Package 'pb210dating'

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Title Pb-210 Dating of Sediment Cores

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Description Dates sediment cores from lead-210 (Pb-210) activity profiles measured by alpha or gamma spectrometry, following the unified formulation and nomenclature of Sanchez-Cabeza and Ruiz-Fernandez (2012) <doi:10.1016/j.gca.2010.12.024>. Implements the Constant Flux (CF) and Constant Flux Constant Sedimentation (CFCS) dating models, together with supporting tools for data input, decay correction, missing inventory estimation, calculation of sediment and mass accumulation rates, and Monte Carlo propagation of dating uncertainties as described in Sanchez-Cabeza et al. (2014) <doi:10.1016/j.quageo.2014.06.002>. Also provides functions to visualize activity profiles and resulting age models.

Depends R (>= 4.3)

Imports lubridate

License GPL (>= 2)

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NeedsCompilation no

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Contents

`AgeModel` *Pb-210 age model and validation*

Description

This function plots the age model after ^{210}Pb dating and, if provided, the validation information (e.g., independent chronological markers). It also provides the statistical significance of the validation.

Usage

```
AgeModel(
  List,
  SavePNG = TRUE,
  Path,
  PlotName = "Age_Model",
  DepthMin = NA,
  DepthMax = NA,
  TimeMin = 1900,
  TimeMax = NA,
  Verbose = TRUE,
  ...
)
```

Arguments

List	Dating object, created by ReadData and transformed with the package functions.
SavePNG	Logical. Only if TRUE, saves a high-resolution PNG file.
Path	Character. Directory where the PNG file will be written when SavePNG = TRUE. Defaults to the working directory.
PlotName	Name of the plot (without extension) to be produced. The extension will automatically be set to .PNG. Default is "Age_Model".
DepthMin	Minimum depth (cm) of the age model plot. Default is NA.
DepthMax	Maximum depth (cm) of the age model plot. Default is NA.
TimeMin	Minimum time (decimal age) of the age model plot. Default is 1900.
TimeMax	Maximum time (decimal age) of the age model plot. Default is NA.
Verbose	Logical. If TRUE, prints progress logs to the console.
...	Extra arguments passed to plotting functions (e.g., par).

Details

The age model is a representation of age (year CE) versus depth. For each point, both uncertainty bars are plotted. Minimum and maximum values for plotting are automatically calculated if not explicitly provided.

For validation, two approaches are used. For visual validation, 1-σ (68%, red) and 2-σ (95%, pink) ellipses of each validation point are plotted. The validation ellipses are calculated assuming that the variables (year and depth of the event) follow a uniform (square) distribution.

The validation ellipses include the user-provided label. As in most cases these will correspond to radionuclides, numbers are superscript, so we recommend using the format "123Element" (e.g., 137Cs).

For statistical validation, a significance (p-value) of the Mahalanobis distance between the validation point and each age-model curve, is also provided.

Value

Generates a .PNG plot of the age model with validation ellipses and p-values. The plot is also reproduced in the R graphics device (e.g., RStudio plots pane).

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

Pb210CF, Pb210CFCS

Examples

```
a <- ReadData(Verbose = FALSE) # Reads example file
a <- DecayCorrection(a, Verbose = FALSE)
a <- CompleteProfile(a, Verbose = FALSE)
a <- Equilibrium(a, Interactive = FALSE, Verbose = FALSE)
a <- Pb210CF(a, MonteCarloRunsCF = 1000, Verbose = FALSE)
AgeModel(a, SavePNG = FALSE, Path = tempdir(), Verbose = FALSE)
a <- Pb210CFCS(a, MonteCarloRunsCFCS = 1000, Verbose = FALSE)
AgeModel(a, SavePNG = FALSE, Path = tempdir(), Verbose = FALSE)
```

CompleteProfile *Complete missing data of core profiles for using the CF model.*

Description

The function completes missing values in sediment core profiles used for ^{210}Pb radiochronology. Only interpolation (not extrapolation) is performed. It leaves original data intact.

Usage

```
CompleteProfile(List, Verbose = TRUE)
```

Arguments

List	Dating list created by ReadData and processed by other package functions.
Verbose	Logical.Print progress messages. Default is TRUE.

Details

Required surface values: MassSection and Pb210ExcessDecay. Ra226 is optional. If no ^{226}Ra data is provided, it is skipped with a warning.

Interpolation rules:

- MassSection: Linear interpolation vs. mean depth.
- Ra226: Linear interpolation vs. cumulative mass.
- Pb210ExcessDecay: Exponential interpolation vs. cumulative mass.

Value

Updated dating list with complete profiles.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

Pb210CF.

Examples

```
a <- ReadData          (Verbose = FALSE)
a <- DecayCorrection(a, Verbose = FALSE)
a <- CompleteProfile(a, Verbose = FALSE)
message("Complete Pb-210 (Bq/kg): ", paste0(round(a$Val$Pb210ExcessDecayComplete), " "))
```

ConstantRa *Constant Ra-226 activity*

Description

If no ^{226}Ra values are available, this function estimates a constant supported (base) ^{210}Pb activity from the bottom-most ^{210}Po or ^{210}Pb total activities.

Usage

```
ConstantRa(List, Mode = "auto", Verbose = TRUE)
```

Arguments

List	Dating list created by ReadData and processed by other package functions.
Mode	Character. Total activity used to determine the constant Ra-226 activity.: "auto" (default), "Pb" or "Po". If both ^{210}Pb and ^{210}Po are present, the user **must** specify which one to use.
Verbose	Logical. Shows estimation details (default TRUE).

Details

At least three non-NA values are required.

The algorithm starts from the core bottom and, if needed, progressively includes more sections to calculate the mean and standard deviation. It stops when the activity of the section immediately above is significantly higher than the current mean + 2 SD (indicating the equilibrium zone has been found).

The resulting mean is assigned as constant Ra226 for the entire profile.

Important: The user should carefully review the result. This function only handles simple cases. If the profile does not reach equilibrium, the last value is used as fallback but it is likely wrong.

Value

Updated dating list with constant ^{226}Ra and its uncertainty.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

ReadData, DecayCorrection, Equilibrium, EquilibriumSet

Examples

```
a <- ReadData     (Verbose = FALSE)
a <- ConstantRa(a, Verbose = FALSE, Mode = "Po")
message("Ra-226 (Bq/kg) = ", round(a$Val$Ra226[1]), " +- ", round(a$Unc$Ra226[1]))
```

DecayCorrection *Radioactive decay correction of Pb-210 and Po-210 to sampling date*

Description

Corrects the **measured (not-decay-corrected) total** activities ('Pb210Total' for gamma spectrometry and 'Po210Total' for alpha spectrometry) from the counting/plating period back to the core sampling date.

This function **must** be called **immediately after** ReadData and **before** CompleteProfile, ConstantRa, or any dating model.

The function uses the per-section dates supplied in the input file ('DatePlating', 'MeasurementAlphaStart', 'MeasurementAlphaEnd', 'MeasurementGammaStart', 'MeasurementGammaEnd'). If dates are not provided, no decay correction is performed. If no ^{226}Ra is present (or missing where Pb/Po data exist) it interpolates linearly in depth only the needed positions.

Correction rules for ^{210}Pb$_{ex}$ (the activity that will be used for dating):

- **Gamma (^{210}Pb)**: corrected with λ_{Pb210} from the sampling date to the mid-point of the gamma measurement interval.
- **Alpha (^{210}Po)**: corrected with λ_{Pb210} from the sampling date to the plating date + λ_{Po210} from the plating date to the mid-point of the alpha measurement interval (secular equilibrium assumption).

Uncertainties are scaled by the same correction factor(s). The function works whether the core file contains only gamma, only alpha, or both datasets.

Usage

```
DecayCorrection(List, Verbose = TRUE)
```

Arguments

`List`	Dating list returned by `ReadData`.
`Verbose`	Logical. Print progress messages (default `TRUE`).

Value

Updated dating list with Decay, Excess, and ExcessDecay fields in `$Val` and `$Unc`.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

`ReadData`.

Examples

```
a <- ReadData          (Verbose = FALSE)
a <- DecayCorrection(a, Verbose = FALSE)
message("Decay corrected values (Bq/kg): ", paste0(round(a$Val$Pb210ExcessDecay), " "))
```

`Equilibrium` *Calculate the bottom layer with no excess Pb-210 below*

Description

Estimates the layer below which there is no measurable excess ^{210}Pb (the "equilibrium layer"). This value is critical for the CF dating model.

The function works after `DecayCorrection`, so the presence of `Pb210ExcessDecay` is expected.

Usage

```
Equilibrium(List, Interactive = TRUE, Verbose = TRUE)
```

Arguments

`List`	Dating list created by `ReadData` and processed by other package functions.
`Interactive`	Logical. If `TRUE` (default), allows interactive visual selection of the equilibrium layer (highly recommended). If `FALSE`, it uses the automatic rule.
`Verbose`	Logical. If TRUE, prints progress logs to the console (default `TRUE`).

Details

Excess ^{210}Pb is shown with 1-sigma uncertainty. In interactive mode the x-axis shows tick marks and labels exactly centered under each red-blue bar pair. You can zoom in/out.

Value

Updated dating list with the value of `Val$LayerDating`.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

`ConstantRa`, `EquilibriumSet`, `MissingInventory`, `Pb210CF`, `Pb210CFCS`

Examples

```
a <- ReadData          (Verbose = FALSE)
a <- DecayCorrection(a, Verbose = FALSE)
a <- CompleteProfile(a, Verbose = FALSE)
a <- Equilibrium    (a, Verbose = FALSE, Interactive = FALSE)
message("Equilibrium depth = ", a$Val$LayerDating, " cm")
```

EquilibriumSet *Manually set the equilibrium layer for Pb-210 dating*

Description

Manually assigns the deepest layer below which there is no measurable excess ^{210}Pb (the "equilibrium layer"). This value is required for the dating models.

Use this function when you prefer to override the automatic proposal or the interactive selection performed by `Equilibrium`.

Usage

```
EquilibriumSet(List, LayerDating, Verbose = TRUE)
```

Arguments

`List`	Dating list created by `ReadData`.
`LayerDating`	Numeric. Bottom depth (cm) of the equilibrium layer. It **must** be one of the values present in `Val$DepthLayerBottom`.
`Verbose`	Logical. If TRUE, prints progress logs to the console (default `TRUE`).

Details

The function performs a strict validation: `LayerDating` must match exactly one of the section bottom depths. No interpolation or nearest-neighbour matching is done.

Value

Updated dating list with the value of `LayerDating` stored in `$Val$LayerDating`.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

`ConstantRa`, `Equilibrium`, `MissingInventory`, `Pb210CF`, `Pb210CFCS`

Examples

```
a <- ReadData          (Verbose = FALSE)
a <- DecayCorrection(a, Verbose = FALSE)
a <- EquilibriumSet (a, Verbose = FALSE, LayerDating = 16)
message("Equilibrium layer set to ", a$Val$LayerDating, " cm.")
```

IsotopeLabel *Isotope label expression for plot axes and titles*

Description

Generates a `plotmath` expression that renders a radionuclide symbol with the mass number as a superscript immediately preceding the element symbol (e.g. ^{137}Cs, ^{210}Pb), in accordance with IUPAC typographic conventions. The returned object is accepted directly by the `xlab`, `ylab`, and `main` arguments of all base-R plotting functions, as well as by `axis`, `mtext`, and `text`.

Usage

```
IsotopeLabel(x, suffix = NULL, units = NULL)
```

Arguments

`x`	A single character string specifying the isotope in any of the plain-text notations commonly used in the literature. Accepted formats are illustrated below; matching is case-insensitive for the element symbol. Alternatively, a two-element character vector `c(mass, element)` may be supplied, e.g. `c("239,240", "Pu")`.
	`"137Cs"` Mass number immediately followed by element symbol.

`"Cs137"`, `"Cs-137"` Element symbol before mass number, optionally separated by a hyphen.

`"239,240Pu"` Comma-separated mass numbers for combined isotopes sharing one element symbol (e.g. ^{239,240}Pu).

`"239+240Pu"`, `"239-240Pu"` Plus- or hyphen-separated mass numbers; both are normalised to a comma in the rendered label.

`suffix` An optional character string appended immediately after the element symbol. Three formats are recognised:

`"_{ex}"` Renders as a plotmath subscript: ^{210}Pb$_{ex}$.

`"^{*}"` Renders as a plotmath superscript after the symbol: ^{210}Pb"*".

any other string Rendered in parentheses: ^{210}Pb(total).

Default `NULL` (no suffix).

`units` An optional plotmath string appended after the isotope label, separated by a thin space (`~`). Standard plotmath syntax applies: use `~` for spaces and `^{-1}` for negative exponents, e.g. `"Bq~kg^{-1}"`. Default `NULL` (no units).

Value

A parsed `expression` object of length 1, suitable for direct use wherever R's plotmath rendering is needed.

See Also

`IsotopeLegend` for legend entries; `plotmath` for the full plotmath syntax reference.

`IsotopeLegend` *Isotope label expressions for plot legends*

Description

Generates a single `expression` object of length n containing one typeset radionuclide label per entry, suitable for direct use as the `legend` argument of `legend`.

Usage

```
IsotopeLegend(isotopes, suffix = NULL, units = NULL)
```

Arguments

`isotopes` A character vector of isotope strings in any format accepted by `IsotopeLabel`.

`suffix` A character vector of suffix strings (recycled). See the `suffix` argument of `IsotopeLabel` for recognised formats. Default `NULL` (no suffix for any entry).

`units` A character vector of plotmath unit strings (recycled). Default `NULL` (no units for any entry).

Details

legend requires its legend argument to be either a plain character vector or a *single* expression object whose elements correspond one-to-one to legend entries. This function ensures that requirement by calling parse on the full character vector of plotmath strings at once, which returns an expression of the correct length.

Each element is formatted by the same rules as IsotopeLabel; the suffix and units arguments are recycled across all entries if a vector shorter than isotopes is supplied.

Value

A parsed expression object of length length(isotopes), ready to be passed as legend = in a call to legend.

See Also

IsotopeLabel for single labels on axes and titles.

MissingInventory *Calculate missing inventory using a reference depth or sediment accumulation rate*

Description

In a sediment core dated with the Pb210CF model, equilibrium may not be reached at the core bottom. This function estimates the missing $^{210}Pb_{ex}$ inventory (below the deepest layer) so that the Constant Flux (CF) model can be applied.

Three estimation modes are available:

- **reference_date** (or any string containing "ref" or "dat"): Uses an independent chronomarker from the validation file.
- **mean_mar** (or any string containing "mea"): Uses the mean mass accumulation rate of the deepest Bottom_n sections excluding the last section (which always has MAR = 0 when no missing inventory is yet assumed).
- **fitted_mar** (or any string containing "fit"): Fits $\log(C)$ versus mass depth on the deepest Bottom_n sections.

At the end, the function re-runs Pb210CF(List) with the updated MissingInventoryBottom (or MissingInventoryTop) to provide consistent ages and accumulation rates.

Usage

```
MissingInventory(
  List,
  Mode = "reference_date",
  ValidationNumber = 1,
  Bottom_n = 3,
  MonteCarloRunsCF = 2e+05,
  Verbose = TRUE
)
```

Arguments

List	Dating list returned by ReadData (can be raw or already processed by Pb210CF).
Mode	Character. One of reference_date (default), mean_mar, or fitted_mar. Partial matching is supported (e.g. ref, dat, mea, fit).
ValidationNumber	Integer. Which validation point (row in the validation table) to use when Mode = "reference_date". Ignored for the other modes. Default is 1.
Bottom_n	Integer. Number of deepest dated sections to use for MAR calculation when Mode = "mean_mar" or "fitted_mar". Must be ≥ 1 for "mean_mar" and ≥ 2 for "fitted_mar". Default is 3.
MonteCarloRunsCF	Number of Monte Carlo iterations for uncertainty. Default is 2e5. Use 0 to skip uncertainty calculations.
Verbose	Logical. If TRUE, prints progress logs (default TRUE).

Value

Updated dating list with the missing inventory in Val$MissingInventoryBottom (or Val$MissingInventoryTop) and the estimated Monte Carlo uncertainty in the corresponding Unc$ entry.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

Equilibrium, Pb210CF, Pb210CFCS

Examples

```
TehuaIIMI <- system.file("extdata", "TehuaIIMI.csv", package = "pb210dating")
a <- ReadData(TehuaIIMI, Verbose = FALSE)
a <- DecayCorrection(a,  Verbose = FALSE)
a <- CompleteProfile(a,  Verbose = FALSE)
a <- Equilibrium    (a,  Verbose = FALSE, Interactive = FALSE)
a <- Pb210CF        (a,  Verbose = FALSE, MonteCarloRunsCF = 100)
b <- MissingInventory(a, Verbose = FALSE, MonteCarloRunsCF = 100, Mode = "mean")
message("Bottom missing inventory (Bq/m2) = ", round(b$Val$MissingInventoryBottom))
c <- MissingInventory(a, Verbose = FALSE, MonteCarloRunsCF = 100, Mode = "fit")
message("Bottom missing inventory (Bq/m2) = ", round(c$Val$MissingInventoryBottom))
d <- MissingInventory(a, Verbose = FALSE, MonteCarloRunsCF = 100, Mode = "ref")
message("Bottom missing inventory (Bq/m2) = ", round(d$Val$MissingInventoryBottom))
```

`Output` *Output merged Pb-210 dating results (CF + CFCS) in a single CSV file*

Description

Creates one single CSV file with per-section data in and core-wide constants in the last four columns (‘Name‘, ‘Value‘, ‘Uncertainty‘, ‘p-value‘).

Usage

```
Output(List, Path, Verbose = TRUE)
```

Arguments

`List`	Dating list created by `ReadData` and processed by `Pb210CF` and/or `Pb210CFCS`.
`Path`	Character. Directory where the output files will be written.
`Verbose`	Logical.Print progress messages. Default is `TRUE`.

Value

Invisibly returns the final data.frame. Side effect: writes `"<CoreName>_results.csv"` and `"<CoreName>.out"` in `Path`.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

`ReadData`, `Pb210CF`, `Pb210CFCS`, `MissingInventory`.

Examples

```
a <- ReadData          (Verbose = FALSE)
a <- DecayCorrection(a, Verbose = FALSE)
a <- ConstantRa     (a, Verbose = FALSE)
a <- CompleteProfile(a, Verbose = FALSE)
a <- Equilibrium    (a, Verbose = FALSE, Interactive = FALSE)
a <- Pb210CF        (a, Verbose = FALSE, MonteCarloRunsCF = 1000)
Output(a, Path = tempdir(), Verbose = TRUE)
```

Pb210CF *Pb-210 dating of sediment cores with the Constant Flux (CF) model*

Description

Performs ^{210}Pb dating using the Constant Flux (CF) model. Based on Sanchez-Cabeza and Ruiz-Fernandez (2012).

Usage

```
Pb210CF(List, MonteCarloRunsCF = 2e+05, Verbose = TRUE)
```

Arguments

List	Dating list created by ReadData and processed by other package functions.
MonteCarloRunsCF	Number of Monte Carlo iterations for uncertainty estimation. Default is 2E5. Use MonteCarloRunsCF = 0 to skip uncertainty calculation.
Verbose	Logical.Print progress messages. Default is TRUE.

Details

Missing inventories at the top (MissingInventoryTop) and bottom (MissingInventoryBottom) of the core are supported but their use requires careful justification. The core is assumed to be cylindrical. Uncertainties are propagated via Monte Carlo simulation (Sanchez-Cabeza et al., 2014).

Value

Updated dating list. Results in $Val, uncertainties in $Unc.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

CompleteProfile, Pb210CFCS, AgeModel, Equilibrium, EquilibriumSet, MissingInventory, Output, PlotMARSAR.

Examples

```
a <- ReadData          (Verbose = FALSE)
a <- DecayCorrection(a, Verbose = FALSE)
a <- CompleteProfile(a, Verbose = FALSE)
a <- Equilibrium(a, Interactive = FALSE, Verbose = FALSE)
a <- Pb210CF(a, MonteCarloRunsCF = 1000, Verbose = FALSE)
message("CF years = ", paste0(round(a$Val$YearSectionMean),  " "))
```

`Pb210CFCS` *Pb-210 dating of sediment cores with the CFCS model*

Description

Performs ^{210}Pb dating using the Constant Flux and Constant Sedimentation (CFCS) model, with optional piece-wise segments, although this option is not yet fully implemented. The user should consider if the profile can meet simultaneoulsy the hypothesis of constant excess ^{210}Pb flux and constant sedimentation. In principal, the user must indicate to which depth the model can be used. Although debatable, some authors use a piece-wise model (by segments), and the user can also provide the proposed break points for the model. However, one must take into account that, in this case, the constant flux hypothesis is only maintained in each profile segment.

When selecting the break sections, the user should be aware of the limitations of linear regression analysis. This very much depends on the dataset and the expected robustness, but we think that a linear regression of less than 5 points may usually be not statitiscally significant.

Please note the required contents of the Breaks() vector, which also defines the maximum layer to which CFCS fitting will be done.

Usage

```
Pb210CFCS(List, Breaks = NA, MonteCarloRunsCFCS = 10000, Verbose = TRUE)
```

Arguments

`List`	Dating list created by `ReadData` and processed by other package functions.
`Breaks`	In order to be as clear as possible about the user intention, the vector must contain the following layers (section bottom depth): • The surface layer (0). • The following intermediate break points (if any). • The depth until which fitting will take place. Its maximum value is the layer down to which excess ^{210}Pb is observed. It can be last break point. The minimum number of elements of Breaks is 2, corresponding to the surface layer and the end of the segment to be used for CFCS fitting.
`MonteCarloRunsCFCS`	Number of Monte Carlo iterations for uncertainty. Default = 10000.
`Verbose`	Logical. If TRUE, prints progress logs to the console (default `TRUE`).

Value

Updated dating list with CFCS results in $Val and uncertainties in $Unc.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

Pb210CF, AgeModel, MissingInventory, Output.

Examples

```
a <- ReadData          (Verbose = FALSE)
a <- DecayCorrection(a, Verbose = FALSE)
a <- CompleteProfile(a, Verbose = FALSE)
a <- Equilibrium    (a, Verbose = FALSE, Interactive = FALSE)
a <- Pb210CFCS    (a, Verbose = FALSE, Breaks = c(0, a$Val$LayerDating), MonteCarloRunsCFCS = 100)
message("CFCS years = ", paste0(round(a$Val$YearCFCS),  " "))
```

Pb210Dating *Complete Pb-210 dating workflow*

Description

Function wrapper to run the complete workflow for a sediment core suitable for ^{210}Pb dating. This function is suitable for calculations with a well-known core, in which the equilibrium depth is well constrained. If run without careful core exploration, the risk of bad results is high and it is discouraged.

Usage

```
Pb210Dating(
  FileName = NA,
  LayerDating = NA,
  Path,
  Verbose = TRUE,
  MonteCarloRunsCF = 2e+05,
  MonteCarloRunsCFCS = 10000
)
```

Arguments

FileName	Character. CSV file containing the sediment-core data. Default = NA uses the package example.
LayerDating	Numeric. Bottom depth (cm) of the dating interval. If NA (default), the equilibrium layer is selected automatically using Equilibrium().
Path	Character. Directory where all PNG and CSV output files produced by the workflow (profiles plot, age model plot, results CSV) are written. Defaults to the working directory.
Verbose	Logical.Print progress messages. Default is TRUE.
MonteCarloRunsCF	Number of Monte Carlo simulations of the CF model.
MonteCarloRunsCFCS	Number of Monte Carlo simulations of the CFCS model.

Value

Dating list containing all calculated variables from the CF and CFCS models.

Examples

```
a <- Pb210Dating(LayerDating = 17, Path = tempdir(),
                 MonteCarloRunsCF = 10, MonteCarloRunsCFCS = 10)
```

PlotMARSAR *Plots accumulation rates of sediment cores dated with the CF model*

Description

This function produces two independent PNG plots for the **MassAccumulationRate** (MAR) and the **SedimentAccumulationRate** (SAR) of cores previously dated with the Constant Flux (CF) model only. It uses the per-section rates calculated by Pb210CF (not the CFCS means).

Usage

```
PlotMARSAR(
  List,
  Path,
  Verbose = TRUE,
  YearMin = 1900,
  YearMax = NA,
  MARMin = 0,
  MARMax = NA,
  SARMin = 0,
  SARMax = NA,
  ...
)
```

Arguments

List	Dating object, created by ReadData and dated with Pb210CF.
Path	Character. Directory where the PNG files will be written.
Verbose	Logical. If TRUE, prints progress logs (default TRUE).
YearMin	Minimum year to be plotted. Default is 1900.
YearMax	Maximum year to be plotted (auto-calculated if NA).
MARMin	Minimum MAR to be plotted. Default is 0.
MARMax	Maximum MAR to be plotted (auto-calculated if NA).
SARMin	Minimum SAR to be plotted. Default is 0.
SARMax	Maximum SAR to be plotted (auto-calculated if NA).
...	Extra arguments passed to plotting functions.

Value

Two PNG files ('Core_MAR.png' and 'Core_SAR.png') + combined plot in Path, plus a combined plot in the active graphics device.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

Pb210CF.

Examples

```
# PlotMARSAR requires a List previously dated with Pb210CF()
a <- ReadData          (Verbose = FALSE)
a <- DecayCorrection(a, Verbose = FALSE)
a <- CompleteProfile(a, Verbose = FALSE)
a <- Equilibrium    (a, Verbose = FALSE, Interactive = FALSE)
a <- Pb210CF        (a, Verbose = FALSE, MonteCarloRunsCF = 1000)
PlotMARSAR          (a, Verbose = FALSE, Path = tempdir())
```

PlotProfiles *Plot of sediment profiles: flexible selection of Pb-210, Po-210, Ra-226 and proxy*

Description

Plots sediment core profiles of any combination of total/excess/complete ^{210}Pb, total/excess/complete ^{210}Po, total/complete ^{226}Ra and one proxy (e.g. ^{137}Cs). The user can select which variables to plot via the `PlotActivities` argument. If left `NULL`, the function checks the input data and plots total values.

Usage

```
PlotProfiles(
  List,
  NamePlot = "Profiles",
  SavePNG = TRUE,
  Path,
  DepthMin = NA,
  DepthMax = NA,
  PbMax = NA,
  RaMax = NA,
  ProxyMax = NA,
  Proxy = FALSE,
  PlotActivities = NULL,
  Verbose = TRUE,
  ...
)
```

Arguments

`List`	Dating list created by `ReadData` and processed by other package functions.
`NamePlot`	Base name for the PNG file (default "Profiles").
`SavePNG`	Logical. If TRUE (default), saves a high-resolution PNG file.
`Path`	Character. Directory where the PNG file will be written when `SavePNG = TRUE`.
`DepthMin`	Minimum depth to plot (cm). If NA, estimated automatically.
`DepthMax`	Maximum depth to plot (cm). If NA, estimated automatically.
`PbMax`	Axis limits when `PlotActivities = NULL`). If not NULL, axis limit is computed automatically from the selected radionuclides.
`RaMax`	Same as above.
`ProxyMax`	Same as above.
`Proxy`	Logical. Needed when `PlotActivities = NULL`).

PlotActivities	Character vector specifying which activities to plot on the main (left/top) axis. Possible values: "Pb210Total", "Pb210Excess", "Pb210ExcessDecay}, \code{"Pb210ExcessDecayC (this is the one used for dating), "Po210Total", "Po210Excess}, \code{"Po210ExcessDecay, "Po210ExcessDecayComplete},\code{"Ra226, "Ra226Complete}, \code{"Proxy"}. The argument is \strong{case-insensitive} (e.g. "pb210excess", "PB210EXCESS", or "Pb210Excess" all work). Default \code{NULL} automatically identifies and plots \code{"Pb210Total"}, \code{"Po210Total"} and \code{"Ra226.
Verbose	Logical. If TRUE, prints progress logs to the console (default TRUE).
...	Further arguments passed to graphical parameters.

Value

Invisibly returns NULL. Side effects: optionally creates a .png file and displays a plot.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^210Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

ReadData, CompleteProfile, ConstantRa, DecayCorrection

Examples

```
a <- ReadData(Verbose = FALSE)
PlotProfiles(a, SavePNG = FALSE, PlotActivities = "Po210Total", Path = tempdir())
```

Prepare4Dating *Prepare sediment-core data for Pb-210 dating*

Description

Performs the standard preprocessing workflow required before applying the ^{210}Pb dating models.

This function is a convenience wrapper that sequentially executes:

1. ReadData
2. DecayCorrection
3. CompleteProfile

The objective is to generate the decay-corrected excess ^{210}Pb profiles required by the dating models.

Depending on the radionuclide information supplied by the user:

- If total ^{210}Pb activities are provided, excess ^{210}Pb activities are calculated, decay-corrected to the sampling date, and stored as `Pb210ExcessDecay`.
- If total ^{210}Po activities are provided, activities are first corrected for the elapsed time between plating and measurement using the ^{210}Po decay constant. The resulting activities are then decay-corrected to the sampling date using the ^{210}Pb decay constant, assuming secular equilibrium between ^{210}Po and ^{210}Pb. Excess activities are stored as `Pb210ExcessDecay`.
- If (^{226}Ra) is not available, it is estimated using `ConstantRa` whenever possible.

Missing sections are subsequently interpolated against cumulative dry mass depth using `CompleteProfile`, generating `Pb210ExcessDecayComplete`.

The resulting object contains:

- `Pb210ExcessDecay`, intended for the Constant Flux-Constant Sedimentation (CFCS) model.
- `Pb210ExcessDecayComplete`, intended for the Constant Flux (CF) model.

No dating model is executed. The user must subsequently define the dating interval through `Equilibrium` or `EquilibriumSet`, which are use to determine `LayerDating`.

Usage

```
Prepare4Dating(NameFile, Path, Verbose = TRUE)
```

Arguments

`NameFile`	Character. Name of the CSV file containing the sediment-core data. If omitted or `NA`, the example dataset included in the package is used.
`Path`	Character. Directory where the profiles PNG plot is written.
`Verbose`	Logical.Print progress messages. Default is `TRUE`.

Value

A list containing original measurements, decay-corrected radionuclide activities, excess ^{210}Pb activities, and completed excess ^{210}Pb profiles.

References

Sanchez-Cabeza, J.A. and Ruiz-Fernandez, A.C. (2012). *210Pb sediment radiochronology: an integrated formulation and classification of dating models*. Geochimica et Cosmochimica Acta, 82, 183–200.

See Also

`ReadData`, `DecayCorrection`, `CompleteProfile`, `Equilibrium`, `EquilibriumSet`, `Pb210CFCS`, `Pb210CF`

Examples

```
a <- Prepare4Dating(NA, Path = tempdir(), Verbose = FALSE)
# used in dating:
message("Excess decay corrected and complete Pb-210 (Bq/kg): ",a$Val$Pb210ExcessDecayComplete)
```

`ReadData` *Read Data for Pb-210 Dating of Sediment Cores*

Description

This function serves as the primary data entry point for the `pb210dating` package. It allows users to either load the built-in example dataset (`TehuaII`) or import user files in CSV format. The function performs automatic cleaning of empty rows and validates that the 21-column structure meets the requirements for radiochronological modeling.

Usage

```
ReadData(NameFile = NA, Verbose = TRUE)
```

Arguments

`NameFile`	Character. Path to the .csv file. If omitted or set to NA (default), the function will load the built-in `TehuaII` dataset from the package.
`Verbose`	Logical. Print progress messages (default TRUE).

Details

The first 21 columns of the input file must follow the required structure:

- **Columns 1-18 (Profiles):** Sample Code, Depth Bottom (cm), Depth Uncertainty, Section Mass (g), Mass Uncertainty, Total Po-210 Activity (Bq/kg), Po-210 Uncertainty, Po plating date, Po measurement start, Po measurement end, Total Pb-210 Activity (Bq/kg), Pb-210 Uncertainty, Ra-226 Activity, Ra-226 Uncertainty, Proxy Value, Proxy Uncertainty, gamma measurement start, gamma measurement end. The column name of the Proxy column is used as the Proxy name (e.g., Cs-137).
- **Columns 19-21 (Metadata block, 15 rows):**
  - **Core** Core name (e.g. TEHUAII).
  - **Alpha spectrometry** Analyst(s) who performed alpha spectrometry (full name or initials, e.g. LHPB).
  - **Gamma spectrometry** Analyst(s) who performed gamma spectrometry (full name or initials, e.g. LHPB).
  - **Dating** Analyst(s) responsible for the ^{210}Pb dating (full name or initials, e.g. JASC).
  - **Sampling date** yyyy-mm-dd
  - **Internal diameter (cm)** and uncertainty.
  - **Half life Pb210 (yr)** and uncertainty.

- **Half life Po210 (yr)** and uncertainty.
- **Validation label** e.g., ^{137}Cs maximum
- **Top layer (cm)** up to where the validation point can be present.
- **Mean depth (cm)** where the validation point is observed.
- **Bottom layer (cm)** down to where the validation point is observed.
- **Year upper** up to where the validation point can be present.
- **Mean year** where the validation point is observed.
- **Year lower** down to where the validation point is observed.

Value

A list containing two elements:

`Val`	A list of numerical variables, dates, and activities.
`Unc`	A list containing the uncertainties associated with numeric variables in 'Val'.

References

Sanchez-Cabeza, J. A. & Ruiz-Fernandez, A. C. (2012). ^{210}Pb sediment radiochronology: an integrated formulation and classification of dating models. *Geochimica et Cosmochimica Acta*, 82, 183-200.

See Also

`DecayCorrection`, `CompleteProfile`, `ConstantRa`

Examples

```
# Reading the example file.
a <- ReadData(Verbose = FALSE)
message("Column names read: ", names(a$Val))
# Reading a named CSV file (here, the example file).
f <- system.file("extdata", "TehuaII.csv", package = "pb210dating")
b <- ReadData(f, Verbose = FALSE)
message("Identical? ", identical(a, b))
```

Index