

ArAR – Argon Age Recalculator: Documentation

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Manual

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1 Installation

ArAR is compatible with the Java™ Platform, Standard Edition (SE) 7 and 8, and is distributed as an executable Java ARchive (JAR) application. All resources necessary for running ArAR will be self-extracted into the same directory as the ArAR JAR the first time the application is launched (or if any resources go missing). These resources include: the ArAR preferences file; a README; a directory with the four editable ArAR libraries (containing (1) ⁴⁰K decay constants, (2) isotopic abundance values, (3) common ⁴⁰Ar/³⁹Ar monitor mineral ages, and (4) ⁴⁰Ar*/⁴⁰K values for common monitor minerals); and a directory with the ArAR documentation (including this manual, a [Quick-Start Guide](#), and documents explaining ArAR [Nomenclature](#) and [Calculations](#)).

1.1 Downloading the Java Runtime Environment

The Java runtime environment (JRE) is freely available as part of the Java SE 7 and 8 releases, which can be downloaded at <http://www.oracle.com/technetwork/java/javase/downloads/index.html>. After downloading and running either the Java SE 7 or 8 installers, you are ready to run ArAR. To check that you have the latest JRE installed, visit: <https://www.java.com/verify/>.¹

1.2 Downloading ArAR

ArAR is freely available to download at tectonics.asu.edu/downloads. Once ArAR is downloaded, you may save it to the directory of your choice (there is no installer to run).

¹Note: some computers may only have Java installed for web browsers. If the Java verification indicates you have Java installed but ArAR doesn't launch, try reinstalling the Java JRE.

2 Starting and Exiting ArAR

ArAR may be launched either by double-clicking the executable JAR, or by opening a command-line tool and navigating to the directory containing the ArAR JAR and running the command

```
java -jar ArAR.jar
```

at the prompt.

To exit ArAR, click the red ‘X’ button at the top of the ArAR window, select ‘Exit ArAR’ from the ‘ArAR’ menu, or use the hotkey combination ‘Meta + Q’, where ‘Meta’ is the ‘Ctrl’ key on a Windows machine and the ‘Cmd’ key on a Macintosh.

3 Data Layout and Handling

ArAR relies on my JDataFrame object for importing, exporting, storing, and manipulating data. Currently, JDataFrame, and hence, ArAR, can only read/write delimited text files that conform to the JDataFrame layout guidelines (see [The JDataFrame Layout](#)); they *cannot* read/write Excel worksheets². ArAR can read/write the following file types: comma separated value files (*.csv), tab-delimited text files (*.txt), space delimited text files (*.prn), and JDataFrame text files (*.jdf). Should you desire to save or import text files where the data are delimited by the string ‘(= Smiles =)’, then you can do so with JDataFrame text files by opening the ArAR preferences pane (see [Editing ArAR Preferences](#)) and setting the JDataFrame import and export delimiters to ‘Custom’ and enter the string ‘(= Smiles =)’ in the appropriate fields. Note, custom delimiters must be alphanumeric, and can only include the following special characters: \ ! @ # \$ % & () [] { }. **Tip:** don’t save or import a file where the contents of individual cells may include the delimiter (e.g., if there are commas in a string of notes, don’t save the dataset to a .csv file).

3.1 The JDataFrame Layout

The JDataFrame object, and hence, ArAR, can read and write data to delimited files as long as those data conform to the JDataFrame Layout. The JDataFrame Layout consists of six major elements: (A) a ‘corner’ piece, (B) a set of alphanumeric column names, (C) a set of alphanumeric row names, (D) an array of numeric data, (E) an array of alphanumeric notes, and (M) a header containing (optional) metadata ([Fig. 1](#)). Only numeric data (located in element D) or notes (located in element E) are required when preparing a delimited file for import into ArAR (i.e., into a JDataFrame)³. All other elements are optional, though default information for A (the ‘corner’

²This functionality may be added to a future release, depending on popular demand, though the internal structure of the Excel worksheets would still need to conform to the [JDataFrame Layout](#).

³If you plan on performing any numeric computations with ArAR, be sure to import a file with at least one column of numeric data, even though it’s possible to import a file filled with only alphanumeric notes.

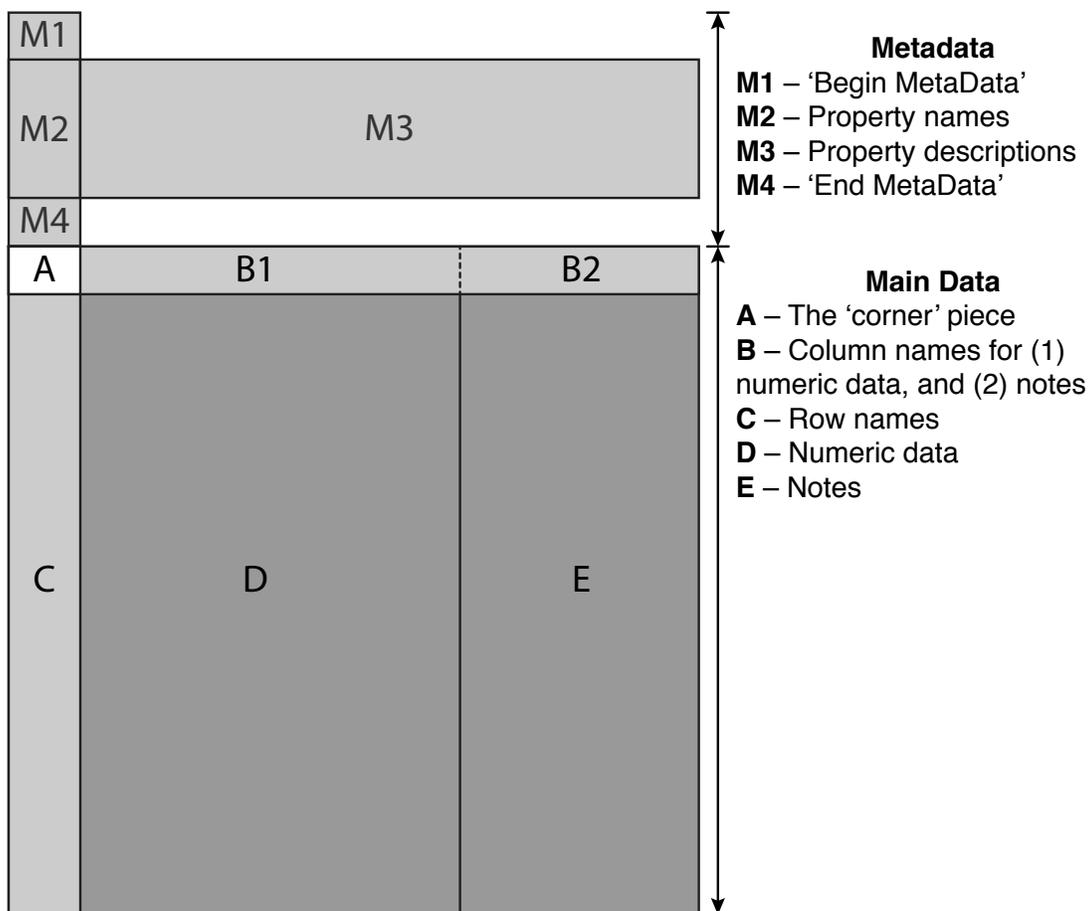


Figure 1. Schematic diagram of the relative positions of the elements of the JDataFrame Layout. Only a set of numeric data (D) or alphanumeric notes (E) are required; all other elements are optional.

piece), B (numeric and/or notes column names), and C (row names) will automatically be generated upon import. If the dataset is subsequently exported to a delimited file, the elements A, B1, C, and D will all be exported to the specified destination. Alphanumeric information (‘notes’) can also be included for each row *as long as it is located to the right of any columns of purely numeric data*.

This layout design allows some flexibility in how you choose to format data before importing them into *ArAR*. For example, though you really only need to have numeric data in your input file, you may also include column headers and sample IDs for convenience in recalculating K-Ar or $^{40}\text{Ar}/^{39}\text{Ar}$ dates. In addition, you may include alphanumeric notes to the right of the numeric data, e.g., to indicate what paper the published date came from, or to indicate what constants were originally used in calculating it.

It is also possible to include metadata in imported and exported datasets by including alphanumeric property:description pairs inside of a block of rows denoted by the ‘Begin Metadata’ and ‘End Metadata’ flags. An example of an acceptable input file with metadata is shown in [Fig. 2](#).

Begin Metadata				
Sample	77115			
Description	Impact melt breccia			
Locality	Taurus-Littrow Valley			
Station	7			
Method	Ar-Ar			
End Metadata				
Sample ID	Plateau Date (Ma)	1 σ (Ma)	Reference	Notes
77115,22	3850	20	Stettler et al., 1975	Melt Matrix
77115,22	3900	15	Stettler et al., 1978	Melt Matrix
77115,75	3910	20	Stettler et al., 1975	Melt Matrix
77115,75	3960	15	Stettler et al., 1975	Clast Material
77115,75	3960	25	Stettler et al., 1978	Clast Material

Figure 2. An example of an acceptable data file that conforms to the JDataFrame format. Note that the sample names and references use commas, and there are spaces in the metadata, references, and notes. Therefore, this would not work as a *.csv or *.prn (space delimited) file unless alternate characters were used. Be aware of the the file contents when choosing a delimiter.

3.2 Creating a New Dataset

To create a new dataset, click on the ‘File’ menu at the top of the *ArAR* window and select ‘New.’ Alternatively, you may use the hotkey combination ‘Meta + N’, where ‘Meta’ is the ‘Ctrl’ key on a Windows machine and the ‘Cmd’ key on a Macintosh. By default, a dialog window will appear prompting for the number of rows, numeric columns, and notes columns to create (Fig. 3). This dialog may be disabled in the *ArAR* preferences pane (see [Editing ArAR Preferences](#)), in which case new datasets are created with 10 rows and 2 numeric columns by default. After the dataset dimensions are specified (or defaults are assumed), then the full dataset editor tool (see [Advanced JDataFrame Editor](#)) is launched, allowing you to manually input data (Fig. 4). Once you are done entering values, click ‘Save Changes’ to finish creating the new dataset. The editor tool may also be disabled during the creation of new datasets in the *ArAR* preferences pane, in which case a blank dataset is created. **Note:** entering data manually in the editor tool at the time of dataset creation allows you to later revert any recalculated data to the values you first entered. If you disable the editor, the original state of the new dataset is considered to be blank and future reversion attempts will return the data to a blank state.

3.3 Importing Delimited Data

To import data from a delimited text file, click on the ‘File’ menu at the top of the *ArAR* window and select ‘Open.’ You can also use the hotkey combination ‘Meta + O’, where ‘Meta’ is the

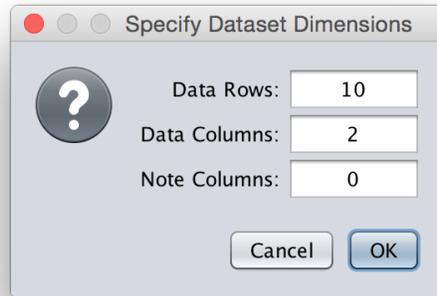


Figure 3. Dialog box prompting for the dimensions of a new dataset.

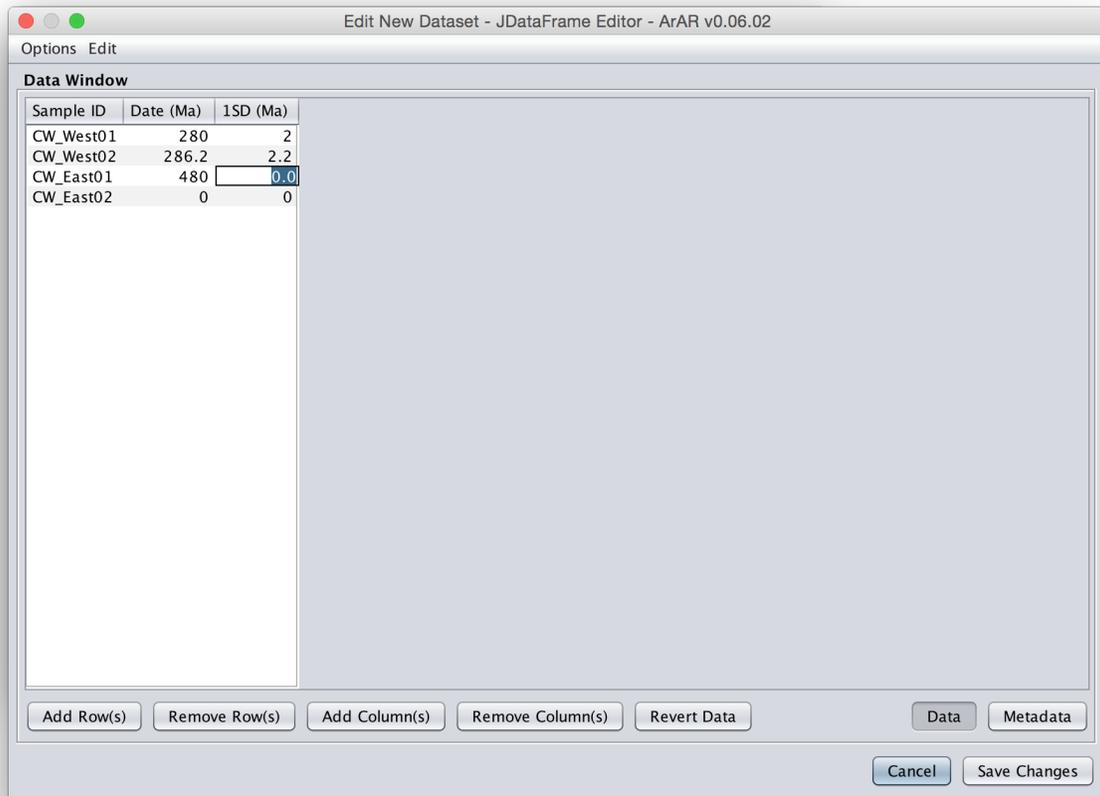


Figure 4. Dataset editor for specifying the original state of a newly created dataset. See the [Advanced JDataFrame Editor](#) section for additional details on using the editor.

'Ctrl' key on a Windows machine and the 'Cmd' key on a Macintosh. A dialog window will appear ([Fig. 5](#)) allowing you to browse for and select one or more of the allowable delimited file types (*.csv, *.txt, *.prn, and *.jdf). Click 'Open' or press 'Enter' once you have finalized your selection, and the files will be imported (provided they conform to the JDataFrame layout, see [The JDataFrame Layout](#)).

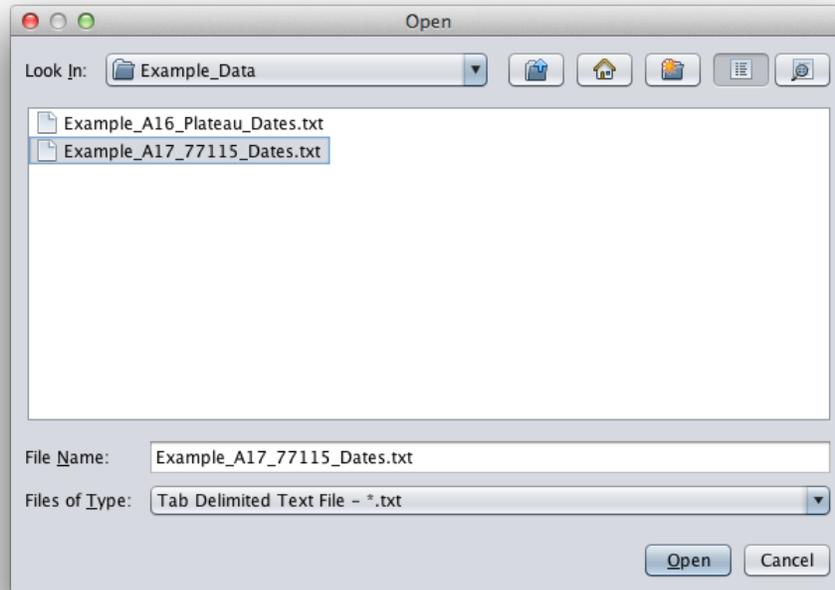


Figure 5. Dialog box for selecting files for import into *ArAR*.

3.4 *Cut, Copy, and Paste*

Cut, copy, and paste operations are available in the main *ArAR* window, the [Advanced JDataFrame Editor](#), and the [Multiple Intercalibration Tool](#). You may use the appropriate items in the ‘Edit’ menu, or use one of the following hotkey combinations: ‘Meta + X’ (cut), ‘Meta + C’ (copy), and ‘Meta + V’ (paste), where ‘Meta’ is the ‘Ctrl’ key on a Windows machine and the ‘Cmd’ key on a Macintosh.

3.5 *Selecting, Renaming, and Removing Datasets*

Once one or more datasets have been created or imported, you may select which dataset is visible, rename the current dataset, and/or remove the current dataset using the controls located at the bottom left of the main *ArAR* window ([Fig. 6](#)). By default, newly created datasets are named ‘New Dataset’ (or ‘Blank Dataset’ if created with the dataset editor disabled; see [Creating a New Dataset](#)), and imported datasets inherit the names of the delimited files that are loaded. When datasets are selected from the drop-down menu their contents are displayed in the table, and the data are available for calculations (see [Selecting Dates to Recalculate or Revert](#)). To rename the currently selected dataset, click the ‘Rename’ button; a dialog will appear allowing you to enter a new name. Datasets can be removed (along with all of their contents and metadata, e.g., those relating to sample selection states and change logs) using the ‘Remove’ button.

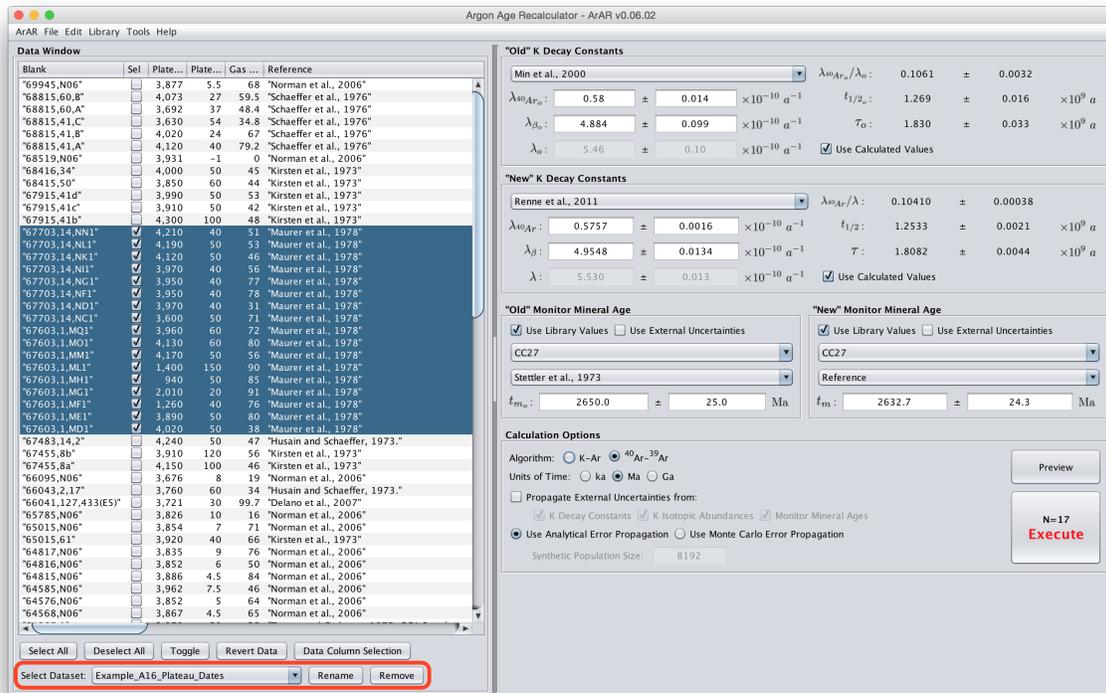


Figure 6. The main ArAR window, with the controls to select, rename, and/or remove datasets highlighted in the red box.

3.6 Exporting Delimited Data

To export the currently visible dataset to a delimited text file, click on the 'File' menu at the top of the ArAR window and select 'Save' or 'Save As.' You can also use one of the hotkey combinations: 'Meta + S' ('Save') or 'Meta + Shift + S' ('Save As'), where 'Meta' is the 'Ctrl' key on a Windows machine and the 'Cmd' key on a Macintosh. If a dataset has not been exported previously, the 'Save' option behaves like 'Save As,' and opens a dialog window (Fig. 7) allowing you to browse to a destination directory and provide a target file name. You may also select one of the allowable delimited file types (*.csv, *.txt, *.prn, and *.jdf), and click 'Save' or press 'Enter' to export the dataset.

3.7 Exporting the Change Log

To export the change log (see [The Change Log](#)) for the currently visible dataset to a delimited text file, click on the 'File' menu at the top of the ArAR window and select 'Export Change Log.' You can also use the hotkey combination 'Meta + L', where 'Meta' is the 'Ctrl' key on a Windows machine and the 'Cmd' key on a Macintosh. A window similar to the 'Save As' dialog will appear (Fig. 7) allowing you to browse to a destination directory and provide a target file name. You may also select one of the allowable delimited file types (*.csv, *.txt, *.prn, and *.jdf),

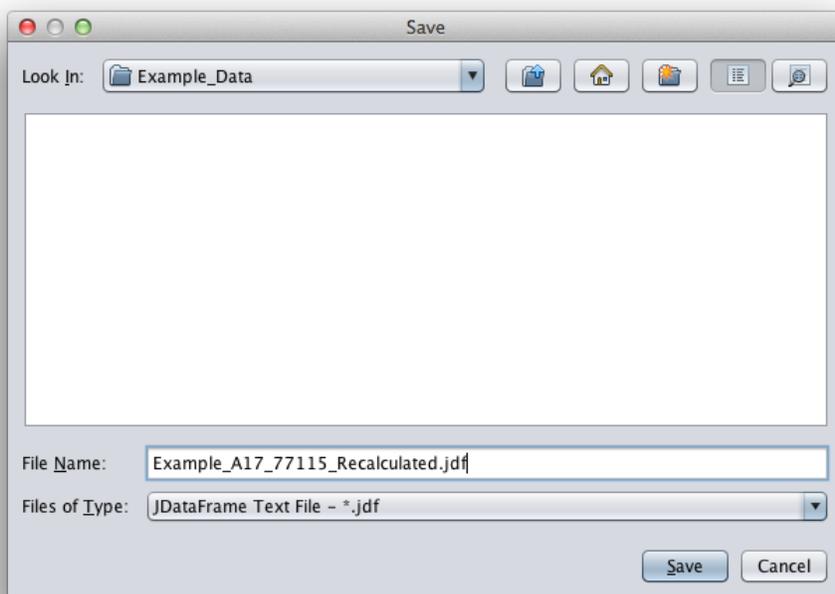


Figure 7. Dialog box for saving *ArAR* datasets to delimited text files.

and click ‘Save’ or press ‘Enter’ to export the change log. Alternatively, the change log may be appended to the right of the active dataset when the dataset is exported using the ‘File > Save As’ or ‘File > Save’ options. You may activate this behavior in the *ArAR* preferences pane (see [Editing *ArAR* Preferences](#)).

4 Recalculating K-Ar and ⁴⁰Ar/³⁹Ar Dates

4.1 Selecting Dates to Recalculate or Revert

After importing or creating a new dataset, samples (i.e., rows in the dataset) are not selected for recalculation by default. You may change this in the *ArAR* preferences pane (see [Editing *ArAR* Preferences](#)) so that all samples are selected upon creation or import. In addition, there are a variety of ways that you can edit the sample selection within the main *ArAR* window ([Fig. 8](#)). First, you can toggle the selection state of individual samples by clicking on the checkboxes in the ‘Sel’ column of the displayed table. Alternatively, you may ‘Select All’ or ‘Deselect All’ samples in a dataset using the buttons at the bottom left of the window. In addition, you can highlight rows by clicking your mouse pointer within the table and dragging⁴, and then pressing the ‘Toggle’ button to invert their selection state. By right-clicking in the table (or holding down the ‘Ctrl’ key and clicking on a Mac), a contextual menu appears that allows you to either clear the current

⁴You can also highlight discontinuous groups of rows by holding down the ‘Ctrl’ key (for Windows) or the ‘Cmd’ key (on a Macintosh) while clicking and dragging within the table.

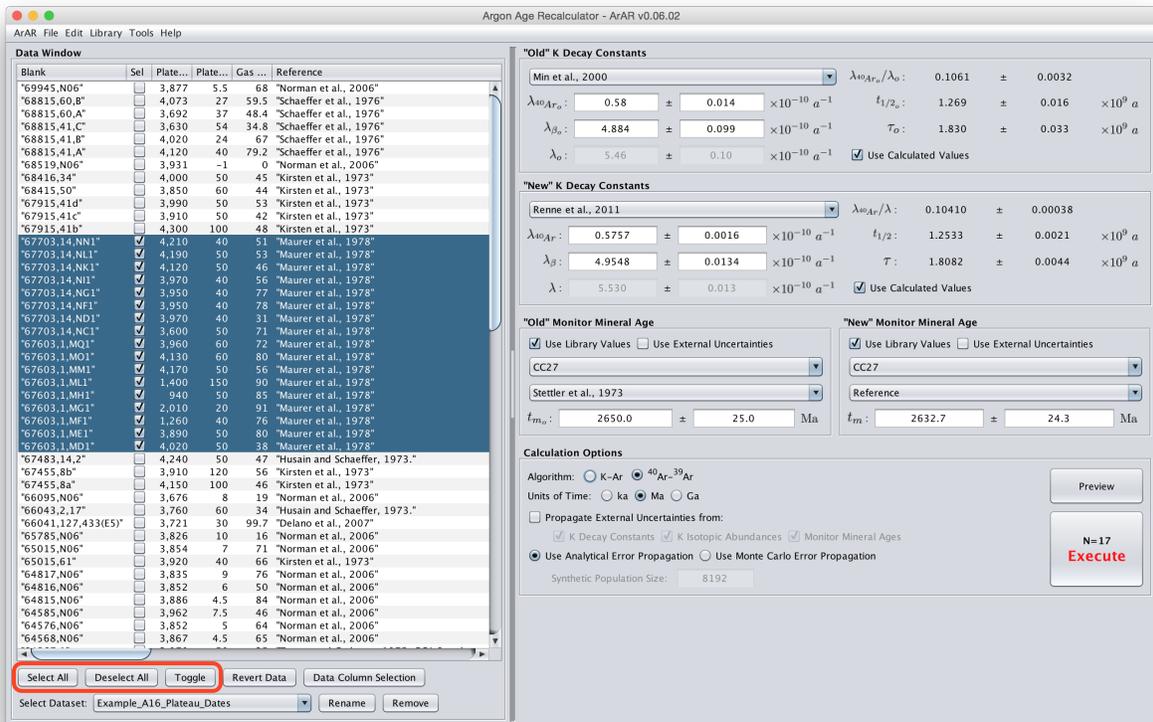


Figure 8. The main ArAR window, with sample selection controls highlighted in the red box.

highlighting of samples or toggle the selection state of the highlighted rows (this is equivalent to pressing the ‘Toggle’ button). The total number of samples (rows) that are selected in the current dataset is displayed in the ‘Execute’ button located in the lower-right part of the ‘Calculation Options’ subpanel in the main ArAR window (Fig. 8).

The checkboxes in the ‘Sel’ column of the table (Fig. 8) only indicate which samples (rows) of the visible dataset are ‘active’ for K-Ar or $^{40}Ar/^{39}Ar$ recalculation. By default, only those numeric data that are located in the first two columns immediately to the right of the ‘Sel’ column will be used during ArAR calculations. This assumes that the data in the first numeric column are K-Ar or $^{40}Ar/^{39}Ar$ dates and that the data in the second numeric column are their corresponding uncertainties. These ‘active columns’ may be changed by clicking the ‘Data Column Selection’ button (Fig. 9) near the bottom of the table. A dialog will appear (Fig. 10) allowing you to specify which columns to use for the K-Ar or $^{40}Ar/^{39}Ar$ dates and uncertainties in ArAR calculations. This gives you some flexibility in your age recalculations as well. For example, you could import a file with $^{40}Ar/^{39}Ar$ dates as well as the ages of the monitor minerals that were used to determine the published $^{40}Ar/^{39}Ar$ dates. You could then process the monitor ages before using the recalculated values to crunch the $^{40}Ar/^{39}Ar$ dates (see [Recalculating \$^{40}Ar/^{39}Ar\$ Dates](#)), thereby streamlining your workflow by using a single imported dataset.

Finally, the data in the active columns of the selected sample rows can be reverted to their original state by clicking on the ‘Revert Data’ button near the bottom of the table in the main ArAR

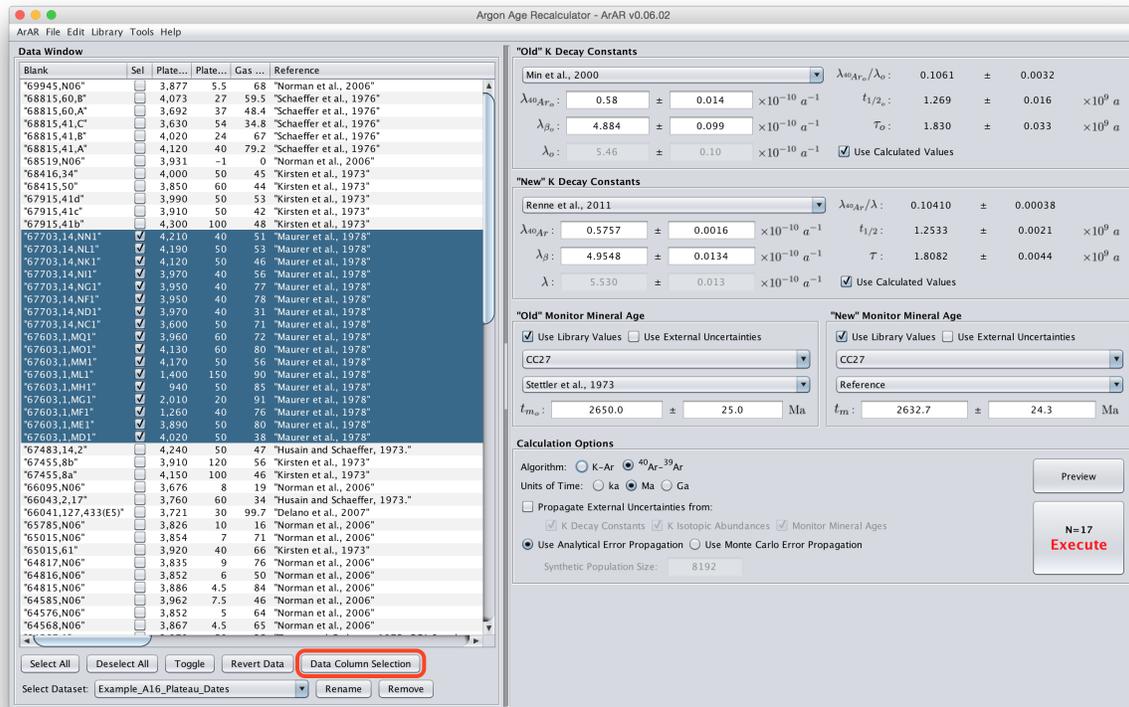


Figure 9. The main ArAR window, with the ‘Data Column Selection’ control highlighted in the red box.

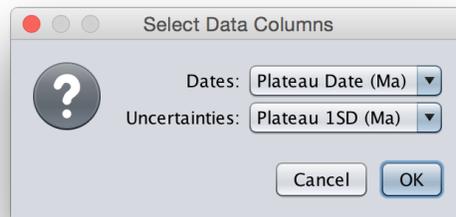


Figure 10. The ‘Data Column Selection’ dialog box.

window (Fig. 11). This allows you to recover the raw data after they have been edited (e.g., by recalculating dates or manually editing values) without having to reimport the original file.

4.2 Recalculating K-Ar Dates

By default, ArAR opens with the K-Ar algorithm selected (indicated by the radio button in the ‘Calculation Options’ subpanel on the right side of the main ArAR window; Fig. 12). This can be changed to make ArAR start with the $^{40}\text{Ar}/^{39}\text{Ar}$ algorithm selected using the preferences pane (see [Editing ArAR Preferences](#)). If the K-Ar algorithm is not selected, you may switch to it by clicking on the appropriate radio button in the ‘Calculation Options’ subpanel.

In addition, calculations in ArAR are performed assuming that any new or imported dates are in units of Ma by default (indicated by the radio button in the ‘Calculation Options’ subpanel on the right side of the main ArAR window; Fig. 12). This can be changed to make ArAR use units of ka,

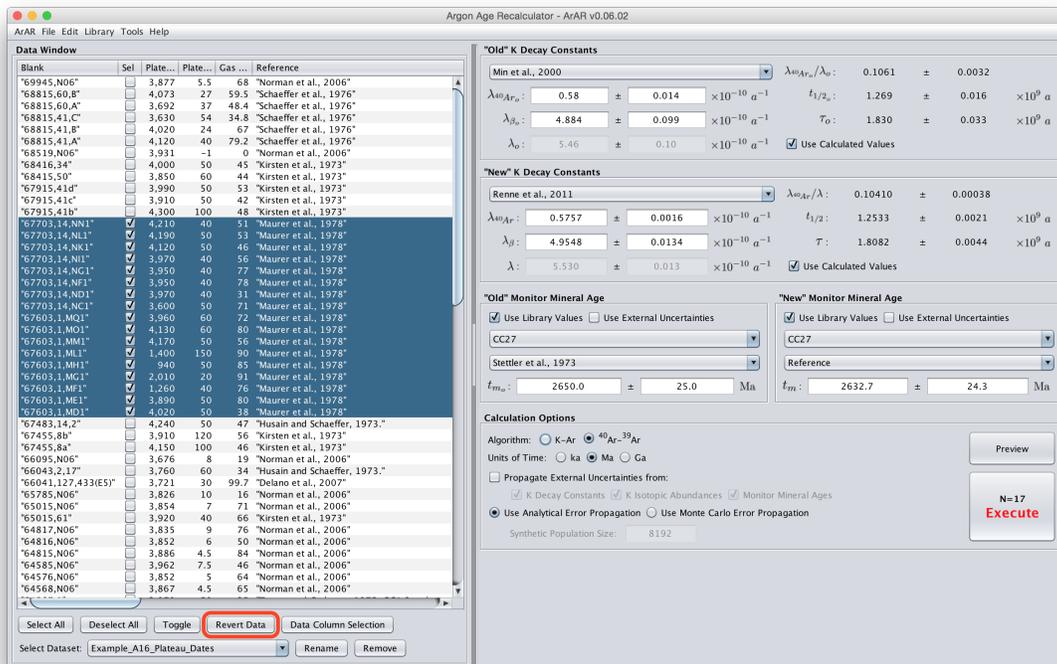


Figure 11. The main ArAR window, with the ‘Revert Data’ control highlighted in the red box.

Ma, or Ga for imported dates using the preferences pane (see [Editing ArAR Preferences](#)). You may switch to the correct units of time by clicking on the appropriate radio button in the ‘Calculation Options’ subpanel. **Note:** the units of time selected in the ‘Calculation Options’ subpanel only apply to dates visible in the ‘Data Window’ on the left side of the main ArAR window; all other input values are assumed to be in the units that are shown in the ArAR interface.

To recalculate legacy K-Ar dates you must specify both ‘old’ and ‘new’ values for the ^{40}K decay constants (in particular, the total decay constants [$\lambda_o \equiv \lambda_{^{40}\text{Ar}_o} + \lambda_{\beta_o}$] and [$\lambda \equiv \lambda_{^{40}\text{Ar}} + \lambda_{\beta}$]), and the relative abundances of the isotopes of K (in particular, the relative abundance of ^{40}K , i.e., $^{40}K_{ao}$ and $^{40}K_a$). (**Note:** All uncertainties for input parameters in ArAR are assumed to be 1σ values.) You may directly enter values for these quantities in the editable text fields (remember to press ‘Enter’ after editing a value!), or you may auto-fill these values by selecting references from the ArAR libraries using the drop-down menus (Fig. 12). When editing or selecting values for the ‘old’ and ‘new’ ^{40}K decay constants, the total decay constants and their uncertainties ($\lambda_o \pm \sigma_{\lambda_o}$ and $\lambda \pm \sigma_{\lambda}$) are calculated from the partial decay constants by default⁵. You may edit the values for the total decay constants by unchecking the ‘Use Calculated Values’ check boxes in the K decay constants subpanels. Also, you may alter the default behavior to always require manual input for the total decay constants using the ArAR preferences pane (see [Editing ArAR Preferences](#)). The values and uncertainties for the branching ratio (e.g., $\lambda_{^{40}\text{Ar}}/\lambda$), half-life, and mean life of ^{40}K are

⁵Note (without loss of generality) that $\lambda \equiv \lambda_{^{40}\text{Ar}} + \lambda_{\beta}$. The uncertainties in the decay constants are propagated analytically as $\sigma_{\lambda} = (\sigma_{\lambda_{^{40}\text{Ar}}}^2 + \sigma_{\lambda_{\beta}}^2)^{1/2}$.

"Old" K Decay Constants

Aldrich and Wetherill, 1958  $\lambda_{40Ar_o}/\lambda_o$: 0.1103 ± 0.0015

λ_{40Ar_o} : 0.585 ± 0.00585 × 10⁻¹⁰ a⁻¹ $t_{1/2_o}$: 1.3066 ± 0.0081 × 10⁹ a

λ_{β_o} : 4.72 ± 0.0472 × 10⁻¹⁰ a⁻¹ τ_o : 1.885 ± 0.017 × 10⁹ a

λ_o : 5.305 ± 0.048 × 10⁻¹⁰ a⁻¹ Use Calculated Values

"New" K Decay Constants

Steiger and Jager, 1977  λ_{40Ar}/λ : 0.1048 ± 0.0014

λ_{40Ar} : 0.581 ± 0.00581 × 10⁻¹⁰ a⁻¹ $t_{1/2}$: 1.2505 ± 0.0078 × 10⁹ a

λ_{β} : 4.962 ± 0.04962 × 10⁻¹⁰ a⁻¹ τ : 1.804 ± 0.016 × 10⁹ a

λ : 5.543 ± 0.050 × 10⁻¹⁰ a⁻¹ Use Calculated Values

"Old" K Isotopic Abundance Values

Nier, 1950

$^{39}K_{ao}$: 93.08 ± 0.04 Atom %

$^{40}K_{ao}$: 0.0119 ± 1.0E-4 Atom %

$^{41}K_{ao}$: 6.91 ± 0.04 Atom %

"New" K Isotopic Abundance Values

Steiger and Jager, 1977 

$^{39}K_a$: 93.2581 ± 0.9326 Atom %

$^{40}K_a$: 0.01167 ± 0.0001167 Atom %

$^{41}K_a$: 6.7302 ± 0.06730 Atom %

Calculation Options

Algorithm: K-Ar ^{40}Ar - ^{39}Ar

Units of Time: ka Ma Ga

Propagate External Uncertainties from:

K Decay Constants K Isotopic Abundances Monitor Mineral Ages

Use Analytical Error Propagation Use Monte Carlo Error Propagation

Synthetic Population Size: 8192

Preview

N=0

Execute

Figure 12. An example of the GUI controls on the right side of the main *ArAR* window that are used for recalculating K-Ar dates.

calculated from the decay constants you specify, and are displayed for convenience (Fig. 12).

If you have auto-filled ^{40}K decay constants or K isotopic abundances from the *ArAR* libraries and subsequently edited the values, buttons with  icons will appear next to the drop-down menus. If you click on these buttons, you will see a dialog box warning you that you have edited library values. If you have intentionally done so, it is safe to continue and recalculate the K-Ar dates. If you intend to use one or more of the edited values regularly, consider adding an entry to the appropriate *ArAR* library (see [The ArAR Libraries](#)), though the value should ideally be traceable to the peer-reviewed literature.

If uncertainties are missing for any ^{40}K decay constants or K isotopic abundance values from the *ArAR* library (e.g., if the selected reference did not report them), buttons with  icons will appear next to the drop-down menus (e.g., Fig. 12). If you click on these buttons, you will see a dialog box warning you that the auto-filled uncertainties were assumed to be some percentage of their corresponding quantities. By default, the assumed relative uncertainties in all quantities are assumed to be 1%. You may edit these default relative uncertainty values in the *ArAR* preferences pane (see [Editing ArAR Preferences](#)). These default (assumed) uncertainties are of course arbitrary,

and are meant only to provide some non-zero values in the event that you would like to propagate external sources of uncertainty into recalculated K-Ar dates.

Once values for the ^{40}K decay constants and K isotopic abundance values have been specified, you can select uncertainty propagation options in the ‘Calculation Options’ subpanel located at the bottom on the right side of the main ArAR window. By checking the ‘Propagate External Uncertainties from:’ checkbox, you can decide to have the uncertainties for either the ^{40}K decay constants, K isotopic abundances, or both propagated into recalculated K-Ar dates. In addition, you can select whether to propagate uncertainties analytically or by a Monte Carlo approach using the specified synthetic population size (see [Calculations](#)). By default, no external sources of uncertainty are propagated, but if you check the ‘Propagate External Uncertainties from:’ box then all external uncertainties will be propagated unless otherwise specified. Error propagation is performed analytically by default, but if you chose to employ Monte Carlo error propagation, a default population size of 8192 (i.e., 2^{13}) is used. To edit the population size, you may enter integer values or powers using the ‘^’ character. For example, if you enter ‘ 2^{14} ’ in the text field and press ‘Enter’, the population size will be set to $2^{14} = 16384$. The default values for all options in the ‘Calculation Options’ subpanel can be edited in the ArAR preferences pane (see [Editing ArAR Preferences](#)).

If you would like to preview the effects of recalculating K-Ar dates with the constants and options you have entered/selected, you can click the ‘Preview’ button located in the ‘Calculation Options’ subpanel above the ‘Execute’ button, select the ‘Preview Results’ item from the ‘Tools’ menu, or use the hotkey combination ‘Meta + P’, where ‘Meta’ is the ‘Ctrl’ key on a Windows machine and the ‘Cmd’ key on a Macintosh (see [Previewing Recalculation Results](#) for more information). To recalculate the selected K-Ar dates using the constants and options that you have entered/selected, press the ‘Execute’ button in ‘Calculation Options’ subpanel ([Fig. 12](#)). See the [Calculations](#) documentation for details on the equations used for recalculating K-Ar dates.

4.3 Recalculating $^{40}\text{Ar}/^{39}\text{Ar}$ Dates

By default, ArAR opens with the K-Ar algorithm selected (indicated by the radio button in the ‘Calculation Options’ subpanel on the right side of the main ArAR window; [Fig. 13](#)). This can be changed to make ArAR start with the $^{40}\text{Ar}/^{39}\text{Ar}$ algorithm selected in the preferences pane (see [Editing ArAR Preferences](#)). If the $^{40}\text{Ar}/^{39}\text{Ar}$ algorithm is not selected, you may switch to it by clicking on the appropriate radio button in the ‘Calculation Options’ subpanel.

In addition, calculations in ArAR are performed assuming that any new or imported dates are in units of Ma by default (indicated by the radio button in the ‘Calculation Options’ subpanel on the right side of the main ArAR window; [Fig. 13](#)). This can be changed to make ArAR use units of ka, Ma, or Ga for imported dates using the preferences pane (see [Editing ArAR Preferences](#)). You may

"Old" K Decay Constants

Min et al., 2000

λ_{40Ar_o} : 0.58 ± 0.014 × 10⁻¹⁰ a⁻¹

λ_{β_o} : 4.884 ± 0.099 × 10⁻¹⁰ a⁻¹

λ_o : 5.46 ± 0.10 × 10⁻¹⁰ a⁻¹

$\lambda_{40Ar_o}/\lambda_o$: 0.1061 ± 0.0032

$t_{1/2_o}$: 1.269 ± 0.016 × 10⁹ a

τ_o : 1.830 ± 0.033 × 10⁹ a

Use Calculated Values

"New" K Decay Constants

Renne et al., 2011

λ_{40Ar_r} : 0.5757 ± 0.0016 × 10⁻¹⁰ a⁻¹

λ_{β_r} : 4.9548 ± 0.0134 × 10⁻¹⁰ a⁻¹

λ_r : 5.530 ± 0.013 × 10⁻¹⁰ a⁻¹

$\lambda_{40Ar_r}/\lambda_r$: 0.10410 ± 0.00038

$t_{1/2_r}$: 1.2533 ± 0.0021 × 10⁹ a

τ_r : 1.8082 ± 0.0044 × 10⁹ a

Use Calculated Values

"Old" Monitor Mineral Age

Use Library Values Use External Uncertainties

FCs

Renne et al., 1998

t_{m_o} : 28.02 ± 0.16 Ma

"New" Monitor Mineral Age

Use Library Values Use External Uncertainties

FCs

Renne et al., 2011

t_m : 28.294 ± 0.036 Ma

Calculation Options

Algorithm: K–Ar ⁴⁰Ar–³⁹Ar

Units of Time: ka Ma Ga

Propagate External Uncertainties from:

K Decay Constants K Isotopic Abundances Monitor Mineral Ages

Use Analytical Error Propagation Use Monte Carlo Error Propagation

Synthetic Population Size: 8192

Preview

N=0

Execute

Figure 13. An example of the GUI controls on the right side of the main *ArAR* window that are used for recalculating ⁴⁰Ar/³⁹Ar dates.

switch to the correct units of time by clicking on the appropriate radio button in the ‘Calculation Options’ subpanel. **Note:** the units of time selected in the ‘Calculation Options’ subpanel only apply to dates visible in the ‘Data Window’ on the left side of the main *ArAR* window; all other input values are assumed to be in the units that are shown in the *ArAR* interface.

To recalculate legacy ⁴⁰Ar/³⁹Ar dates you must specify both ‘old’ and ‘new’ values for the ⁴⁰K decay constants (in particular, the total decay constants [$\lambda_o \equiv \lambda_{40Ar_o} + \lambda_{\beta_o}$] and [$\lambda \equiv \lambda_{40Ar_r} + \lambda_{\beta_r}$]), and the age of the monitor mineral that was used in the ⁴⁰Ar/³⁹Ar experiment (i.e., t_{m_o} and t_m). (**Note:** All uncertainties for input parameters in *ArAR* are assumed to be 1 σ values.) You may directly enter values for these quantities in the editable text fields (remember to press ‘Enter’ after editing a value!), or you may auto-fill these values by selecting references from the *ArAR* libraries using the drop-down menus (Fig. 13). When editing or selecting values for the ‘old’ and ‘new’ ⁴⁰K decay constants, the total decay constants and their uncertainties ($\lambda_o \pm \sigma_{\lambda_o}$ and $\lambda \pm \sigma_{\lambda}$) are calculated from the partial decay constants by default⁶. You may edit the values for the total

⁶Note (without loss of generality) that $\lambda \equiv \lambda_{40Ar_r} + \lambda_{\beta_r}$. The uncertainties in the decay constants are propagated analytically as $\sigma_{\lambda} = (\sigma_{\lambda_{40Ar_r}}^2 + \sigma_{\beta_r}^2)^{1/2}$.

"Old" K Decay Constants

Min et al., 2000

$\lambda_{40Ar_o} : 0.58 \pm 0.014 \times 10^{-10} a^{-1}$ $\lambda_{40Ar_o}/\lambda_o : 0.1061 \pm 0.0032$

$\lambda_{\beta_o} : 4.884 \pm 0.099 \times 10^{-10} a^{-1}$ $t_{1/2_o} : 1.269 \pm 0.016 \times 10^9 a$

$\lambda_o : 5.46 \pm 0.10 \times 10^{-10} a^{-1}$ $\tau_o : 1.830 \pm 0.033 \times 10^9 a$

Use Calculated Values

"New" K Decay Constants

Renne et al., 2011

$\lambda_{40Ar} : 0.5757 \pm 0.0016 \times 10^{-10} a^{-1}$ $\lambda_{40Ar}/\lambda : 0.10410 \pm 0.00038$

$\lambda_{\beta} : 4.9548 \pm 0.0134 \times 10^{-10} a^{-1}$ $t_{1/2} : 1.2533 \pm 0.0021 \times 10^9 a$

$\lambda : 5.530 \pm 0.013 \times 10^{-10} a^{-1}$ $\tau : 1.8082 \pm 0.0044 \times 10^9 a$

Use Calculated Values

"Old" Monitor Mineral Age

Use Library Values Use External Uncertainties

FCs

Renne et al., 1998

$t_{m_o} : 28.02 \pm 0.16$ Ma

"New" Monitor Mineral Age

Use Library Values Use External Uncertainties

Monitor Ages (Ma)

N/A

$t_{m} : 0.0 \pm 0.0$ Ma

Calculation Options

Algorithm: K-Ar $^{40}Ar-^{39}Ar$

Units of Time: ka Ma Ga

Propagate External Uncertainties from:

K Decay Constants K Isotopic Abundances Monitor Mineral Ages

Use Analytical Error Propagation Use Monte Carlo Error Propagation

Synthetic Population Size: 8192

Preview

N=101
Execute

Figure 14. Another example of the GUI controls on the right side of the main ArAR window that are used for recalculating $^{40}Ar/^{39}Ar$ dates. In this case, values for the ‘new’ age of the monitor mineral are sourced from the ‘Monitor Ages (Ma)’ column of the active dataset.

decay constants by unchecking the ‘Use Calculated Values’ check boxes in the K decay constants subpanels. Also, you may alter the default behavior to always require manual input for the total decay constants using the ArAR preferences pane (see [Editing ArAR Preferences](#)). The values and uncertainties for the branching ratio (e.g., λ_{40Ar}/λ), half-life, and mean life of ^{40}K are calculated from the decay constants you specify, and are displayed for convenience ([Fig. 13](#)).

To select monitor mineral ages from the ArAR library, you must select both a mineral name and a reference from the drop-down menus in the monitor mineral age subpanels. You may also choose to use external uncertainties for the monitor ages (if they were reported by the selected reference and are present in the ArAR library) by checking the ‘Use External Uncertainties’ boxes ([Fig. 13](#)). By default, only the internal uncertainties are used (i.e., the ‘Use External Uncertainties’ boxes are unchecked). If you do not want to use the library values for monitor mineral ages, you can uncheck the ‘Use Library Values’ boxes and select a column in the active dataset from which to source the monitor ages ([Fig. 14](#)). If the uncertainties in the monitor age values are going to be propagated into the recalculated $^{40}Ar/^{39}Ar$ dates (see below), then the uncertainties are assumed to be in the column immediately to the right of the selected source column. This gives you some flexibility

in your $^{40}\text{Ar}/^{39}\text{Ar}$ age recalculations. For example, you could import a file with $^{40}\text{Ar}/^{39}\text{Ar}$ dates as well as the ages of the monitor minerals that were used to determine the published $^{40}\text{Ar}/^{39}\text{Ar}$ dates. You could first process the monitor ages (by changing the active columns to the monitor dates, see [Selecting Dates to Recalculate or Revert](#)), and then use the recalculated values to crunch the $^{40}\text{Ar}/^{39}\text{Ar}$ dates (by swapping the active columns back to the $^{40}\text{Ar}/^{39}\text{Ar}$ dates and selecting the recalculated monitor values in the monitor mineral age subpanels). This can help to streamline your workflow by using a single imported dataset rather than separate datasets. Note that all defaults for the monitor mineral age subpanels may be edited in the ArAR preferences pane (see [Editing ArAR Preferences](#)).

If you have auto-filled ^{40}K decay constants or monitor mineral ages from the ArAR libraries and subsequently edited the values, buttons with  icons will appear next to the drop-down menus. If you click on these buttons, you will see a dialog box warning you that you have edited library values. If you have intentionally done so, it is safe to continue and recalculate the $^{40}\text{Ar}/^{39}\text{Ar}$ dates. If you intend to use one or more of the edited values regularly, consider adding an entry to the appropriate ArAR library (see [The ArAR Libraries](#)), though the value should ideally be traceable to the peer-reviewed literature.

If uncertainties are missing for any ^{40}K decay constants or monitor mineral ages from the ArAR library (e.g., if the selected reference did not report them), buttons with  icons will appear next to the drop-down menus (e.g., [Fig. 12](#)). If you click on these buttons, you will see a dialog box warning you that the auto-filled uncertainties were assumed to be some percentage of their corresponding quantities. By default, the assumed relative uncertainties in all quantities are assumed to be 1 %. You may edit these default relative uncertainty values in the ArAR preferences pane (see [Editing ArAR Preferences](#)). These default (assumed) uncertainties are of course arbitrary, and are meant only to provide some non-zero values in the event that you would like to propagate external sources of uncertainty into recalculated $^{40}\text{Ar}/^{39}\text{Ar}$ dates.

Once values for the ^{40}K decay constants and monitor mineral ages have been specified, you can select uncertainty propagation options in the ‘Calculation Options’ subpanel located at the bottom on the right side of the main ArAR window. By checking the ‘Propagate External Uncertainties from:’ checkbox, you can decide to have the uncertainties for either the ^{40}K decay constants, monitor mineral ages, or both propagated into recalculated $^{40}\text{Ar}/^{39}\text{Ar}$ dates. In addition, you can select whether to propagate uncertainties analytically or by a Monte Carlo approach using the specified synthetic population size (see [Calculations](#)). By default, no external sources of uncertainty are propagated, but if you check the ‘Propagate External Uncertainties from:’ box then all external uncertainties will be propagated unless otherwise specified. Error propagation is performed analytically by default, but if you chose to employ Monte Carlo error propagation, a default population size of 8192 (i.e., 2^{13}) is used. To edit the population size, you may enter integer values or powers

using the '^' character. For example, if you enter '2^14' in the text field and press 'Enter', the population size will be set to $2^{14} = 16384$. The default values for all options in the 'Calculation Options' subpanel can be edited in the ArAR preferences pane (see [Editing ArAR Preferences](#)).

If you would like to preview the effects of recalculating $^{40}\text{Ar}/^{39}\text{Ar}$ dates with the constants and options you have entered/selected, you can click the 'Preview' button located in the 'Calculation Options' subpanel above the 'Execute' button, or use the hotkey combination 'Meta + P', where 'Meta' is the 'Ctrl' key on a Windows machine and the 'Cmd' key on a Macintosh (see [Previewing Recalculation Results](#) for more information). To recalculate the selected $^{40}\text{Ar}/^{39}\text{Ar}$ dates using the constants and options that you have entered/selected, press the 'Execute' button in 'Calculation Options' subpanel ([Fig. 13](#)). See the [Calculations](#) documentation for details on the equations used for recalculating $^{40}\text{Ar}/^{39}\text{Ar}$ dates.

4.4 The Main ArAR Change Log

For each sample (i.e., row) in datasets that are loaded into or created within ArAR, there is a change log that tracks all information relevant to recalculating K-Ar or $^{40}\text{Ar}/^{39}\text{Ar}$ dates, as well as ancillary information related to the ^{40}K decay constants, K isotopic abundances, monitor minerals, and any warnings that have been activated (e.g., if you have edited values from the ArAR libraries, or if relative uncertainties have been assumed where values are missing). The change log is intended to preserve a complete record of all age recalculations, and can be exported either on its own or appended to the right of its affiliated dataset (see [Exporting the Change Log](#)). To quickly view the recalculation history of K-Ar and/or $^{40}\text{Ar}/^{39}\text{Ar}$ dates in ArAR, see the section on [Viewing the Recalculation History](#).

The values that are required to recalculate K-Ar dates are: t_o , $\lambda_{^{40}\text{Ar}_o}$, λ_o , $\lambda_{^{40}\text{Ar}}$, λ , $^{40}\text{K}_{ao}$, and $^{40}\text{K}_a$. These quantities and their 1σ uncertainties are all recorded in the change log, along with the recalculated K-Ar date, t .

The values that are required to recalculate $^{40}\text{Ar}/^{39}\text{Ar}$ dates are: t_o , λ_o , λ , t_{m_o} , and t_m . These quantities and their 1σ uncertainties are all recorded in the change log, along with the recalculated $^{40}\text{Ar}/^{39}\text{Ar}$ date, t .

If a K-Ar or $^{40}\text{Ar}/^{39}\text{Ar}$ date is recalculated multiple times (e.g., by converting first to one set of constants, and then from those to a second set), the change log for that date will preserve all of the values used for each step.

For a full list and explanations of the quantities that are recorded in the main ArAR change log, see the [Nomenclature](#) documentation.

5 Additional Tools

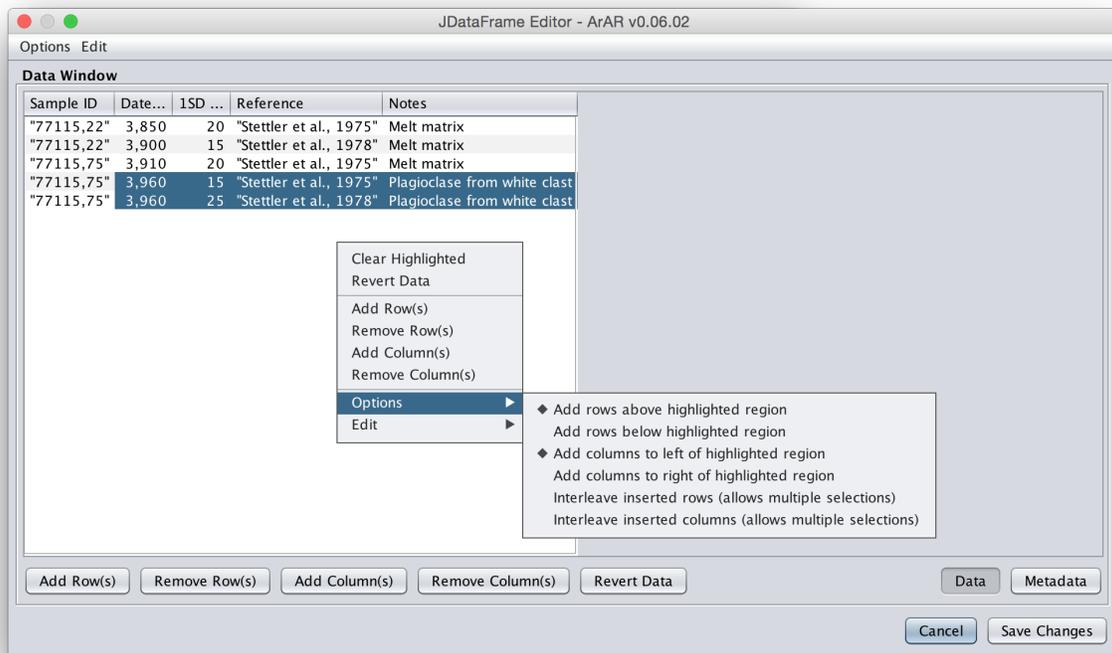


Figure 15. The advanced JDataFrame Editor with the example dataset from Fig. 2 shown. Note that the add/remove rows/columns buttons and contextual menu items operate based on the number and locations of highlighted cells. The ‘Editing Options’ are accessible from both the contextual menu and the drop-down menu of the same name at the top left of the JDataFrame Editor window.

5.1 Advanced JDataFrame Editor

While the numeric data and notes of a dataset can be edited directly in the main ArAR window, the advanced JDataFrame Editor (Fig. 15) provides a number of additional editing capabilities. The advanced editor can be accessed by selecting the ‘Edit Dataset’ item from the ‘Tools’ menu, or by using the hotkey combination ‘Meta + E’, where ‘Meta’ is the ‘Ctrl’ key on a Windows machine and the ‘Cmd’ key on a Macintosh. In the JDataFrame Editor, you may edit the column names and row names of the dataset (remember to press ‘Enter’ when you are done!) as well as the numeric data and notes. You may also insert or append rows and columns relative to cells that you highlight by clicking and dragging your mouse cursor in the table. Rows can either be added above or below the highlighted cells, and columns can be added to the right or left of the highlighted cells. To choose between these options, you can click on the ‘Editing Options’ menu in the top left of the JDataFrame Editor window, or right-click in the table to activate a contextual menu and access the editing options (Fig. 15). Additionally, you may choose to have the inserted rows or columns interleaved with the cells that you highlight (activate this behavior in the ‘Editing Options’). An example of this would be if you imported a dataset without uncertainties for multiple columns of dates, and you would like to insert columns to the right of each column of dates. You may clear the current highlighting of cells using the contextual menu. Finally, you may revert all

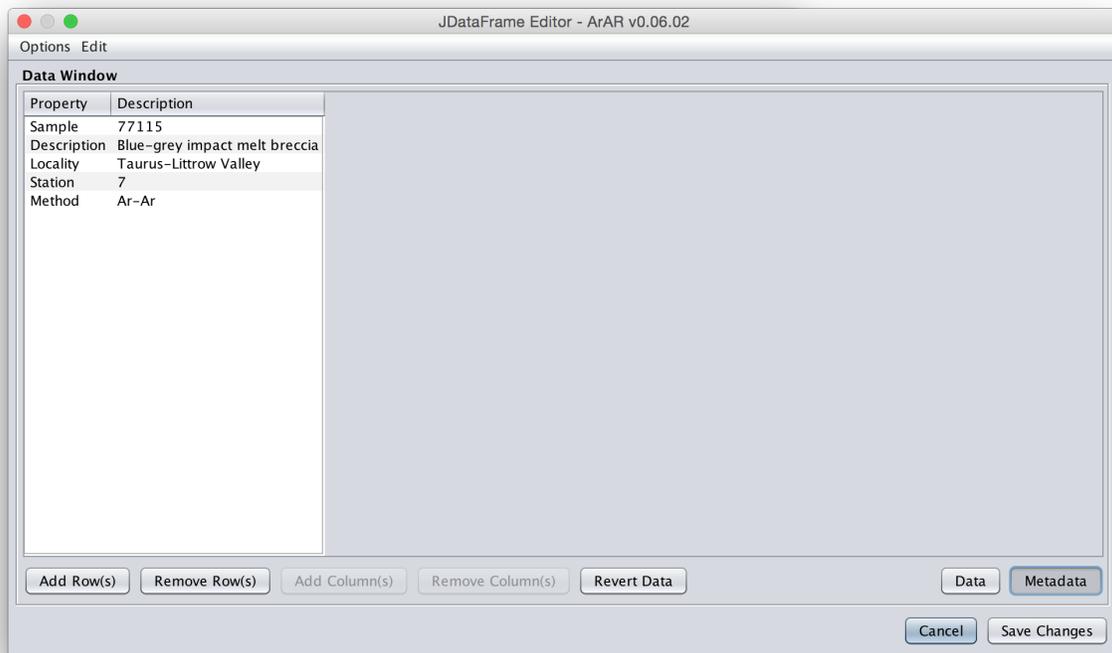


Figure 16. The advanced JDataFrame Editor with the metadata for the example dataset from Fig. 2 shown. Note that only the add/remove rows buttons (and contextual menu items) are enabled when editing metadata.

of the data to their original (un-edited) state by clicking on the ‘Revert Data’ button or selecting the contextual menu item of the same name.

In addition to viewing and editing the contents of a dataset, the advanced JDataFrame Editor allows you to view any metadata that are associated with the data (Fig. 16). This allows you to edit any of the existing metadata properties and descriptions, as well as add or remove metadata entries.

Once you are done editing the data and/or metadata in the JDataFrame Editor, you can click ‘Save Changes’ to transfer your modifications to the main ArAR window, or click ‘Cancel’ to scrap your changes. If you have added or removed rows or columns to the dataset, then a new dataset is created with the string ‘Edited’ appended to the name of the original dataset, and both the original and edited datasets are selectable from the drop-down menu at the bottom left of the main ArAR window.

5.2 Previewing Recalculation Results

Once you have specified values for the ^{40}K decay constants and K isotopic abundances (for the K-Ar algorithm) or monitor mineral ages (for the $^{40}\text{Ar}/^{39}\text{Ar}$ algorithm), you can preview the effects of recalculating K-Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ dates. This does not require a dataset to be created or imported. Rather, a synthetic set of dates are automatically generated that span the age of the Solar System, and they are recalculated using your present selection of constants. The results are

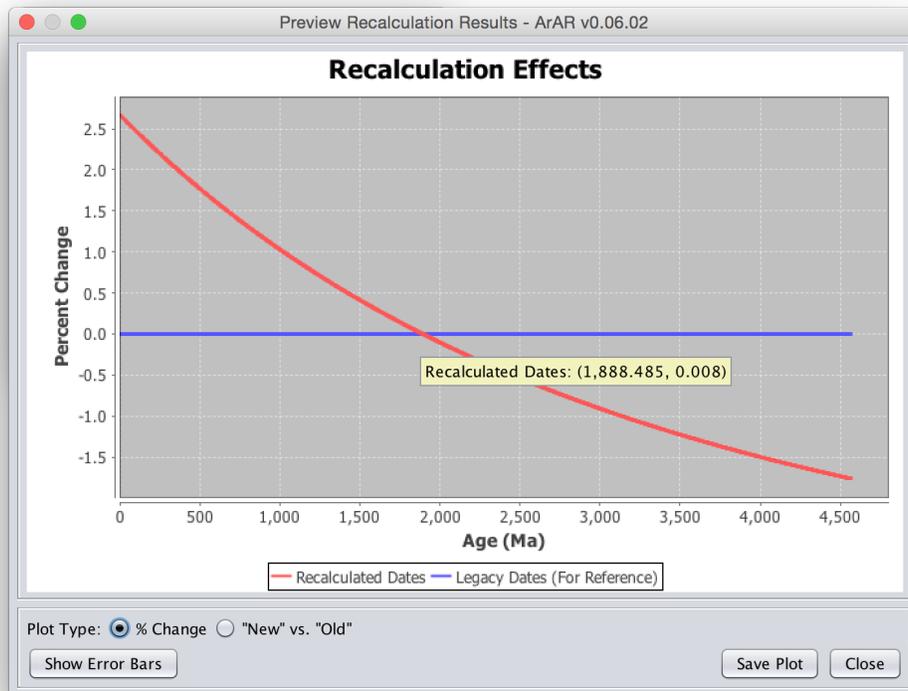


Figure 17. An example preview plot of recalculation results, shown as a percentage change from the original synthetic dates.

plotted either as a percentage change from the original synthetic dates (Fig. 17), or on a plot of recalculated vs. original dates (Fig. 18). These preview plots can be opened by: (1) clicking on the ‘Preview’ button located just above the ‘Execute’ button in the ‘Calculation Options’ subpanel (e.g., Fig. 14); (2) by selecting the ‘Preview Results’ item from the ‘Tools’ menu; or (3) by using the hotkey combination: ‘Meta + P’, where ‘Meta’ is the ‘Ctrl’ key on a Windows machine and the ‘Cmd’ key on a Macintosh.

Once the preview plot panel is open, you can switch between the two plot types using the radio buttons at the bottom left of the figure. In addition, you can choose to show the propagated uncertainties on the plots by clicking the ‘Show Error Bars’ button. By default, the relative uncertainty for the original synthetic dates is assumed to be 1 %, but you can freely edit this value (using the text field that appears when the ‘Show Error Bars’ button is selected), and the plot will automatically update to use the new value.

You can zoom into the plot by clicking your mouse cursor on the plot and dragging down and to the right to select a smaller sub-region. To zoom back out, click your mouse cursor on the plot and drag up and to the left. If you would like to export a copy of the preview plot, use the ‘Save Plot’ button in the lower right corner of the preview panel, and specify a destination for the file. You can export the plots as either *.png or *.jpeg files. To return to the main ArAR window, click the ‘Close’ button.

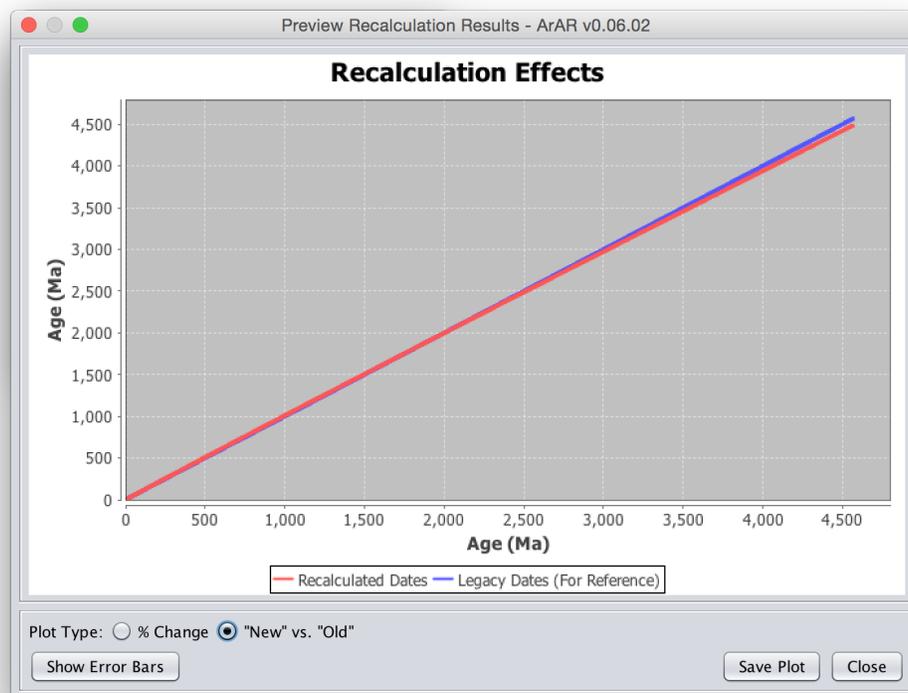


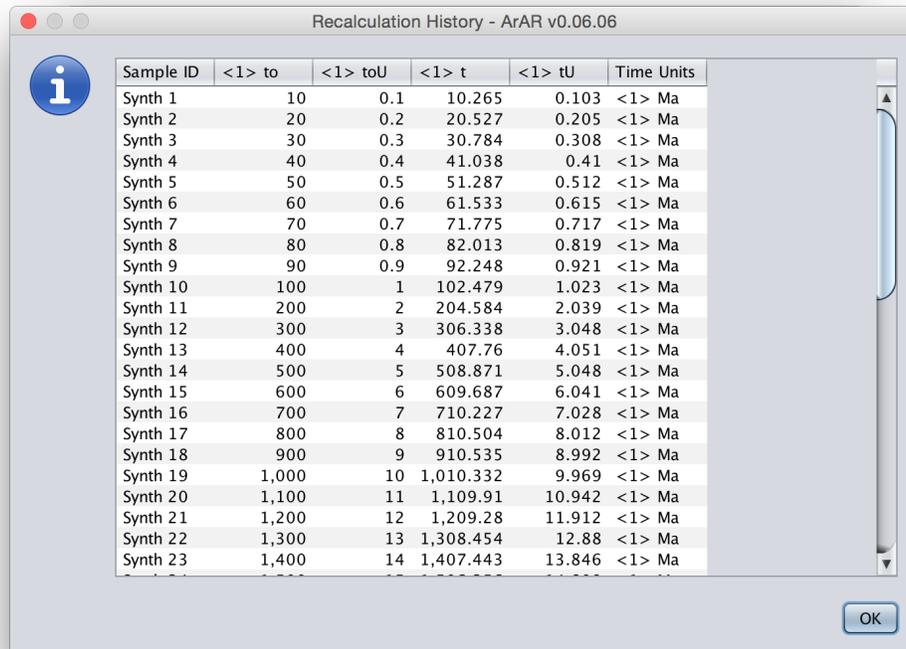
Figure 18. An example preview plot of recalculation results, showing the recalculated dates versus the original synthetic dates.

5.3 Viewing the Recalculation History

You may view the change history after recalculating K-Ar or $^{40}\text{Ar}/^{39}\text{Ar}$ dates one or more times by selecting the ‘View Recalculation History’ item from the ‘Tools’ menu or by using the hotkey combination ‘Meta + Shift + H’, where ‘Meta’ is the ‘Ctrl’ key on a Windows machine and the ‘Cmd’ key on a Macintosh. The ‘Recalculation History’ dialog box will appear (Fig. 19) containing the change history of the dates that are selected in the main ArAR window (see [Selecting Dates to Recalculate or Revert](#)). The dialog shows: (1) the row names associated with each recalculated date; (2) four columns with the original and recalculated dates and their uncertainties (i.e., t_o , σ_{t_o} , t , and σ_t) for each time that you executed calculations; and (3) a column listing the units of time associated with each set of calculations. The column names for the original and recalculated dates conform to the conventions used in the main ArAR change log (see the [Nomenclature](#) documentation). **Note:** the values that are displayed in the Recalculation History Tool are not affected by rounding (see the section on the [Rounding Tool](#)).

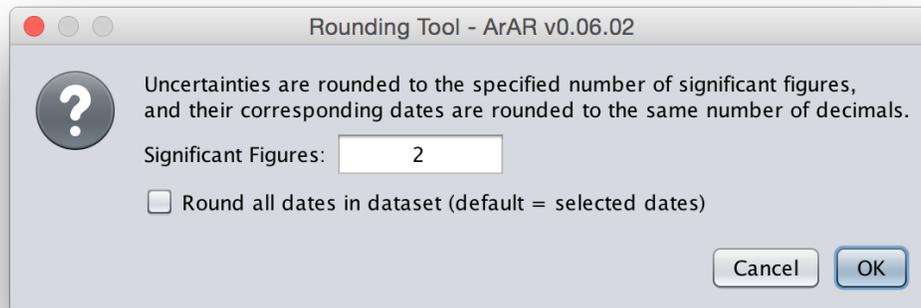
5.4 Rounding Measurements to the Proper Number of Significant Digits

After recalculating K-Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ dates, the results are stored as double-precision 64-bit IEEE 754 floating point numbers. You can either round the results yourself outside of ArAR, or



Sample ID	<1> to	<1> toU	<1> t	<1> tU	Time Units
Synth 1	10	0.1	10.265	0.103	<1> Ma
Synth 2	20	0.2	20.527	0.205	<1> Ma
Synth 3	30	0.3	30.784	0.308	<1> Ma
Synth 4	40	0.4	41.038	0.41	<1> Ma
Synth 5	50	0.5	51.287	0.512	<1> Ma
Synth 6	60	0.6	61.533	0.615	<1> Ma
Synth 7	70	0.7	71.775	0.717	<1> Ma
Synth 8	80	0.8	82.013	0.819	<1> Ma
Synth 9	90	0.9	92.248	0.921	<1> Ma
Synth 10	100	1	102.479	1.023	<1> Ma
Synth 11	200	2	204.584	2.039	<1> Ma
Synth 12	300	3	306.338	3.048	<1> Ma
Synth 13	400	4	407.76	4.051	<1> Ma
Synth 14	500	5	508.871	5.048	<1> Ma
Synth 15	600	6	609.687	6.041	<1> Ma
Synth 16	700	7	710.227	7.028	<1> Ma
Synth 17	800	8	810.504	8.012	<1> Ma
Synth 18	900	9	910.535	8.992	<1> Ma
Synth 19	1,000	10	1,010.332	9.969	<1> Ma
Synth 20	1,100	11	1,109.91	10.942	<1> Ma
Synth 21	1,200	12	1,209.28	11.912	<1> Ma
Synth 22	1,300	13	1,308.454	12.88	<1> Ma
Synth 23	1,400	14	1,407.443	13.846	<1> Ma

Figure 19. The ArAR Recalculation History Tool dialog box, with an example synthetic dataset that has been recalculated once.



Uncertainties are rounded to the specified number of significant figures, and their corresponding dates are rounded to the same number of decimals.

Significant Figures:

Round all dates in dataset (default = selected dates)

Cancel OK

Figure 20. The ArAR Rounding Tool dialog box.

you can use the built-in rounding tool by selecting the ‘Round to Sig Figs’ item from the ‘Tools’ menu or by using the hotkey combination ‘Meta + R’, where ‘Meta’ is the ‘Ctrl’ key on a Windows machine and the ‘Cmd’ key on a Macintosh. The ‘Rounding Tool’ dialog box will appear (Fig. 20) prompting you for the number of significant figures⁷ to round to (the default is 2). By default, only those data in the selected rows are rounded, but you can override this in the dialog box by checking the ‘Round all dates in dataset’ box. By clicking ‘OK’, the data in the active columns (see [Selecting Dates to Recalculate or Revert](#)) will be rounded using the following

⁷To learn about significant figures, see: http://en.wikipedia.org/wiki/Significant_figures.

method. First, the uncertainty for each date will be rounded to the specified number of significant figures. Next, the corresponding date will be rounded to the same decimal location as the least significant digit in the uncertainty. All rounding is performed using the unbiased ‘round-half-to-even’ approach (see http://en.wikipedia.org/wiki/Rounding#Round_half_to_even).

Warning: After using the ArAR Rounding Tool, you will still need to visually inspect the rounded results to ensure that the dates and uncertainties are displayed with the proper number of digits/decimals/significant figures. This is because of how Java and other software packages, such as Microsoft *Excel*, handle the display of floating point numbers in a table. Specifically, most software packages trim trailing zeros from decimal numbers (under the assumption that such an action should be considered a feature rather than a bug). For example, if there is a rounded date that should be represented as ‘124.20 ± 0.58 Ma’ (2 significant figures in the uncertainty), ArAR (and *Excel*) will instead show the date as ‘124.2’ and the uncertainty as ‘0.58’ by default. As another example, the rounded date ‘236.2 ± 1.0 Ma’ (2 significant figures in the uncertainty) will be incorrectly displayed with the values ‘236.2’ and ‘1’. Thus, while the ArAR Rounding Tool can do much of the leg-work for you, you must be on the lookout for the rather unfortunate ‘trim-the-trailing-zeros’ feature of many spreadsheet-based programs (including ArAR).

5.5 The Multiple Intercalibration Tool

The ArAR Multiple Intercalibration Tool allows a K-bearing sample to be intercalibrated relative to a ‘primary’ standard and an arbitrary number of secondary standards with known K-Ar or $^{40}\text{Ar}/^{39}\text{Ar}$ ages. Note, the Multiple Intercalibration Tool cannot be used to account for differences in ^{40}K decay constants, K isotopic abundances, or monitor mineral ages. Furthermore, it should only be used with data from samples that were irradiated simultaneously and in the same position within the package the was sent to a nuclear reactor. See the **Calculations** documentation for details on the equations used for multiple intercalibration of coirradiated samples.

The Multiple Intercalibration Tool can be opened by selecting the ‘Multiple Intercalibration’ item from the ‘Tools’ menu or by using the hotkey combination: ‘Meta + M’, where ‘Meta’ is the ‘Ctrl’ key on a Windows machine and the ‘Cmd’ key on a Macintosh. The ‘Multiple Intercalibration Tool’ window will appear (Fig. 21), allowing you to specify all of the parameters that are required to intercalibrate a sample. In the ‘Algorithm Selection’ subpanel, you can select one of two forms for the data required for the primary standard, and you can select one of two forms for the data required for the intercalibration factors, R_i^{i+1} . The equations show in the ‘Algorithm Selection’ subpanel will update, and input fields for quantities in the ‘Sample/Unknown’, ‘Primary Standard’, and ‘Secondary Standard(s)’ subpanels will be enabled or disabled, to reflect your algorithm selections.

Algorithm Selection

Primary Monitor: $^{40}\text{Ar}^*/^{40}\text{K}$ $\exp[\lambda t] - 1$

$$t_u \equiv t_{n-1} = \frac{1}{\lambda} \log \left[\frac{\lambda}{\lambda_{40\text{Ar}}} \left(\frac{^{40}\text{Ar}^*}{^{40}\text{K}} \right)_0 \prod_{i=0}^{n-1} R_i^{i+1} + 1 \right]$$

Form of R: $^{40}\text{Ar}^*/^{39}\text{Ar}_K$ $\exp[\lambda t] - 1$

$$R_i^{i+1} \equiv \frac{(^{40}\text{Ar}^*/^{39}\text{Ar}_K)_{i+1}}{(^{40}\text{Ar}^*/^{39}\text{Ar}_K)_i}$$

K Decay Constants

Custom

$\lambda_{40\text{Ar}}$: 0.0 \pm 0.0 $\times 10^{-10} \text{ a}^{-1}$

λ_β : 0.0 \pm 0.0 $\times 10^{-10} \text{ a}^{-1}$

λ : 0.0 \pm 0.0 $\times 10^{-10} \text{ a}^{-1}$

Use Calculated Values

Sample/Unknown

Use last secondary standard as unknown

Sample: Custom Select Reference

Name: Unknown

t_{n-1} : 0.0 \pm 0.0 Ma

$^{40}\text{Ar}^*/^{39}\text{Ar}_K$: 0.0 \pm 0.0

Primary Standard

Calculate κ from standard age

Standard: Custom Select Reference

Name: Unknown

t_o : 0.0 \pm 0.0 Ma

$^{40}\text{Ar}^*/^{40}\text{K}$: 0.0 \pm 0.0

$^{40}\text{Ar}^*/^{39}\text{Ar}_K$: 0.0 \pm 0.0

Secondary Standard(s)

Standard Name	40Ar*/39Ar	1SD 40Ar*/39Ar

Append

Insert

Replace

Remove

Standard: Custom Select Reference

Name: Unknown

t_i : 0.0 \pm 0.0 Ma

$^{40}\text{Ar}^*/^{39}\text{Ar}_K$: 0.0 \pm 0.0

Intercalibration Options and Results

Calculation Options:

Propagate External Uncertainties

Analytical Error Propagation Monte Carlo Error Propagation

Synthetic Population Size: 8192

Warning Missing Values

Warning Missing Uncertainties

Execute

Multiple Intercalibration Tool

Instructions:

- (1) Select an algorithm
- (2) Select/enter values for K decay constants (required)
- (3) Select/enter data for:
 - [1] the unknown/sample to intercalibrate (required)
 - [2] the primary standard (required)
 - [3] one or more secondary standards
- (4) Select the desired calculation options
- (5) Press "Execute"

Export... Close

Figure 21. The ArAR Multiple Intercalibration Tool window, shown in its default state.

In the ‘K Decay Constants’ subpanel, you may directly enter values for the ^{40}K decay constants (remember to press ‘Enter’ after editing a value!), or you may auto-fill these values by selecting references from the ArAR library using the drop-down menu. (**Note:** All uncertainties for input parameters in the ArAR Multiple Intercalibration Tool are assumed to be 1σ values.) When editing or selecting values for the ^{40}K decay constants, the total decay constant and its associated uncertainty ($\lambda \pm \sigma_\lambda$) are calculated from the partial decay constants by default⁸. You may edit the values for the total decay constants by unchecking the ‘Use Calculated Values’ check boxes in the ‘K Decay Constants’ subpanel. Also, you may alter the default behavior to always require manual input for the total decay constants using the ArAR preferences pane (see [Editing ArAR Preferences](#)).

⁸Note (without loss of generality) that $\lambda \equiv \lambda_{40\text{Ar}} + \lambda_\beta$. The uncertainties in the decay constants are propagated analytically as $\sigma_\lambda = (\sigma_{\lambda_{40\text{Ar}}}^2 + \sigma_\beta^2)^{1/2}$

In the ‘Primary Standard’ subpanel, you may specify the name and values for the age ($t_0 \pm \sigma_{t_0}$), κ value (${}^{40}\text{Ar}^*/{}^{40}\text{K} \pm \sigma_{{}^{40}\text{Ar}^*/{}^{40}\text{K}}$), and/or the measured ${}^{40}\text{Ar}^*/{}^{39}\text{Ar}_K$ ratio ($\pm \sigma_{{}^{40}\text{Ar}^*/{}^{39}\text{Ar}_K}$) of the primary standard. The information that you are required to enter depends on your algorithm selections and whether you have checked the boxes labelled ‘Calculate κ from standard age’ or ‘Calculate standard age from κ ’ (only one of which will be visible, depending on your primary algorithm selection and assuming you have selected the (${}^{40}\text{Ar}^*/{}^{39}\text{Ar}_K$) algorithm for the form of R_i^{i+1}). You will be able to auto-fill values from either the library of monitor ages or the library of monitor κ values depending on your algorithm selections. If you have selected the (${}^{40}\text{Ar}^*/{}^{40}\text{K}$) primary monitor algorithm and the $(\exp[\lambda t] - 1)$ algorithm for the form of R_i^{i+1} , you will be able to select either the ‘Monitor Age Library’ or the ‘Monitor κ Library’ as the source for auto-filled values. If you selected the $(\exp[\lambda t] - 1)$ options for both of the algorithms, you can only auto-fill values from the monitor age library. In most cases, κ will be calculated automatically from the primary standard age, t_0 , or vice versa, depending on your algorithm and library source selections. (Note: you will see ‘NaN’ values if you have not specified values for the ${}^{40}\text{K}$ decay constants.) If both sets of input fields are enabled for the primary standard age and κ values, you can manually enter values for both quantities to override any calculated values.

In the ‘Sample/Unknown’ and ‘Secondary Standard(s)’ subpanels, you may specify the name and values for either the age ($t_{n-1} \pm \sigma_{t_{n-1}}$) or the measured ${}^{40}\text{Ar}^*/{}^{39}\text{Ar}_K$ ratio ($\pm \sigma_{{}^{40}\text{Ar}^*/{}^{39}\text{Ar}_K}$) of the sample/unknown that is being intercalibrated or a secondary standard. The information that you are required to enter depends on your algorithm selection for R_i^{i+1} . If the fields for the sample/unknown/secondary standard age are enabled, you may auto-fill the values from the ArAR library by selecting a standard name and reference from the dropdown menus (see Fig. 21). Once you have specified the required data in the ‘Secondary Standard(s)’ subpanel, you must append/insert those values into the secondary standards list using the appropriate buttons. If you would like to modify the data shown for a standard in the list, you can specify the values in the appropriate fields, highlight the standard in the list that you would like to update by clicking on it, and then click the ‘Replace’ button. To remove a standard from the list, highlight it and click the ‘Remove’ button. If no standard is highlighted in the list, the ‘Insert’ button will append data to the end of the list, the ‘Replace’ button will update the last standard in the list, and the ‘Remove’ button will remove the last standard from the list. Use the buttons with the up/down arrows to shift selected standards up or down in the list. If no standard is highlighted in the list, the arrow buttons will do nothing. If you check the box labelled ‘Use last secondary standard as unknown’ in the ‘Sample/Unknown’ subpanel, then all controls in that panel will be disabled and the data entered for the last secondary standard that is appended to the list will be used for the sample/unknown.

As you begin specifying values in the ‘K Decay Constants’, ‘Sample/Unknown’, ‘Primary Standard’, and/or ‘Secondary Standard(s)’ subpanels, you will notice large warning buttons near

the bottom left of the ‘Intercalibration Options and Results’ subpanel. You may click on the warning buttons to see which values you are missing. These warning buttons will disappear once you have entered the minimum amount of information that is required for multiple intercalibration calculations, and the ‘Execute’ button will light up. Also in the ‘Intercalibration Options and Results’ subpanel, you have the option to propagate external uncertainties (from the ^{40}K decay constants), and you can select whether error propagation will be performed analytically or by a Monte Carlo approach. (See the [Calculations](#) documentation for details on error propagation.)

If you have added data for at least one sample/unknown and one secondary standard and have the ($^{40}\text{Ar}^*/^{39}\text{Ar}_K$) algorithm selected for the form of R_i^{i+1} , a checkbox labelled ‘Perform Additional Intercalibration with Mean $^{40}\text{Ar}^*/^{39}\text{Ar}_K$ Value’ will appear. If all of the sample/unknown and ‘secondary standard’ grains are the same mineral type and are from the same rock (and were coirradiated)⁹, consider selecting this checkbox. This activates a supplementary intercalibration algorithm where the mean $^{40}\text{Ar}^*/^{39}\text{Ar}_K$ value is determined before calculating the intercalibration factor between the sample S and the primary monitor P , R_P^S . When you check the ‘Perform Additional Intercalibration with Mean $^{40}\text{Ar}^*/^{39}\text{Ar}_K$ Value’ box, additional calculation options appear ([Fig. 22](#)). In particular, you may select whether the Multiple Intercalibration Tool calculates an arithmetic or an inverse-variance weighted mean $^{40}\text{Ar}^*/^{39}\text{Ar}_K$ value from the sample data. If you select the arithmetic mean, you also have the option of having the Multiple Intercalibration Tool calculate the standard deviation or the standard deviation of the mean for the mean $^{40}\text{Ar}^*/^{39}\text{Ar}_K$ value. Finally, if you check the ‘Perform Additional Intercalibration with Mean $^{40}\text{Ar}^*/^{39}\text{Ar}_K$ Value’ box, an additional checkbox appears that is labelled ‘Expand Uncertainties for Mean’. This is selected by default, and the Multiple Intercalibration Tool will expand the uncertainty for the mean $^{40}\text{Ar}^*/^{39}\text{Ar}_K$ value if it detects a high degree of dispersion in the sample data. (See the [Calculations](#) documentation for more details on the uncertainty types, how they are used in error propagation, and how the error expansion is performed.)

Once you have finished specifying the input parameters and calculation options, click the ‘Execute’ button to perform intercalibration calculations. The text field on the right side of the ‘Intercalibration Options and Results’ subpanel (which contains basic instructions the first time you open the Multiple Intercalibration Tool, e.g., [Fig. 22](#)) will fill with a report of results. Note that all values and their associated uncertainties have been rounded as if by the [Rounding Tool](#) using two significant figures. Additionally, the ‘Export...’ button will light up at the bottom right corner of the Multiple Intercalibration Tool window. When you click on the ‘Export...’ button, a dialog appears allowing you to specify a folder in which to export the ‘Intercalibration Summary Report’ and/or the ‘Full Intercalibration Log’ ([Fig. 23](#)). The ‘Intercalibration Summary Report’ is exported

⁹If these conditions apply, the distinction between sample/unknown and secondary standards no longer applies, and the ArAR Multiple Intercalibration Tool can treat them as a single group.

Algorithm Selection

Primary Monitor: $^{40}\text{Ar}^*/^{40}\text{K}$ $\exp[\lambda t] - 1$

$$t_u \equiv t_{n-1} = \frac{1}{\lambda} \log \left[\frac{\lambda}{\lambda_{39\text{Ar}}} \left(\frac{^{40}\text{Ar}^*}{^{40}\text{K}} \right)_0 \prod_{i=0}^{n-1} R_i^{i+1} + 1 \right]$$

Form of R: $^{40}\text{Ar}^*/^{39}\text{Ar}_K$ $\exp[\lambda t] - 1$

$$R_i^{i+1} \equiv \left(\frac{^{40}\text{Ar}^*/^{39}\text{Ar}_K \right)_{i+1} / \left(\frac{^{40}\text{Ar}^*/^{39}\text{Ar}_K \right)_i$$

K Decay Constants

Steiger and Jager, 1977

$\lambda_{^{40}\text{Ar}}$: 0.581 ± 0.00581 × 10⁻¹⁰ a⁻¹

λ_{β} : 4.962 ± 0.04962 × 10⁻¹⁰ a⁻¹

λ : 5.543 ± 0.050 × 10⁻¹⁰ a⁻¹

Use Calculated Values

Sample/Unknown

Use last secondary standard as unknown

Sample: Custom Select Reference

Name: Unknown

t_{n-1} : 0.0 ± 0.0 Ma

$^{40}\text{Ar}^*/^{39}\text{Ar}_K$: 0.0 ± 0.0

Primary Standard

Calculate κ from standard age

Standard: GA-1550 Renne et al., 1998

Name: GA-1550

t_o : 98.79 ± 0.27 Ma

$^{40}\text{Ar}^*/^{40}\text{K}$: 0.005900 ± 0.000017

$^{40}\text{Ar}^*/^{39}\text{Ar}_K$: 4.937 ± 0.0027

Secondary Standard(s)

Standard Name	$^{40}\text{Ar}^*/^{39}\text{Ar}$	1SD $^{40}\text{Ar}^*/^{39}\text{Ar}$
FCs-A	1.374	0.001
FCs-B	1.378	0.001
FCs-C	1.366	0.001
FCs-D	1.374	0.001

Append Insert Replace Remove

Standard: Custom Select Reference

Name: FCs-D

t_i : 0.0 ± 0.0 Ma

$^{40}\text{Ar}^*/^{39}\text{Ar}_K$: 1.3742 ± 0.0008

Intercalibration Options and Results

Calculation Options:

Perform Additional Intercalibration with Mean $^{40}\text{Ar}^*/^{39}\text{Ar}$ Value

Use Arithmetic Mean Use Weighted Mean

Use Standard Deviation Use Standard Deviation of the Mean

Propagate External Uncertainties Expand Uncertainties for Mean

Analytical Error Propagation Monte Carlo Error Propagation

Synthetic Population Size: 8192

Execute

Multiple Intercalibration Tool

Instructions:

- (1) Select an algorithm
- (2) Select/enter values for K decay constants (required)
- (3) Select/enter data for:
 - [1] the unknown/sample to intercalibrate (required)
 - [2] the primary standard (required)
 - [3] one or more secondary standards
- (4) Select the desired calculation options
- (5) Press "Execute"

Export... Close

Figure 22. The ArAR Multiple Intercalibration Tool window, shown with supplemental intercalibration options in the ‘Intercalibration Options and Results’ subpanel.

as a plain text file, and contains an exact copy of the results shown in the text field at the bottom right corner of the Multiple Intercalibration Tool. The ‘Full Intercalibration Log’ is exported as a tab-delimited file (openable in *Excel*), and contains all intercalibration results, input values, algorithm selections, and calculation options that were used by the Multiple Intercalibration Tool. (Note: all values exported in the ‘Full Intercalibration Log’ are shown to the tenth decimal place.) See the **Nomenclature** documentation for details on all of the quantities that are exported in the ‘Full Intercalibration Log’.

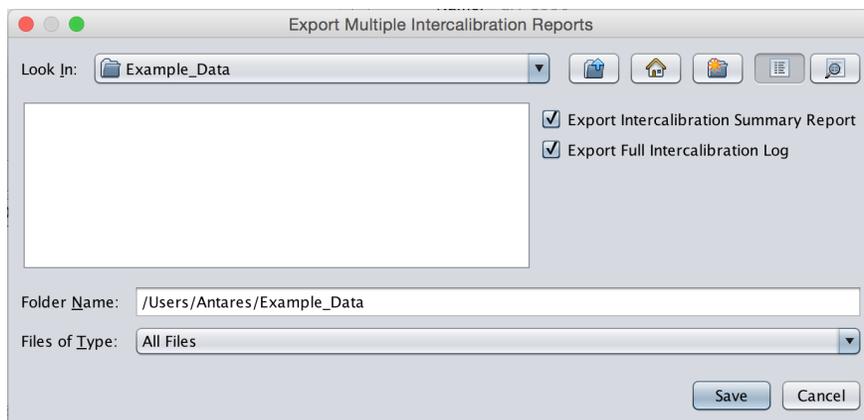


Figure 23. The Export Multiple Intercalibration Reports dialog.

6 The ArAR Libraries

To facilitate rapidly recalculating K-Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ dates, *ArAR* has four user-editable libraries containing values for: (1) ^{40}K decay constants, (2) K isotopic abundances, (3) ages reported for common monitor minerals, and (4) $^{40}\text{Ar}^*/^{40}\text{K}$ values for common monitor minerals. The default libraries that are distributed with *ArAR* only contain some of the more common sets of constants for these three quantities, and are undoubtedly incomplete. Thus, you can freely edit the *ArAR* libraries, either directly within *ArAR*, or by editing the tab-delimited text files in the ‘Library’ directory, which is extracted when *ArAR* starts. You can open a library for editing by selecting from the ‘Library’ menu. A JDataFrame Editor will launch, allowing you to modify the contents and metadata for the selected library (e.g., Fig. 24). However, you will be unable to add or remove columns to the libraries. This is because the libraries are expected to conform to a strict layout and column order. If you edit the libraries using software other than *ArAR* (e.g., using Microsoft *Excel*), do not add, remove, or rearrange the columns. To recover a default *ArAR* library, simply delete the library in question from the ‘Library’ directory and restart *ArAR*; a new copy will be extracted. However, be aware that any entries you have made will be lost. If you have suggestions for library entries that should be included with *ArAR* by default, please contact me at: cameron.m.mercer@asu.edu.

See the [Nomenclature](#) documentation for an explanation of the plain-text column headings that appear in the tab-delimited text files of the *ArAR* libraries. Also, see the section on the [Advanced JDataFrame Editor](#) for more information on how to edit the *ArAR* libraries.

6.1 ^{40}K Decay Constants

The ^{40}K decay constants library contains the following columns of information (in the specified order, from left to right): (1) a short reference (this is used in the drop-down menus in the main

Short Reference	L_40...	L_40...	L_b (...)	L_b ...	Full Reference
Aldrich and Wetherill, 1958	0.585	-1	4.72	-1	"Aldrich, L. T., and G. W. Wetherill, 1958. Geochronology by radioactive decay. Annual Review in Nuc
Beckinsale and Gale, 1969	0.575	0.004	4.905	0.009	"Beckinsale, R. D., and N. H. Gale, 1969. A reappraisal of the decay constants and branching ratio o
Steiger and Jager, 1977	0.581	-1	4.962	-1	"Steiger, R. H., and E. Jager, 1977. Subcommission on geochronology: Convention on the use of deca
Endt, 1990	0.579	0.011	4.849	0.022	"Endt, P. M., 1990. Energy levels of A = 21-44 nuclei (VII). Nuclear Physics, A521, pp. 1-830."
Audi et al., 1997	0.582	0.007	4.846	0.007	"Audi, G., O. Bersillon, J. Blachot, and A. H. Wapstra, 1995. The NUBASE evaluation of nuclear and de
Min et al., 2000	0.58	0.014	4.884	0.099	"Min, K., R. Mundil, P. R. Renne, and K. R. Ludwig, 2000. A test for systematic errors in $^{40}\text{Ar}/^{39}\text{Ar}$ g
Audi et al., 2003	0.594	0.007	4.947	0.007	"Audi, G., O. Bersillon, J. Blachot, and A. H. Wapstra, 2003. The NUBASE evaluation of nuclear and de
Renne et al., 2010	0.576	0.002	4.974	0.009	"Renne, Paul R., Roland Mundil, Greg Balco, Kyoungwon Min, Kenneth R. Ludwig, 2010. Joint determi
Renne et al., 2011	0.576	0.002	4.955	0.013	"Renne, Paul R., Greg Balco, Kenneth R. Ludwig, Roland Mundil, Kyoungwon Min, 2011. Response to

Figure 24. An example of editing an ArAR library. The ^{40}K decay constants library is shown here.

ArAR GUI); (2) the partial decay constant of ^{40}K that accounts for the production of ^{40}Ar , $\lambda_{^{40}\text{Ar}}$; (3) the 1σ uncertainty in $\lambda_{^{40}\text{Ar}}$, i.e., $\sigma_{\lambda_{^{40}\text{Ar}}}$; (4) the partial decay constant of ^{40}K that accounts for the production of ^{40}Ca , λ_{β} ; (5) the 1σ uncertainty in λ_{β} , i.e., $\sigma_{\lambda_{\beta}}$; and (6) the full reference from which the values for $\lambda_{^{40}\text{Ar}}$ and λ_{β} were sourced. The number ‘-1’ indicates that a value was not reported by the reference from which the data were taken. The ^{40}K decay constants library is stored in the tab-delimited text file named ‘arLib_K_dc.txt’ in the ‘Library’ directory.

6.2 K Isotopic Abundances

The library of K isotopic abundance values contains the following columns of information (in the specified order, from left to right): (1) a short reference (this is used in the drop-down menus in the main ArAR GUI); (2) the abundance of ^{39}K relative to total K, $^{39}\text{K}_a$; (3) the 1σ uncertainty in $^{39}\text{K}_a$, i.e., $\sigma_{^{39}\text{K}_a}$; (4) the abundance of ^{40}K relative to total K, $^{40}\text{K}_a$; (5) the 1σ uncertainty in $^{40}\text{K}_a$, i.e., $\sigma_{^{40}\text{K}_a}$; (6) the abundance of ^{41}K relative to total K, $^{41}\text{K}_a$; (7) the 1σ uncertainty in $^{41}\text{K}_a$, i.e., $\sigma_{^{41}\text{K}_a}$; (8) the ratio $^{39}\text{K}_a/^{41}\text{K}_a$; (9) the 1σ uncertainty in $^{39}\text{K}_a/^{41}\text{K}_a$, i.e., $\sigma_{^{39}\text{K}_a/^{41}\text{K}_a}$; (10) the ratio $^{41}\text{K}_a/^{40}\text{K}_a$; (11) the 1σ uncertainty in $^{41}\text{K}_a/^{40}\text{K}_a$, i.e., $\sigma_{^{41}\text{K}_a/^{40}\text{K}_a}$; and (12) the full reference from which the K isotopic abundance values were sourced. The number ‘-1’ indicates that a value was not reported by the reference from which the data were taken. The library of K isotopic abundance values is stored in the tab-delimited text file named ‘arLib_K_ia.txt’ in the ‘Library’ directory.

6.3 Monitor Mineral Ages

The monitor mineral age library contains the following columns of information (in the specified order, from left to right): (1) the name of the monitor mineral (this is used in the drop-down menus in the main ArAR GUI); (2) the age of the monitor mineral, in units of Ma; (3) the internal 1σ uncertainty in the monitor mineral age; (4) the external 1σ uncertainty in the monitor mineral age; (5) a short reference (this is used in the drop-down menus in the main ArAR GUI); (6) the full reference from which the monitor mineral age was sourced; and (7) miscellaneous notes about a particular monitor mineral and reference. The number ‘-1’ indicates that a value was not reported by the reference from which the data were taken. The monitor mineral age library is stored in the tab-delimited text file named ‘arLib_M_ma.txt’ in the ‘Library’ directory.

6.4 Monitor Mineral κ Values

The monitor mineral κ value library is only used in the **Multiple Intercalibration Tool**, and contains the following columns of information (in the specified order, from left to right): (1) the name of the monitor mineral (this is used in the drop-down menus in the main ArAR GUI); (2) the $\kappa \equiv {}^{40}\text{Ar}^*/{}^{40}\text{K}$ value of the monitor mineral; (3) the 1σ uncertainty in κ , i.e., σ_κ ; (4) a short reference (this is used in the drop-down menus in the main ArAR GUI); (5) the full reference from which the monitor mineral κ value was sourced; and (6) miscellaneous notes about a particular monitor mineral and reference. The number ‘-1’ indicates that a value was not reported by the reference from which the data were taken. The monitor mineral κ value library is stored in the tab-delimited text file named ‘arLib_M_Kappa.txt’ in the ‘Library’ directory.

7 Editing ArAR Preferences

To edit ArAR preferences, select the ‘Preferences’ item from the ‘ArAR’ menu at the top of the main ArAR window, or use the the hotkey combination: ‘Meta + ,’, where ‘Meta’ is the ‘Ctrl’ key on a Windows machine and the ‘Cmd’ key on a Macintosh. The preferences editor window will open (Fig. 25), allowing you to customize the behavior of ArAR. Preferences are grouped into five categories: (1) general preferences; (2) import preferences; (3) export preferences; (4) calculation preferences; and (5) multiple intercalibration preferences. When you are done customizing the ArAR preferences, you can click the ‘Save Changes’ button in the lower right corner to apply your selections. If you would like the modified preferences to be enforced immediately, check the ‘Auto-Fill Editable Fields with Default Values’ box before clicking ‘Save Changes.’ To restore all preferences to their defaults, delete the file named ‘ArAR_Preferences.xml’ (located in the same directory as ArAR) and restart ArAR.

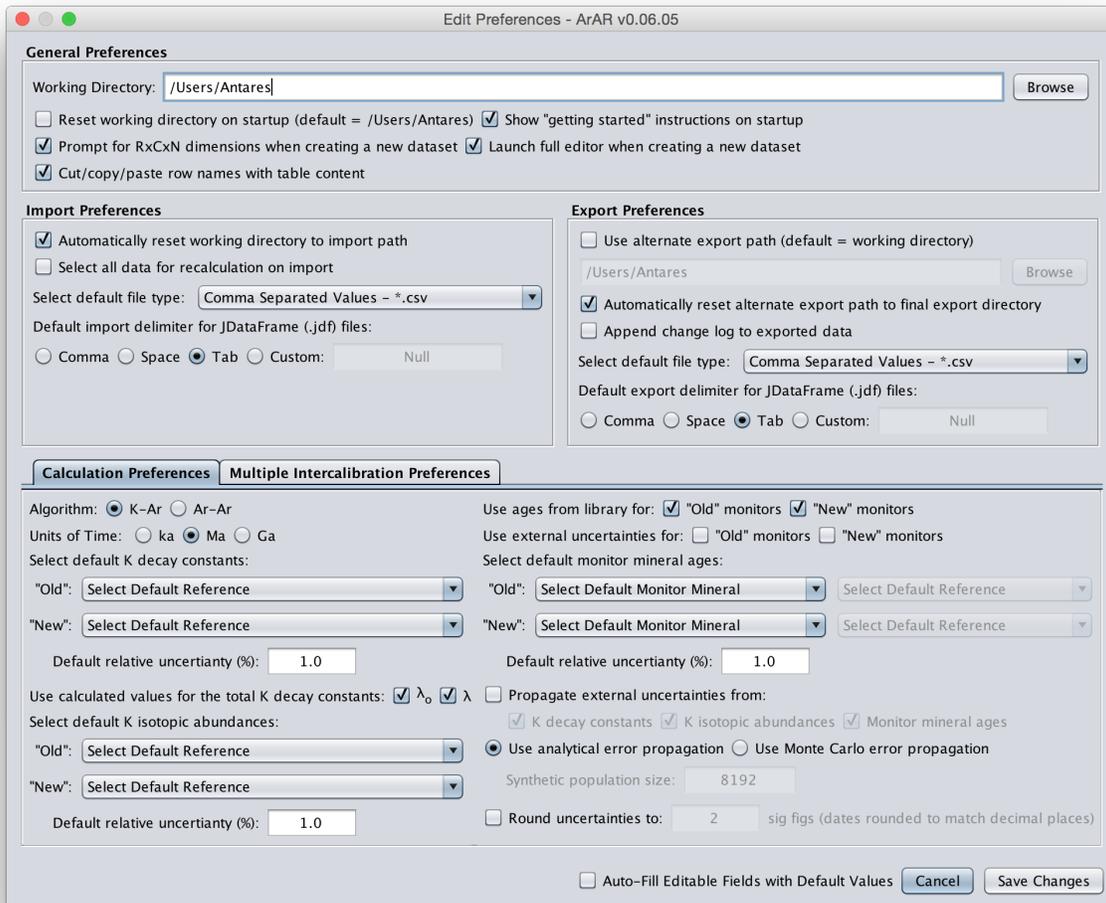


Figure 25. The ArAR preferences editor window, with the ‘Calculation Preferences’ tab displayed. All preferences are shown in their default states.

7.1 General Preferences

Under ‘General Preferences’ (Fig. 25), you can specify the ArAR working directory, which is where ArAR looks by default when importing and exporting delimited text files. You can either directly enter the path to the working directory, or click the ‘Browse’ button to navigate to the desired working directory. In addition, you can have ArAR reset the working directory each time it starts to the default user directory for your operating system. You can enable/disable: (1) the “Getting Started” dialog box that appears on startup (it is always accessible from the Help menu); (2) the dialog box that requests the dimensions for new datasets; and (3) the advanced JDataFrame Editor that appears during dataset creation. Be aware that, if you disable the editor during dataset creation, the ‘original’ states of the data are considered to be blank, so reverting edited data later will return them to zero or null values (for numeric or notes data, respectively). Finally, you may enable/disable the cut/copy/paste behavior where row names are copied along with other table content in the main ArAR window and the advanced JDataFrame Editor window.

7.2 Import and Export Preferences

By default, *ArAR* will automatically change its working directory to the folder containing imported text file(s). You can disable this behavior in the ‘Import Preferences’ subpanel (Fig. 25) to preserve a specific working directory. You can also choose to have all samples selected for age recalculations upon creation/import (by default, no samples are selected). In addition, you can select the default file type you would like to use for importing files (one of *.csv, *.txt, *.prn, or *.jdf). If you choose JDataFrame (*.jdf) text files as the default, you can also specify what delimiter to use (comma, tab, space, or a custom string). This provides you with additional flexibility for importing files with alternate delimiters. Note, custom delimiters must be alpha-numeric, and can only include the following special characters: \ ! @ # \$ % & () [] { }. As an extreme example, you could read files where the data are delimited by the string ‘(= Smiles =)’. Go wild!

When exporting data files, *ArAR* uses the working directory by default as a starting point for the export dialogs. You can have *ArAR* use an alternate export path, which you can either enter directly in the available text field in the ‘Export Preferences’ subpanel (Fig. 25), or you can click the ‘Browse’ button to navigate to a destination directory. This allows you to have one directory containing input files (the working directory), and a separate directory for storing recalculated data (at the alternate export path). If desired, you can also have *ArAR* automatically reset the alternate export path to the directory where you save files. (This will only occur if you enable the alternate export path.) In analogy to the import preferences, you can select the default file type you would like to use for exporting files (one of *.csv, *.txt, *.prn, or *.jdf), and feel free to use custom delimiters for *.jdf files.

An important additional export preference is the ability to have the change log for each date appended to any exported data files (it is not appended by default). If you choose this option, the change log will be placed to the right of any of the numeric data and notes in the file. This allows you to always have the change log associated with the recalculated dates rather than having to manually export the change log as a separate file.

7.3 Calculation Preferences

In the ‘Calculation Preferences’ tab of the bottom subpanel (Fig. 25), you can set the default algorithm (K-Ar or $^{40}\text{Ar}/^{39}\text{Ar}$) and units of time (ka, Ma, or Ga) that will be selected when *ArAR* launches. In addition, you can select default datasets from the *ArAR* libraries for the ^{40}K decay constants, K isotopic abundance values, and monitor mineral ages. You can also set the default relative uncertainties to use where values are missing from these three libraries. For the ^{40}K decay constants library, you can select whether the automatically calculated values for λ_o and λ are used, or if they must be entered manually. For monitor mineral ages, you can select whether values are

taken from the ArAR libraries or the imported dataset. If they are taken from the library, you may specify whether internal or external age uncertainties are used by default.

In addition to selecting default sets of constants, you can set whether external sources of uncertainties are propagated into recalculated dates or not. If you choose for external uncertainties to be propagated by default, you can also choose which sources of external uncertainties are propagated (i.e., those related to the ^{40}K decay constants, K isotopic abundances, and monitor mineral ages). You can also select how uncertainties are propagated, either analytically or by a Monte Carlo approach. If you select the Monte Carlo approach, you can specify the default synthetic population size by entering integer values or powers using the ‘^’ character. For example, if you enter ‘2^14’ in the text field and press ‘Enter’, the population size will be set to $2^{14} = 16384$.

Finally, you can have all recalculated uncertainties rounded automatically to the specified number of significant figures. If you select this option, rounding will be performed as if by the **Round-
ing Tool**, but no dialog box will be shown for setting the number of significant figures. Rather, that value is drawn from the ArAR preferences pane.

7.4 Multiple Intercalibration Preferences

In the ‘Multiple Intercalibration Preferences’ tab of the bottom subpanel (Fig. 26), you can select the default algorithms for the primary monitor and the form of R_i^{i+1} that will be selected when the Multiple Intercalibration Tool is first launched. In addition, you can specify the default dataset to use from the ArAR library for the ^{40}K decay constants, and the default relative uncertainty to use where values are missing. You may also select whether the automatically calculated values for $\lambda \pm \sigma_\lambda$ are used, or if they must be entered manually.

You may specify whether or not data for the last secondary standard are used for the sample/unknown by default. When the ($^{40}\text{Ar}^*/^{39}\text{Ar}_K$) algorithm is selected for the form of R_i^{i+1} , you can select whether the κ value of the primary standard is calculated from the standard age (primary monitor algorithm: $^{40}\text{Ar}^*/^{40}\text{K}$), and/or whether the standard age is calculated from κ (primary monitor algorithm: $\exp[\lambda t] - 1$) by default. In a similar fashion, if the ($\exp[\lambda t] - 1$) algorithm is selected for the form of R_i^{i+1} , you can specify which ArAR library will be used to auto-fill κ values or ages for the primary monitor.

Finally, you can select whether external uncertainties from the ^{40}K decay constants are propagated by default, and whether uncertainties are propagated analytically or by a Monte Carlo approach. If you select the Monte Carlo approach, you can specify the default synthetic population size by entering integer values or powers using the ‘^’ character. For example, if you enter ‘2^14’ in the text field and press ‘Enter’, the population size will be set to $2^{14} = 16384$.

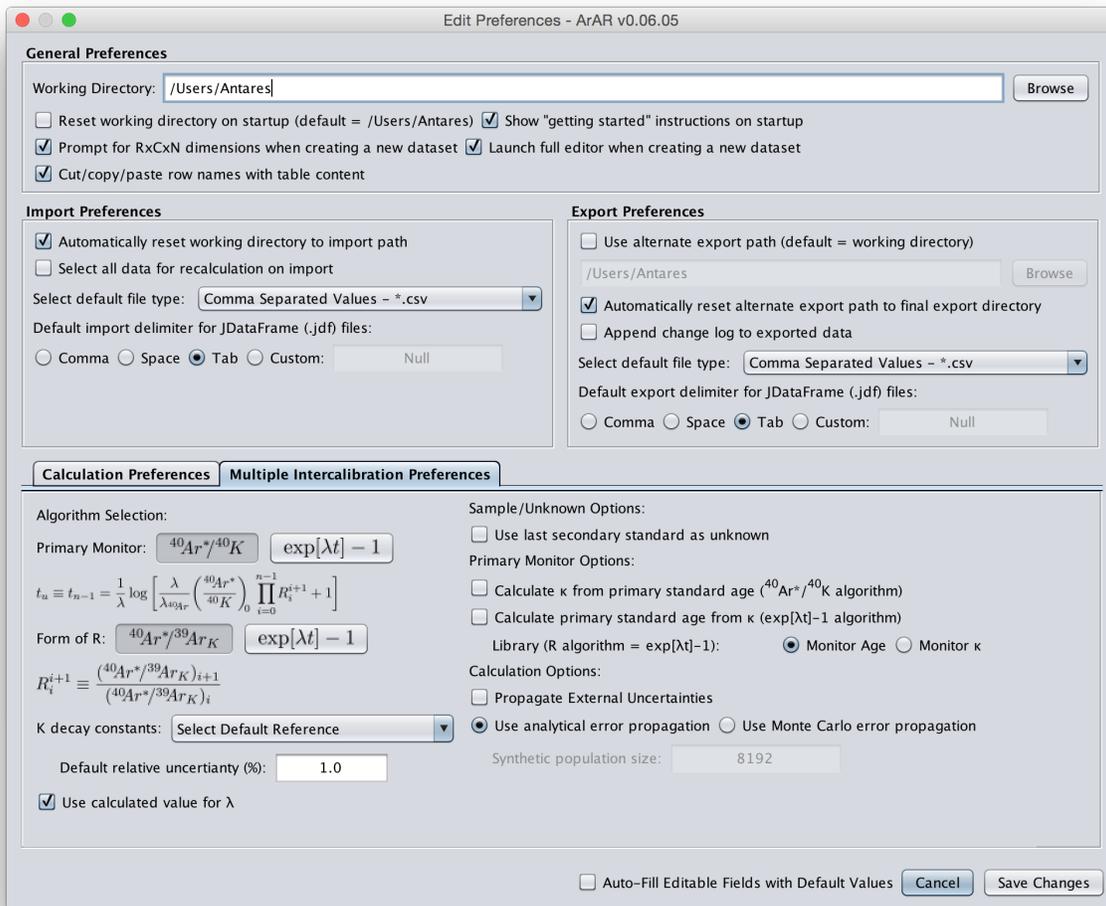


Figure 26. The ArAR preferences editor window, with the ‘Multiple Intercalibration Preferences’ tab displayed. All preferences are shown in their default states.