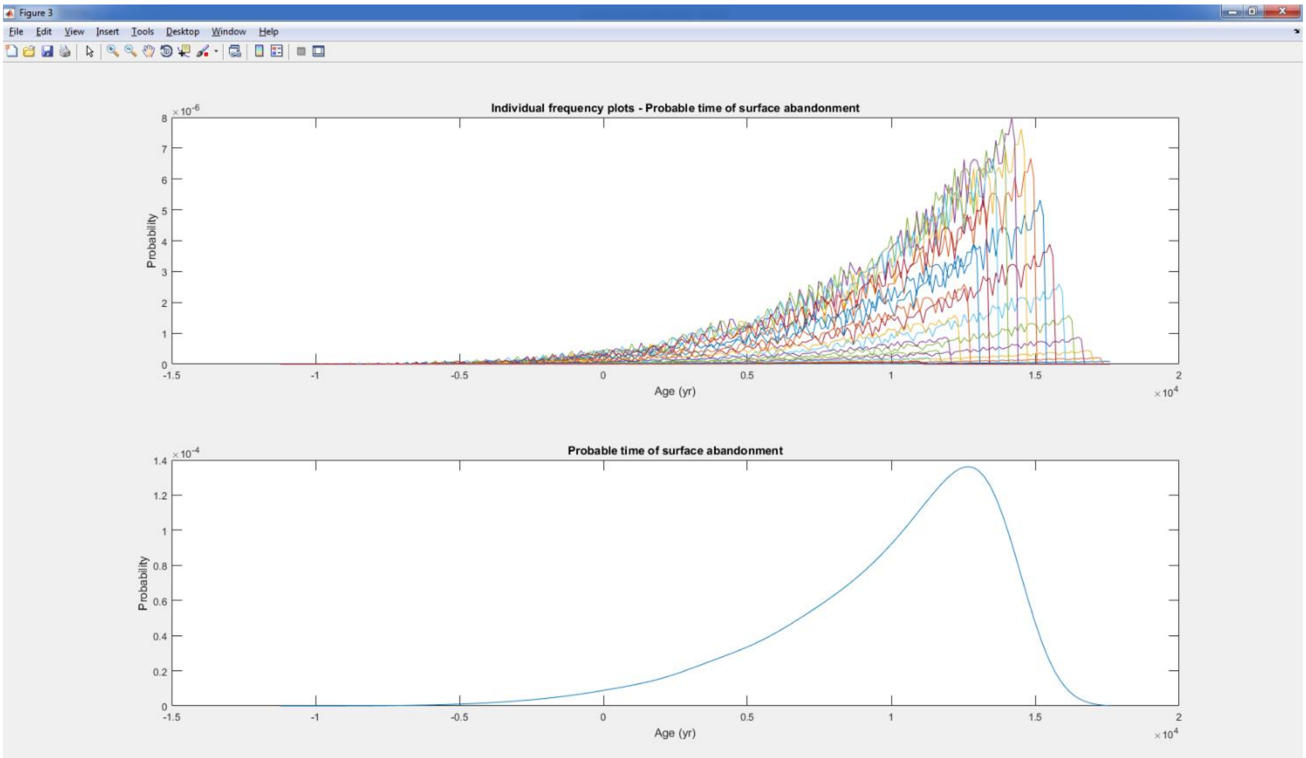


Fig. 3. This figure shows the full probability of abandonment timing and incorporation of age uncertainty on the youngest sample age obtained (i.e., following Fig. 7 in the main article). The top panel shows the frequency distribution of τ derived from the artificial data, iteratively plotted for each potential value of a_{min} derived by discretizing its probability distribution (from Fig. 2, lower-right). We have set this discretization to be equal to 1/10 of the 1σ uncertainty on a_{min} to provide a highly-resolved result, and the frequency distributions of τ are weighted according to the probability distribution of a_{min} values. The weighted, temporally-shifted τ distributions are then summed to produce a final probability distribution of surface abandonment timing that incorporates uncertainty on the youngest age (lower panel).

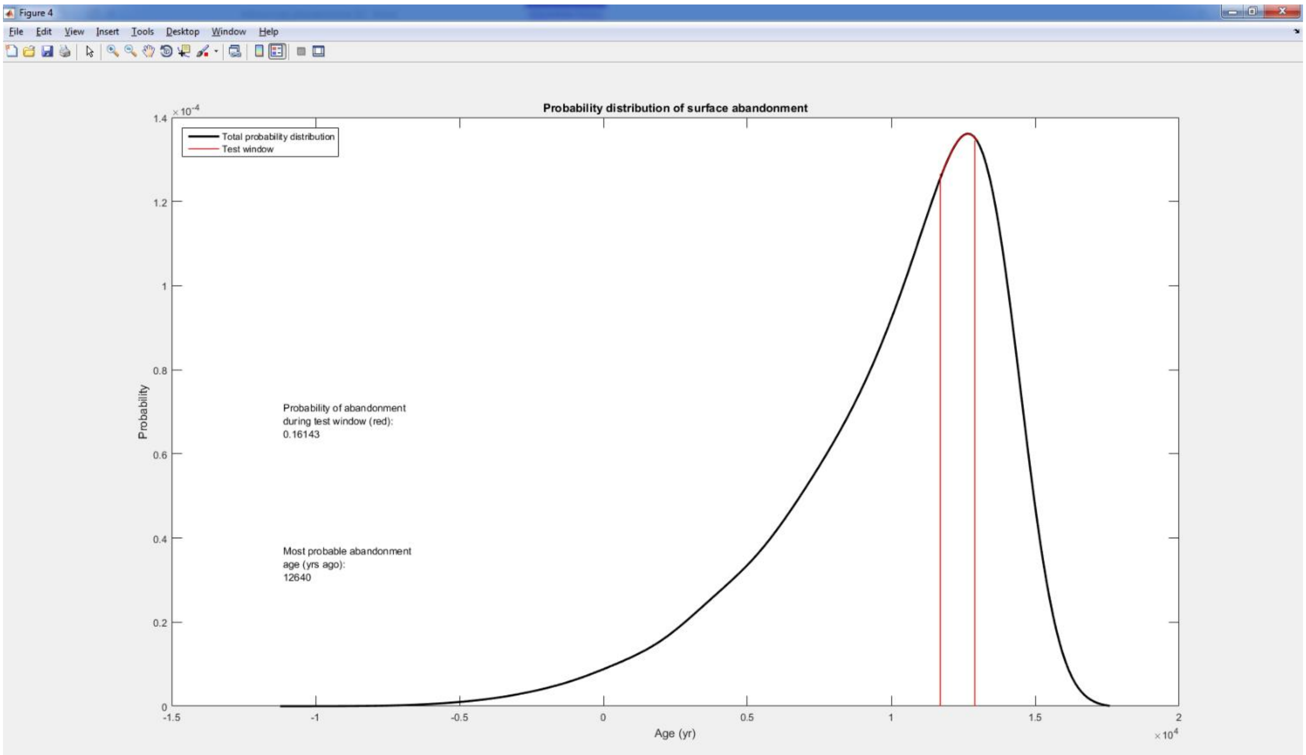


Fig. 4. This figure shows the total probability distribution of abandonment ages derived for the specified scenario using artificial data, plus the total probability integrated within the interval of interest defined by `test_range_upper` and `test_range_lower` (marked by the red lines). The results are given as a fraction of a sum total of 1, and the single most probable age of abandonment is annotated.

3. Reproduction of figures in the main article

The figures plotted in the main article and the results of our artificial-data analyses can be reproduced using either the spreadsheet or the Matlab code.

In the Excel spreadsheet, the data needed to plot Fig. 3 in the main article (i.e., for a specific scenario of T = 30 kyr) are linked into Table 1 in the ‘Summary’ tab and associated graphs. The active links demonstrate how these figures are derived from the underlying artificial data and allow the user to re-link to different scenarios if desired. Table 2 actively links to the data needed to reproduce Fig. 4 in the main article. Tables 3-5 actively link to the data needed to reproduce Fig. 5 in the main article. All formulas have been preserved in the spreadsheet, including for the random selection of every cluster of ages that generates the artificial datasets. Therefore, re-calculating the Excel file will refresh the entire artificial-data analysis from start to finish.

The Matlab tool can be used to reproduce Fig. 3 in the main article by deactivating the formula-driven calculation of T at line 67 (this is the default setting) and activating line 70 where a fixed value of T is imposed, in this case 30,000 years. A value of n is chosen at line 47. The values of `amax`, and `amin` do not matter for reproducing Fig. 3 in the main article, because a probability distribution of τ is not being produced for a particular set of measured surface ages. The various panels comprising Fig. 3a-c in the main article are output as Figs 1 (upper-right, lower-left) and 2 (upper-left) by the Matlab script. Fig. 3d and Fig. 4 in the main article can then be reproduced by compiling the results for different values of n.