Package 'deltar'

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Type Package

Title Calculation of Delta R Values

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Description Computes the regional correction factor of 14C age offset in marine-derived samples (Delta R). This is possible with the recently established ``marine13'' calibration curve and the 'BchronCalibrate' function from the 'Bchron' package. The algorithm of Delta R computation includes four steps: measure radiocarbon age of a marine sample; identify its true age; compute its modeled radiocarbon age corresponding to the true age; and finally calculate the difference between its measured and modeled radiocarbon ages. This package has functions that compute Delta R with three methods: by using marine samples with known collection dates (before 1950s), usually molluscan shells from museum collections, (function dr_shell()); by measuring other radioactive isotopes, mainly uranium-thorium (230Th/234U), ratio (dr_pair() function and the ``pair'' method in the dr_df() function); and finally by using a pair of coeval samples, one being marine and the other terrestrial (dr_pair() function and the ``pair'' method for the dr_df() function as well). Usually such samples originate from archaeological sites where the context, in which paired samples were found, is taken as a guarantee of their synchronicity.
References:
Oeschger H, Siegenthaler U, Schotterer U, Gugelmann A (1975) <doi:10.3402/tellusa.v27i2.9900>
Reimer PJ, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE, Cheng H, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Haflidason H, Hajdas I, Hatté C, Heaton TJ, Hoffmann DL, Hogg AG, Hughen KA, Kaiser KF, Kromer B, Manning SW, Niu M, Reimer RW, Richards DA, Scott EM, Southon JR, Staff RA, Turney CSM, van der Plicht J (2013) <doi:10.2458/azu_js_rc.55.16947>
Soulet G (2015) <doi:10.1016/j.quageo.2015.05.023>
Stuiver M, Braziunas TF (1993) <doi:10.1017/S0033822200013874> .

License GPL (>= 2)

URL https://github.com/teemour/deltaR

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Imports Bchron

NeedsCompilation no

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R topics documented:

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adak   *Radiocarbon dates from Adak Island (Aleutians Islands, Alaska)*

Description

This data set provides radiocarbon dates made from several archaeological sites in Adak Island (Aleutians Islands, Alaska). Terrestrial and marine samples originating from the same archaeological context were amalgamated in pairs. There are nine pairs in this data set organized as columns. For more details see Khasanov et al., 2015.

Usage

```
data(adak)
```

Format

A data frame containing ten columns and four rows. First column indicates a type of radiocarbon dates constituting each of nine pairs stored in the other columns. Rows correspond to (in descending order): terrestrial date of a pair, standard deviation of the terrestrial date, marine date and its standard deviation. Column names indicate pair identification codes, which can be further used for pair identification.

Source

Data were published in Khasanov et al., 2015 (Table 2).

References

Khasanov BF, Nakamura T, Okuno M, Gorlova EN, Krylovich OA, West DL, Hatfield V, Savinetsky AB. 2015. The Marine Radiocarbon Reservoir Effect on Adak Island (Central Aleutian Islands), Alaska. Radiocarbon. 57(5): 955-964 <doi:10.2458/azu_rc.57.18329>

BSea	*Radiocarbon dates of marine shells from the Bering Sea*

Description

This data set provides radiocarbon dates made from marine shells with known collection dates sampled in the Bering Sea. There are four samples in this data set organized as columns. For more details see McNeely et al, 2006.

Usage

```
data(BSea)
```

Format

A data frame containing five columns and three rows. First column indicates a type of dates constituting each of four samples stored in the other columns. Rows correspond to (in descending order): sample collection date (in calendar years AD/BC), radiocarbon date of the sample and its standard deviation. Column names indicate sample identification codes, which is further used for sample identification.

Source

Data were published in McNeely et al, 2006 and available at CHRONO Marine Reservoir Database (http://calib.qub.ac.uk/marine/).

References

McNeely R, Dyke AS, Southon J. 2006. Canadian marine reservoir ages: preliminary data assessment. Geological Survey of Canada Open File 5049. <doi:10.13140/2.1.1461.6649>

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coral   *Dates of corals from the South China Sea*

Description

This data set provides radiocarbon and 230Th dates of corals sampled in the South China Sea. There are five pairs of dates in this data set organized as columns. For more details see Yu et al, 2010.

Usage

```
data(coral)
```

Format

A data frame containing six columns and four rows. First column indicates a type of dates constituting each of five pairs stored in the other columns. Rows correspond to (in descending order): 230Th date of a coral sample, its standard deviation, radiocarbon date of the same sample and its standard deviation. Column names indicate pair identification codes, which is further used for pair identification.

Source

Data were published in Yu et al, 2010, table 2.

References

Yu K, Hua Q, Zhao J, Hodge E, Fink D, Barbetti M. 2010. Holocene marine 14C reservoir age variability: Evidence from 230Th-dated corals in the South China Sea. Paleoceangraphy. 25: PA3205 <doi:10.1029/2009PA001831>

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deltar   *Calculation of Delta R Values*

Description

Computes the regional correction factor of 14C age offset in marine-derived samples (Delta R). This is possible with the recently established "marine13" calibration curve and the 'BchronCalibrate' function from the 'Bchron' package. The algorithm of Delta R computation includes four steps: measure radiocarbon age of a marine sample; identify its true age; compute its modeled radiocarbon age corresponding to the true age; and finally calculate the difference between its measured and modeled radiocarbon ages. This package has functions that compute Delta R with three methods: by using marine samples with known collection dates (before 1950s), usually molluscan shells from museum collections, (function dr_shell()); by measuring other radioactive isotopes, mainly uranium-thorium (230Th/234U), ratio (dr_pair() function and the "pair" method in the dr_df() function); and finally by using a pair of coeval samples, one being marine and the other terrestrial (dr_pair() function and the "pair" method for the dr_df() function as well). Usually such

samples originate from archaeological sites where the context, in which paired samples were found, is taken as a guarantee of their synchronicity.

References:

Oeschger H, Siegenthaler U, Schotterer U, Gugelmann A. 1975. A box diffusion model to study the carbon dioxide exchange in nature. Tellus 27(2): 168–92.

Reimer PJ, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE, Cheng H, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Haflidason H, Hajdas I, Hatté C, Heaton TJ, Hoffmann DL, Hogg AG, Hughen KA, Kaiser KF, Kromer B, Manning SW, Niu M, Reimer RW, Richards DA, Scott EM, Southon JR, Staff RA, Turney CSM, van der Plicht J. 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4): 1869–87.

Soulet G. 2015. Methods and codes for reservoire atmosphere 14C age offset Calculations. Quaternary Geochronology. 29: 97-103.

Stuiver M, Braziunas TF. 1993. Modeling atmospheric 14C influences and 14C ages of marine samples to 10,000 BC. Radiocarbon 35(1):137–89.

deltar functions

`dr_shell` for marine samples with known collection date, `dr_pair` for a sample which has its true age identified, `dr_df` for a set of dates contained in a data frame, and `dr_plot` for plotting Delta R values from a list produced by `dr_df`

See Also

Useful links:

* https://github.com/teemour/deltaR

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dr_df   *Compute Delta R values for a set of dates*

Description

Computes Delta R values for a set of dates in a data frame either with dr_shell() or dr_pair() function. Multiple radiocarbon dates of marine samples with known collection dates or true ages identified in other ways can be downloaded as a data frame and Delta R for each column of the latter is computed

Usage

```
dr_df(df, N = 10000, CI = 0.95, method = "pair",
                    calCurves = "intcal13", make.plot = FALSE)
```

Arguments

df	A data frame. Its first column indicates a type of dates constituting each sample or pair. If Delta R is computed for dates amalgamated in pairs, each pair is stored in its own column. The order of rows is essential: first, terrestrial (or uranium-thorium) date of a pair, then its standard deviation, then marine radiocarbon date, and its standard deviation (see "adak" and "coral" datasets as examples). If Delta R is computed for marine samples with known collection date, each sample is stored in its own column. The order of rows is essential: first, the collection date (in calendar years AD/BC), then radiocarbon date of a sample and its standard deviation (see "BSea" dataset as an example). Column names are further used as identification codes.
N	Number of iterations. Must be a positive integer. Note that numbers too big can result in very long computation times. Default is 10000.
CI	Probability with which true Delta R value is contained within computed interval. Must be between 0 and 1. Default is 0.95.
method	A character vector. If Delta R is computed for dates amalgamated in pairs, "pair" should be supplied to this argument. If Delta R is computed for marine samples with known collection date, "shell" should be supplied to this argument.
calCurves	A character vector to determine whether to calibrate the first date of a pair or not. If the first date is terrestrial radiocarbon date, it should be calibrated with "intcal13" calibration curve (or "shcal13" for Southern Hemisphere, see Reimer et al, 2013 and Hogg et al, 2013 for calibration curves details) and the same curve has to be supplied to the calCurves argument. If it is uranium-thorium date, calibration is not needed and "normal" curve, which treats ages as normally distributed with given standard deviation, should be passed to calCurves. Default is "intcal13".
make.plot	A logical flag. Makes histograms of the Delta R values for each sample or pair if TRUE.

Details

The function computes Delta R values for each column of the data frame according to the chosen method. See details of dr_pair() and dr_shell() functions. See examples of data frame format in "adak" and "coral" data sets for method "pair" and in "BSea" data set for method "shell". The output of this function can be supplied to the dr_plot() function for plotting Delta R values.

If the make.plot argument is set to TRUE, the function produces histograms of Delta R values for each sample or a pair. The histograms have a total area of one and are supplemented with curves of probability densities of the corresponding normal distributions.

Value

If the make.plot argument is set to TRUE, the function produces histograms of Delta R values obtained during each iteration. Histogram of each sample or a pair is produced in its own window. Regardless of the make.plot argument settings, function returns a list containing:

- statistics — a data frame. Basic statistics computed for pairs or samples supplied to the function are the following: mean (mean Delta R value), median (median Delta R value), sd (standard deviation of Delta R value), low.lim and up.lim (the lower and upper limits of an interval containing true Delta R value with a probability set by the CI argument), p.value (p value of the Kolmogorov – Smirnov test of normality of computed Delta R values). These statistics are organized as columns, while pairs or samples supplied to the function are organized as rows.

- deltaR — a data frame. For each pair or a sample supplied to the function a numeric vector of length N containing a series of assessments of Delta R values obtained during each iteration is created. All of them are combined in this data frame with an identification code of a pair or a sample as a column name.

References

Hogg AG, Hua Q, Blackwell PG, Niu M, Buck CE, Guilderson TP, Heaton TJ, Palmer JG, Reimer PJ, Ron W, Turney CSM, Zimmerman SR. 2013. SHCal13 Southern Hemisphere calibration, 0–50,000 cal yr BP. Radiocarbon. 55 (4): 1889-1903. <doi: 10.2458/azu_js_rc.55.16783>

Reimer PJ, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE, Cheng H, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Haflidason H, Hajdas I, Hatté C, Heaton TJ, Hoffmann DL, Hogg AG, Hughen KA, Kaiser KF, Kromer B, Manning SW, Niu M, Reimer RW, Richards DA, Scott EM, Southon JR, Staff RA, Turney CSM, van der Plicht J. 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4): 1869–87. <doi: 10.2458/azu_js_rc.55.16947>

See Also

dr_shell dr_pair dr_plot

Examples

```
#' # Acquire "BSea" data set
data(BSea)
# Compute Delta R values and store them in the new object
# Note, that samples with known collection date need "shell" method
bsea_res <- dr_df(BSea, method = "shell")
# See basic statistics of the computed Delta R values
bsea_res$statistics
## Not run:
# Acquire "adak" data set
data(adak)
# Compute Delta R values and store them in the new object
adak_res <- dr_df(adak)
# See basic statistics of the computed Delta R values
adak_res$statistics
# Save the results in the file "Adak.txt"
write.table(adak_res$statistics, "Adak.txt")
# Note, that it will be saved in the working directory
# See the path to the working directory
getwd()
# Acquire "coral" data set
data(coral)
```

```
# Compute Delta R values and store them in the new object
# Note, that 230Th dates do not need calibration
coral_res <- dr_df(coral, calCurves = "normal")
# See basic statistics of the computed Delta R values
coral_res$statistics

## End(Not run)
```

---

dr_pair   *Calculate Delta R from a pair of dates*

Description

Computes Delta R value for a radiocarbon dated marine sample, the true age of which was identified
with one of the following methods: 1. by measuring other radioactive isotopes, mainly uranium-
thorium (230Th/234U), ratio; 2. by radiocarbon dating of its terrestrial counterpart.

Usage

```
dr_pair(dates, name = "", N = 10000, CI = 0.95,
calCurves = "intcal13", make.plot = FALSE)
```

Arguments

dates	A numeric vector, which supplies dates to the function. The order of dates in this vector is essential: first, terrestrial (or uranium-thorium) date of a pair, then its standard deviation, then marine radiocarbon date and its standard deviation.
name	An identification code of a pair of dates. Default is blank.
N	Number of iterations. Must be a positive integer. Note that numbers too big can result in very long computation times. Default is 10000
CI	Probability with which true Delta R value is contained within computed interval. Must be between 0 and 1. Default is 0.95.
calCurves	A character vector to determine whether to calibrate the first date or not. If the first date is terrestrial radiocarbon date, it should be calibrated with the "intcal13" calibration curve (or "shcal13" for Southern Hemisphere, see Reimer et al, 2013 and Hogg et al, 2013 for calibration curves details) and the same curve should be supplied to calCurves argument. If it is uranium-thorium date, calibration is not needed and the "normal" curve, which treats ages as normally distributed with given standard deviation, should be passed to this argument. Default is "intcal13".
make.plot	A logical flag. Makes a histogram of the Delta R values obtained during each iteration if TRUE.

Details

Delta R is defined as a difference between measured and modeled radiocarbon ages of a marine sample (Stuiver, Braziunas, 1993). Measured radiocarbon age of a sample is supplied to the function by the "dates" argument. To compute modeled radiocarbon age the function first looks at the "calCurves" argument. If it is supplied with "intcal13" or "shcal13" curve, the function calibrates terrestrial date of a pair with the BchronCalibrate() function from the 'Bchron' package (Haslett, Parnell, 2008; Parnell et al., 2008) using "intcal13" or "shcal13" calibration curve (Reimer et al. 2013; Hogg et al, 2013). Calibration creates a grid of ages covering that part of the calibration curve, for which age probabilities are greater than 1e-05, and calculates the probability of each age from this range.

If the "calCurves" argument is supplied with the "normal" curve, BchronCalibrate() treats the first date of a pair as normally distributed with given standard deviation. For each age from the grid produced by BchronCalibrate() it is possible to look for a corresponding modeled radiocarbon age in the "marine13" data set (Reimer et al. 2013). For full details and references of the "marine13" calibration curve see http://www.radiocarbon.org/IntCal13.htm. For this and other functions of the 'deltar' package "marine13", "intcal13" and "shcal13" data sets are made available via the 'Bchron' package (Haslett, Parnell, 2008; Parnell et al., 2008).

Then the function computes Delta R value in a series of iterations, number of which is defined by the "N" argument. During each iteration it chooses: 1. One year of measured radiocarbon age of the marine sample. The latter is supplied as its mean and standard deviation thus forming normal distribution from which the year is chosen according to its probability. 2. One year from the grid of ages produced by BchronCalibrate(). The function chooses a year according to its probability and then looks for a corresponding modeled radiocarbon age in the "marine13" data set. 3. Modeled radiocarbon age is also accompanied with its standard deviation, so the function again chooses one year from the corresponding normal distribution. Then it finds the difference between measured and modeled radiocarbon ages. This gives a series of assessments of Delta R value stored in a vector of length N. The function then computes basic statistics of these Delta R assessments and produces a histogram of Delta R probability densities. The histogram has a total area of one and is supplemented with a curve of probability densities of a corresponding normal distribution.

The results of the function call can be slightly different with the same arguments supplied to function. This difference is due to the chosen numerical method of computations and is insignificant with reasonable number of iterations.

Value

If the make.plot argument is set to TRUE, the function produces a histogram of Delta R values obtained during each iteration. Regardless of the make.plot argument settings, the function returns a list containing:

- mean — mean Delta R value

- median — median Delta R value

- sd — standard deviation of the Delta R value

- quantile — an interval containing true Delta R value with a probability set by the "CI" argument. Default is 0.95

- p.value — the p value of Kolmogorov – Smirnov test of normality of computed Delta R values
- delta — a numeric vector of length N containing a series of assessments of Delta R value obtained during each iteration

References

Haslett J, Parnell AC. 2008. A simple monotone process with application to radiocarbondated depth chronologies. Journal of the Royal Statistical Society, Series C. 57: 399-418. <doi: 10.1111/j.1467-9876.2008.00623.x>

Hogg AG, Hua Q, Blackwell PG, Niu M, Buck CE, Guilderson TP, Heaton TJ, Palmer JG, Reimer PJ, Ron W, Turney CSM, Zimmerman SR. 2013. SHCal13 Southern Hemisphere calibration, 0–50,000 cal yr BP. Radiocarbon. 55 (4): 1889-1903. <doi: 10.2458/azu_js_rc.55.16783>

Khasanov BF, Nakamura T, Okuno M, Gorlova EN, Krylovich OA, West DL, Hatfield V, Savinetsky AB. 2015. The Marine Radiocarbon Reservoir Effect on Adak Island (Central Aleutian Islands), Alaska. Radiocarbon. 57(5): 955-964 <doi: 10.2458/azu_rc.57.18329>

Parnell AC, Haslett J, Allen JRM, Buck CE, Huntley B. 2008. A flexible approach to assessing synchroneity of past events using Bayesian reconstructions of sedimentation history. Quaternary Science Reviews. 27(19-20): 1872-1885. <doi: 10.1016/j.quascirev.2008.07.009>

Reimer PJ, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE, Cheng H, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Haflidason H, Hajdas I, Hatté C, Heaton TJ, Hoffmann DL, Hogg AG, Hughen KA, Kaiser KF, Kromer B, Manning SW, Niu M, Reimer RW, Richards DA, Scott EM, Southon JR, Staff RA, Turney CSM, van der Plicht J. 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4): 1869–87. <doi: 10.2458/azu_js_rc.55.16947>

Stuiver M, Braziunas TF. 1993. Modeling atmospheric 14C influences and 14C ages of marine samples to 10,000 BC. Radiocarbon 35(1):137–89. <doi: 10.1017/S0033822200013874>

Ulm S, Petchey F, Ross A. 2009. Marine reservoir corrections for Moreton Bay, Australia. Archaeol. Oceania. 44: 160–168. <doi: 10.1002/j.18344453.2009.tb00060.x>

Yu K, Hua Q, Zhao J, Hodge E, Fink D, Barbetti M. 2010. Holocene marine 14C reservoir age variability: Evidence from 230Th-dated corals in the South China Sea. Paleoceangraphy. 25: PA3205. <doi: 10.1029/2009PA001831>

See Also

dr_shell dr_df dr_plot

Examples

```
## Calculation of Delta R for the last pair (pair 9)
## from the "adak" data set (see Khasanov et al., 2015
```

```
## for details). Terrestrial date of this pair is 835 ± 20
## (laboratory code NUTA2-20937), marine date 1765 ± 20
## (laboratory code NUTA2-20553).

# Compute and store the results in the new object
p9 <- dr_pair(dates = c(835, 20, 1765, 20), name = "Adak, pair 9")
# Mean value of Delta R
p9$mean
# Median value of Delta R
p9$median
# Standard deviation of Delta R
p9$sd
# An interval containing true Delta R value with probability 0.95
p9$quantile
# p value of Kolomogorov - Smirnov test
p9$p.value

## Calculation of Delta R for the pair of terrestrial and
## marine materials from the Lazaret Midden (Moreton Bay,
## Australia). Charcoal sample was dated 500 ± 50
## (laboratory code Wk-8009) and marine shell yielded 840 ± 50
## (laboratory code Wk-8013). Data from Ulm et al, 2009, table 2.

# Compute and store the results in the new object
# Note, that for 14C dates from the Southern Hemisphere
# "shcal13" curve is used
LM <- dr_pair(c(500, 50, 840, 50), name = "Lazaret Midden", calCurves = "shcal13")

## Calculation of Delta R for the coral M2-3 dated
## 2170 ± 15 with 230Th and 2550 ± 30 with radiocarbon
## (data from Yu et al, 2010; table 2)

# Compute and store the results in the new object
# Note, that 230Th dates do not need calibration
M2_3 <- dr_pair(c(2170, 15, 2550, 30),  name = "M2-3", calCurves = "normal")
```

---

dr_plot   *Plot Delta R values from an object produced by dr_df()*

Description

This function makes a plot of Delta R values from a list produced by the dr_df() function. It can produce two kinds of plots: either medians of computed Delta R values can be plotted along with their quantiles, or curves of Delta R densities can be plotted on the same plot.

Usage

```
dr_plot(deltar_list, name = "", method = "quantile", lim = c(0,0))
```

Arguments

deltar_list	a list produced by the dr_df() function.
name	an identification code of a data set. Default is blank.
method	a character vector. If "quantile" is passed to this argument, medians of computed Delta R values will be plotted along with their quantiles. The latter are defined by the "CI" argument during the dr_df() function call. If "density" is passed to this argument, curves of Delta R densities will be plotted on the same plot.
lim	a numeric vector, which contains values used to expand x-axis limits. Default is zero.

Details

This function creates a plot of Delta R values computed for a data set by the dr_df() function. If "quantile" is passed to the "method" argument, Delta R values computed for each sample or pair are being ordered by their medians and then their medians are plotted along with intervals containing true Delta R value with a previously set probability. If "density" is passed to the "method" argument, curves of Delta R densities will be plotted on the same plot.

Value

None. Invoked for a side effect (plot).

See Also

[dr_shell](#) [dr_df](#) [dr_pair](#)

Examples

```
# Acquire "BSea" data set
data(BSea)
# Compute Delta R values and store them in the new object
bsea_res <- dr_df(BSea, method = "shell")
# Plot Delta R values with "quantile" method
dr_plot(bsea_res, name = "BSea")
# Expand x-axis of the plot
dr_plot(bsea_res, name = "BSea", lim = c(150, 250))
# Plot Delta R values with "density" method
dr_plot(bsea_res, name = "BSea", method = "density")
```

---

dr_shell	*Delta R from the radiocarbon date of the marine material with known collection date*

Description

Computes Delta R value from the radiocarbon date of a marine sample with known collection date. In most cases such materials are represented by molluscan shells from museum collections.

Usage

```
dr_shell(dates, name = "", N = 10000, CI = 0.95,  make.plot = FALSE)
```

Arguments

dates	A numeric vector, which supplies dates to the function. The order of dates in this vector is essential: first, a collection date (in calendar years AD/BC), then marine radiocarbon date and its standard deviation.
name	Laboratory code of a radiocarbon date or any other sample ID. Default is blank.
N	Number of iterations. Must be a positive integer. Note that numbers too big can result in very long computation times. Default is 10000.
CI	Probability with which true Delta R value is contained within computed interval. Must be between 0 and 1. Default is 0.95.
make.plot	A logical flag. Makes a histogram of the Delta R values obtained during each iteration if TRUE.

Details

Delta R or regional correction is defined as a difference between measured and modeled radiocarbon ages of a sample (Stuiver, Braziunas, 1993). Measured radiocarbon age of a sample is supplied to the function by the "dates" argument. To compute modeled radiocarbon age the function first transforms a collection date into the year BP and looks for a corresponding modeled radiocarbon age in the "marine13" data set (Reimer et al. 2013). For full details and references of the "marine13" calibration curve see http://www.radiocarbon.org/IntCal13.htm. For this and other functions of the 'deltar' package the "marine13" data set is made available via the 'Bchron' package (Haslett, Parnell, 2008; Parnell et al., 2008).

Then the function computes Delta R value in a series of iterations, number of which is defined by the "N" argument. During each iteration it chooses one year of measured radiocarbon age. The latter is supplied as its mean and standard deviation, thus forming normal distribution from which the year is chosen according to its probability. The function does the same with the modeled radiocarbon age and finds the difference between the two. This gives a series of assessments of Delta R values stored in a vector of length N. The function then computes basic statistics of these Delta R assessments and produces a histogram of Delta R probability densities. The histogram has a total area of one and is supplemented with a curve of probability densities of the corresponding normal distribution.

The results of the function call can be slightly different with the same arguments supplied to the function. This difference is due to the chosen numerical method of computations and is insignificant with reasonable number of iterations.

Value

If the "make.plot" argument is set to TRUE, the function produces a histogram of Delta R values obtained during each iteration. Regardless of the "make.plot" argument settings, the function returns a list containing:

- mean — mean Delta R value

- median — median Delta R value

- sd — standard deviation of Delta R value

- quantile — an interval containing true Delta R value with a probability set by the "CI" argument. Default is 0.95

- p.value — the p value of Kolmogorov – Smirnov test of normality of computed Delta R values

- delta — a numeric vector containing a series of assessments of Delta R value obtained during each iteration

References

Haslett J, Parnell AC. 2008. A simple monotone process with application to radiocarbondated depth chronologies. Journal of the Royal Statistical Society, Series C. 57: 399-418. <doi: 10.1111/j.1467-9876.2008.00623.x>

Parnell AC, Haslett J, Allen JRM, Buck CE, Huntley B. 2008. A flexible approach to assessing synchroneity of past events using Bayesian reconstructions of sedimentation history. Quaternary Science Reviews. 27(19-20): 1872-1885. <doi: 10.1111/j.14679876.2008.00623.x>

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See Also

dr_pair dr_df dr_plot

Examples

```
## Calculation of Delta R for Pseudocardium sybillae shell
## collected in Sakhalin in 1906 and radiocarbon dated
## 826 ± 35 years BP, laboratory code TERRA-072305a15
## (data from Yoneda et al., 2007, table 2)

# Compute and store the results in the new object
Ps <- dr_shell(c(1906, 826, 35), name = "TERRA-072305a15")
# Mean value of Delta R
Ps$mean
# Median value of Delta R
```

```
Ps$median
# Standard deviation of Delta R
Ps$sd
# An interval containing true Delta R value with probability 0.95
Ps$quantile
# p value of Kolomogorov - Smirnov test
Ps$p.value
```

Index