

Package: imputeREE (via r-universe)

August 27, 2024

Title Impute Missing Rare Earth Element Data in Zircon

Version 0.0.5

Description Set of functions to impute missing rare earth data, calculate La and Pr concentrations and Ce anomalies in zircons based on the Chondrite-Onuma and Chondrite-Lattice of Carrasco-Godoy and Campbell (2023) <[doi:10.1007/s00410-023-02025-9](https://doi.org/10.1007/s00410-023-02025-9)> and the Logarithmic regression from Zhong et al. (2019) <[doi:10.1007/s00710-019-00682-y](https://doi.org/10.1007/s00710-019-00682-y)>.

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Depends R (>= 4.0)

URL <https://github.com/cicarrascog/imputeREE>

BugReports <https://github.com/cicarrascog/imputeREE/issues>

Repository <https://cicarrascog.r-universe.dev>

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add_element_data	<i>Add ionic radius and chondrite and mantle values, Z and Mass</i>
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Description

This is a helper function to work with `Element_norm()` and `Element_denorm()`. Add Ionic Radius to data and chondrite values. For now, only supports 3+ in eight-fold coordination for REE, Zr and Y. Values are from Shannon(1976), McDonough and Sun (1995) and Palme and O'Neill (2014).

Usage

```
add_element_data(dat)
```

Arguments

dat	Long data REE format
-----	----------------------

Value

A data frame

add_ID	<i>Add_ID</i>
--------	---------------

Description

Add an unique ID per observation and checks that is not overwriting an existing column. If the column already exist, it will take no action. This is a wrapper of `tibble::rowid_to_column()` that checks that not columns is overwritten.

Usage

```
add_ID(dat, ID = "rowid")
```

Arguments

dat	a tibble or a dataframe
ID	Name of column to use for rownames. 'rowid' is used if none is specified. er parameters passed onto the <code>tibble::rowid_to_column()</code> function

Value

a data frame

add_IonicRadii	<i>Add Chondrite or Mantle values for normalization.</i>
----------------	----------------------------------------------------------

Description

This is a helper function to work with `Element_norm()` and `Element_denorm()`. Takes long pivoted data to match element name and add normalizing values from the `Element_data` dataset.

Usage

```
add_IonicRadii(dat, method = ShannonRadiiVIII_Coord_3plus)
```

Arguments

dat	a dataframe or tibble.
method	Ionic Radii from Shannon, 1976

Value

a data frame or tibble

add_NormValues *Add Chondrite or Mantle values for normalization.*

Description

This is a helper function to work with Element_norm() and Element_denorm(). Takes long pivoted data to match element name and add normalizing values from the Element_data dataset.

Usage

```
add_NormValues(dat, chondrite = PalmeOneill2014CI)
```

Arguments

dat Dataframe or tibble. doc
 chondrite PalmeOneill2014CI, Oneill2014Mantle, McDonough1995CI

Value

a data frame or tibble

Ballard_et_al_Zircon *Zircon Rare earth Element Data from Ballard et al. 2001 and 2002.*

Description

Trace element data from selected zircons from the data of Ballard et al. 2001 and 2002.

Usage

```
Ballard_et_al_Zircon
```

Format

A data frame with 210 rows and 18 variables:

Reference Reference of the data
Deposit Deposit associated with the data
Zr_Y_ppm Y concentrations in ppm
Zr_P_ppm P concentrations in ppm
Zr_La_ppm La concentrations in ppm
Zr_Ce_ppm Ce concentrations in ppm
Zr_Pr_ppm Pr concentrations in ppm
Zr_Nd_ppm Nd concentrations in ppm

Zr_Sm_ppm Sm concentrations in ppm
Zr_Eu_ppm Eu concentrations in ppm
Zr_Gd_ppm Gd concentrations in ppm
Zr_Tb_ppm Tb concentrations in ppm
Zr_Dy_ppm Dy concentrations in ppm
Zr_Ho_ppm Ho concentrations in ppm
Zr_Er_ppm Er concentrations in ppm
Zr_Tm_ppm Tm concentrations in ppm
Zr_Yb_ppm Yb concentrations in ppm
Zr_Lu_ppm Lu concentrations in ppm

Source

Ballard, J. R., Palin, J. M., Williams, I. S., Campbell, I. H., and Faunes, A., 2001, Two ages of porphyry intrusion resolved for the super-giant Chuquicamata copper deposit of northern Chile by ELA-ICP-MS and SHRIMP: *Geology*, v. 29, p. 383–386. (<https://pubs.geoscienceworld.org/gsa/geology/article-abstract/29/5/383/192017/Two-ages-of-porphry-intrusion-resolved-for-the?redirectedFrom=fulltext>)

Ballard, J. R., Palin, M. J., and Campbell, I. H., 2002, Relative oxidation states of magmas inferred from Ce(IV)/Ce(III) in zircon: application to porphyry copper deposits of northern Chile: *Contributions to Mineralogy and Petrology*, v. 144, p. 347–364. (<https://link.springer.com/article/10.1007/s00410-002-0402-5>)

calc_all

Calculate and Impute REE missing data and anomalies.

Description

This is a wrapper for data %>% model_REE() %>% impute_REE() %>% add_parameters()

Usage

```
calc_all(dat, prefix = NULL, suffix = NULL, chondrite = PalmeOneill2014CI)
```

Arguments

dat	A data frame with REE data in ppm
prefix	A prefix in your columns e.g. ICP_La
suffix	A suffix in your columns e.g. La_ppm
chondrite	an option from: PalmeOneill2014CI, Oneill2014Mantle, McDonough1995CI

Value

A data frame. Includes imputed REE, model metrics, and calculated variables.

Examples

```
Ballard_et_al_Zircon %>% calc_all(prefix = 'Zr_', suffix = '_ppm')
```

CleanColnames

Clean variable names that have prefixes or suffixes

Description

This is a helper function

Usage

```
CleanColnames(dat, prefix = NULL, suffix = NULL)
```

Arguments

dat	a data frame
prefix	A character of length 1
suffix	A character of length 1

Value

A data frame

correct_heavy

Corrects for the model deviations of Er, Yb, Lu and Y

Description

Calculated value of Yb, Lu and Y slightly deviates from the linear regression. This function apply a correction to compensates those deviations. This function is wrapped inside model_REE()

Usage

```
correct_heavy(
  dat,
  Y_correction_fact = 1/0.72,
  Ho_correction_fact = 1,
  Er_correction_fact = 1/0.974,
  Tm_correction_fact = 1,
  Yb_correction_fact = 1/0.907,
  Lu_correction_fact = 1/0.926
)
```

Arguments

dat A dataframe
 Y_correction_fact a number: correction factor for underestimated Y. 1/ 0.72 by default.
 Ho_correction_fact a number: correction factor for Ho. 1 by default.
 Er_correction_fact a number: correction factor for underestimated Er. 1/0.974 by default.
 Tm_correction_fact a number: correction factor for Tm. 1 by default.
 Yb_correction_fact a number: correction factor for underestimated Yb. 1/0.907 by default.
 Lu_correction_fact a number: correction factor for underestimated Lu. 1/0.926 by default.

Value

a data frame

correct_middle	<i>Corrects for the model deviations of Yb, Lu and Y</i>
----------------	----------------------------------------------------------

Description

Calculated value of Yb, Lu and Y slightly deviates from the linear regression. This function apply a correction to compensates those deviations. This function is wrapped inside model_REE()

Usage

```

correct_middle(
  dat,
  Nd_correction_fact = 1/0.989,
  Sm_correction_fact = 1/1.022,
  Gd_correction_fact = 1/1.033,
  Tb_correction_fact = 1/1.05,
  Dy_correction_fact = 1/1.032,
  Pr_correction_fact = 1/0.918
)

```

Arguments

dat A dataframe
 Nd_correction_fact a number: correction factor for underestimated Nd 1/0.989
 Sm_correction_fact a number: correction factor for overestimated Sm 1/1.022

Gd_correction_fact
 a number: correction factor for overestimated Gd 1/1.033
 Tb_correction_fact
 a number: correction factor for overestimated Tb 1/1.050
 Dy_correction_fact
 a number: correction factor for overestimated Dy 1/1.032
 Pr_correction_fact
 a number: correction factor for overestimated Pr 1/0.918

Value

a data frame

Element_Data	<i>Element data for calculations</i>
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Description

A dataset containing CI and Mantle values for normalization for selected elements. The data used is from IUPAC, Palme and O'Neill (2014), and McDonough and Sun (1995). Ionic Radii are from Shannon (1976).

Usage

Element_Data

Format

A data frame with 77 rows and 11 variables:

Z Atomic Number

Element_name Element Symbol

Atomic_Mass Atomic Mass from IUPAC

Unit Measure Unit of the Concentrations, ppm = parts per million, pct = percentage

PalmeOneill2014CI Chondrite values from Palme and Oneil (2014)

PalmeOneill2014CI_RSD Uncertainty from chondrite values from Palme and O'Neill (2014) as RSD (Relative standard Deviation)

PalmeOneill2014Mantle Primitive Mantle values from Palme and O'Neill (2014)

PalmeOneill2014Mantle_RSD Uncertainty from Primitive Mantle Values from Palme and O'Neill (2014) as RSD (Relative standard Deviation)

McDonough1995CI Chondrite values from McDonough and Sun (1995)

ShannonRadiiVIII_Coord_3plus Shannon (1976) Ionic Radii for elements in Eight-fold coordination and 3+ charge

Z_Zhong numbers assigned by Zhong et al. (2019) for a logarithmic regression to calculate Zircon REE. ...

Source

IUPAC Website (<https://iupac.org/>)

Palme, H., and O'Neill, H. St. C., 2014, 3.1 - Cosmochemical Estimates of Mantle Composition, in Holland, H. D. and Turekian, K. K. eds., Treatise on Geochemistry (Second Edition): Oxford, Elsevier, p. 1-39. ([doi:10.1016/B9780080959757.002011](https://doi.org/10.1016/B9780080959757.002011))

McDonough, W. F., and Sun, S. -s., 1995, The composition of the Earth: Chemical Geology, v. 120, p. 223-253. ([doi:10.1016/00092541\(94\)001404](https://doi.org/10.1016/00092541(94)001404))

Shannon, R. D., 1976, Revised effective ionic radii and systematic studies of interatomic distances in halides and chalcogenides: Acta Crystallographica Section A, v. 32, p. 751-767. [doi:10.1107/S0567739476001551](https://doi.org/10.1107/S0567739476001551)

Shannon, R. D., 1976, Revised effective ionic radii and systematic studies of interatomic distances in halides and chalcogenides: Acta Crystallographica Section A, v. 32, p. 751-767. [doi:10.1107/S0567739476001551](https://doi.org/10.1107/S0567739476001551)

Zhong, S., Seltmann, R., Qu, H., and Song, Y., 2019, Characterization of the zircon Ce anomaly for estimation of oxidation state of magmas: a revised Ce/Ce* method: Mineralogy and Petrology, v. 113, no. 6, p. 755-763. [doi:10.1007/s0071001900682y](https://doi.org/10.1007/s0071001900682y)

element_denorm

Denormalize chrodrile Normalize to ppm

Description

Denormalize chrodrile Normalize to ppm

Usage

```
element_denorm(dat, method = PalmeOneill2014CI)
```

Arguments

dat	A dataframe
method	an option from: 'PalmeOneill2014CI', 'Oneill2014Mantle', 'McDonough1995CI'

Value

A dataframe

Element_norm	<i>Calculate normalized values for a list of elements</i>
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Description

Element norm normalize values according to published values for the Primitive mantle and chondrites. By defect, it uses the values from Palme and O'Neill (2014). By default, REE + Y list is provided

Usage

```
Element_norm(
  data,
  return = "rect",
  chondrite = PalmeOneill2014CI,
  prefix = NULL,
  suffix = NULL,
  Element_list = REE_plus_Y_Elements
)
```

Arguments

data	a data frame
return	a character from: "rect" for a wide data return, "raw" for a long data return, "append" to append the results to the input data
chondrite	an option from: PalmeOneill2014CI, Oneill2014Mantle, McDonough1995CI
prefix	A prefix in your columns e.g. ICP_La
suffix	A suffix in your columns e.g. La_ppm
Element_list	a character vector: indicating the elements that should be normalized. REE + Y by default

Value

a data frame

impute_REE	<i>Impute Rare earth elements</i>
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Description

Imputes missing REE after modelling. Expect the output of 'model_REE()' function. Only missing values are replaced.

Usage

```
impute_REE(data, prefix = NULL, suffix = NULL, rsquared = 0.95)
```

Arguments

data	A dataframe resulting from 'model_ree()'
prefix	A prefix in your columns e.g. ICP_La
suffix	A suffix in your columns e.g. La_ppm
rsquared	A numerical value between 0 and 1. Tolerance to mis-fitting models. set as 0.9 by default.

Details

By default, exclude models with R-squared lower than 0.95. This limit is flexible and method dependent. As guidelines, the Chondrite-Lattice method should consider R-squared > 0.95 for at least 3 points. The Chondrite-Onuma method should consider R-squared > 0.98 for at least 4 points.

Value

A dataframe

Examples

```
Ballard_et_al_Zircon %>%
  dplyr::slice(1:100) %>%
  model_REE(prefix = 'Zr', suffix = 'ppm') %>%
  impute_REE(prefix = 'Zr', suffix = 'ppm')
```

modelChondrite_lattice

*Model REE contents using the Chondrite-Lattice method of
Rhref<https://link.springer.com/article/10.1007/s00410-023-02025-9>
Carrasco-Godoy and Campbell (2023)*

Description

This function apply the Chondrite-Lattice method which is a linear regression between the misfit parameter from the lattice strain equation and the logarithm of their chondrite normalized values. At least 2 points are required to use this method. This method is based on the work of [Blundy and Wood \(1994\)](#) but using chondrite normalized values as noted by [Carrasco-Godoy and Campbell \(2023\)](#). Refer to [Carrasco-Godoy and Campbell \(2023\)](#) for details.

Usage

```

modelChondrite_lattice(
  dat,
  exclude = c("La", "Pr", "Ce", "Eu", "Y"),
  Calibrate = T,
  prefix = NULL,
  suffix = NULL,
  r0 = 0.87,
  chondrite = PalmeOneill2014CI,
  Pr_correction_fact = 1/0.918,
  Y_correction_fact = 1/0.72,
  Dy_correction_fact = 1/1.032,
  Ho_correction_fact = 1,
  Er_correction_fact = 1/0.974,
  Tm_correction_fact = 1,
  Yb_correction_fact = 1/0.8785,
  Lu_correction_fact = 1/0.8943,
  Nd_correction_fact = 1/0.989,
  Sm_correction_fact = 1/1.022,
  Gd_correction_fact = 1/1.033,
  Tb_correction_fact = 1/1.05
)

```

Arguments

dat	A data frame with REE data in ppm
exclude	a string: vector including elements that should be omitted from modelling. La, Ce and Eu are the default. Ce and Eu should be always included
Calibrate	Logical (T or F). If True, the model is calibrated using the correction factors. By default it is the reciprocal of the median REE from the work of Carrasco-Godoy and Campbell is used.
prefix	A prefix in your columns e.g. ICP_La
suffix	A suffix in your columns e.g. La_ppm
r0	A number: ionic radii of the lattice site r0. By default is 0.87 Å, the median value obtained by Carrasco-Godoy and Campbell.
chondrite	an option from: PalmeOneill2014CI, Oneill2014Mantle, McDonough1995CI
Pr_correction_fact	a number: correction factor for overestimated Pr 1/0.918
Y_correction_fact	a number: correction factor for underestimated Y. 1/ 0.72 by default.
Dy_correction_fact	a number: correction factor for overestimated Dy 1/1.032
Ho_correction_fact	a number: correction factor for Ho. 1 by default.
Er_correction_fact	a number: correction factor for underestimated Er. 1/0.97 by default.

Tm_correction_fact
 a number: correction factor for Tm. 1 by default.

Yb_correction_fact
 a number: correction factor for underestimated Yb. 1/0.8785 by default.

Lu_correction_fact
 a number: correction factor for underestimated Lu. 1/0.8943 by default.

Nd_correction_fact
 a number: correction factor for underestimated Nd 1/0.989

Sm_correction_fact
 a number: correction factor for overestimated Sm 1/1.022

Gd_correction_fact
 a number: correction factor for overestimated Gd 1/1.033

Tb_correction_fact
 a number: correction factor for overestimated Tb 1/1.050

Value

a dataframe

See Also

Other model REE: [modelChondrite_Onuma\(\)](#), [modelZhong\(\)](#), [model_REE\(\)](#)

Examples

```
Ballard_et_al_Zircon %>% modelChondrite_lattice(prefix = 'Zr', suffix = 'ppm')
```

modelChondrite_Onuma *Model REE contents using the Chondrite-Onuma method of Rhref<https://link.springer.com/article/10.1007/s00410-023-02025-9>Carrasco-Godoy and Campbell (2023)*

Description

This function apply the Chondrite-Onuma method which is a quadratic regression between the ionic radius of the REE and the logarithm of their chondrite normalized values. At least 3 non-linear points are required to use this method. This method is based on the work of [Onuma et al. \(1968\)](#) but using chondrite normalized values as noted by [Carrasco-Godoy and Campbell \(2023\)](#). Refer to [Carrasco-Godoy and Campbell \(2023\)](#) for details.

Usage

```
modelChondrite_Onuma(  

  dat,  

  exclude = c("La", "Pr", "Ce", "Eu", "Y"),  

  Calibrate = T,  

  chondrite = PalmeOneill2014CI,
```

```

prefix = NULL,
suffix = NULL,
Pr_correction_fact = 1/1,
Nd_correction_fact = 1/1.026486418,
Sm_correction_fact = 1/0.971111041,
Gd_correction_fact = 1/0.95928241,
Tb_correction_fact = 1/1.000985745,
Dy_correction_fact = 1/1.030049321,
Ho_correction_fact = 1/1.018711009,
Er_correction_fact = 1/0.996610693,
Tm_correction_fact = 1/1.053205463,
Yb_correction_fact = 1/0.982656111,
Lu_correction_fact = 1/0.952608321,
Y_correction_fact = 1/0.665380561
)

```

Arguments

dat	A data frame with REE data in ppm
exclude	a string: vector including elements that should be omitted from modelling. La, Ce and Eu are the default. Ce and Eu should be always included
Calibrate	Logical (T or F). If True, the model is calibrated using the correction factors. By default it is the reciprocal of the median REE from the work of Carrasco-Godoy and Campbell is used.
chondrite	an option from: PalmeOneill2014CI, Oneill2014Mantle, McDonough1995CI
prefix	A prefix in your columns e.g. ICP_La
suffix	A suffix in your columns e.g. La_ppm
Pr_correction_fact	a number: correction factor for overestimated Pr 1/0.918
Nd_correction_fact	a number: correction factor for underestimated Nd 1/0.989
Sm_correction_fact	a number: correction factor for overestimated Sm 1/1.022
Gd_correction_fact	a number: correction factor for overestimated Gd 1/1.033
Tb_correction_fact	a number: correction factor for overestimated Tb 1/1.050
Dy_correction_fact	a number: correction factor for overestimated Dy 1/1.032
Ho_correction_fact	a number: correction factor for Ho. 1 by default.
Er_correction_fact	a number: correction factor for underestimated Er. 1/0.97 by default.
Tm_correction_fact	a number: correction factor for Tm. 1 by default.

Yb_correction_fact
 a number: correction factor for underestimated Yb. 1/0.8785 by default.

Lu_correction_fact
 a number: correction factor for underestimated Lu. 1/0.8943 by default.

Y_correction_fact
 a number: correction factor for underestimated Y. 1/0.72 by default.

Value

a dataframe

See Also

Other model REE: [modelChondrite_lattice\(\)](#), [modelZhong\(\)](#), [model_REE\(\)](#)

Examples

```
Ballard_et_al_Zircon %>% modelChondrite_Onuma(prefix = 'Zr', suffix = 'ppm')
```

modelZhong	<i>Model REE contents using the method of Zhong et al. (2019)</i>
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Description

This function apply the logarithmic regression using the method of [Zhong et al. \(2019\)](#). This method considers the relationship between the logarithm of the REE atomic number vs their chondrite normalized values. For more information refer to the [Zhong et al. \(2019\)](#) and [Carrasco-Godoy and Campbell \(2023\)](#) for a discussion of its limitations to calculate La or Ce*.

Usage

```
modelZhong(  

  dat,  

  exclude = c("La", "Pr", "Ce", "Eu", "Y"),  

  Calibrate = F,  

  chondrite = PalmeOneill2014CI,  

  prefix = NULL,  

  suffix = NULL  

)
```

Arguments

dat	A data frame with REE data in ppm
exclude	a string: vector including elements that should be omitted from modelling. La, Ce and Eu are the default. Ce and Eu should be always included
Calibrate	Logical (T or F). If True, the model is calibrated using the correction factors. By default it is the reciprocal of the median REE from the work of Carrasco-Godoy and Campbell is used.
chondrite	an option from: <code>PalmeOneill2014CI</code> , <code>Oneill2014Mantle</code> , <code>McDonough1995CI</code>
prefix	A prefix in your columns e.g. <code>ICP_La</code>
suffix	A suffix in your columns e.g. <code>La_ppm</code>

Value

a dataframe

See Also

Other model REE: `modelChondrite_Onuma()`, `modelChondrite_lattice()`, `model_REE()`

Examples

```
Ballard_et_al_Zircon %>% modelZhong(prefix = 'Zr', suffix = 'ppm')
```

model_REE

Model REE + Y contents using different methods.

Description

This function models REE + Y using different methods. The Chondrite-Lattice method use a linear regression between the REE (+Y) chondrite-normalized and the missfit term from the lattice strain equation $(r_i/3 + r_0/6)(r_i - r_0)^2$. The Chondrite-Onuma method use the quadratic relationship between the ionic radii and chondrite normalized REE values. The method of Zhong et al. (2019) use a logarithmic relationship between the atomic number of the REE and the chondrite normalized REE. For details in the lattice strain theory, see Blundy and Wood 1994. For more details in the imputation methods see [Carrasco-Godoy and Campbell \(2023\)](#), and [Zhong et al. \(2019\)](#)

Usage

```
model_REE(
  dat,
  method = 1,
  long_format = F,
  exclude = c("La", "Pr", "Ce", "Eu", "Y"),
  r0 = 0.84,
  chondrite = PalmeOneill2014CI,
  estimate_r0 = FALSE,
```



```

r0_step = 0.01,
r0_min = 0.01,
r0_max = 0.15,
prefix = NULL,
suffix = NULL,
Calibrate = T,
Pr_correction_fact = 1/0.918,
Y_correction_fact = 1/0.72,
Dy_correction_fact = 1/1.032,
Ho_correction_fact = 1,
Er_correction_fact = 1/0.974,
Tm_correction_fact = 1,
Yb_correction_fact = 1/0.8785,
Lu_correction_fact = 1/0.8943,
Nd_correction_fact = 1/0.989,
Sm_correction_fact = 1/1.022,
Gd_correction_fact = 1/1.033,
Tb_correction_fact = 1/1.05
)

```

Arguments

dat	A data frame with REE data in ppm
method	a number. a choice of 1 for Chondrite Lattice or 2 for Zhong et al. (2019) or 3 for Chondrite-Onuma method.
long_format	If T, rectangular long data is returned.
exclude	a string: vector including elements that should be omitted from modelling. La, Ce and Eu are the default. Ce and Eu should be always included
r0	A number: ionic radii of the lattice site r0. By default is 0.87 Å, the median value obtained by Carrasco-Godoy and Campbell.
chondrite	an option from: PalmeOneill2014CI, Oneill2014Mantle, McDonough1995CI
estimate_r0	If T, r0 is estimated using a method similar to the one from Loader et al. 2022.
r0_step	If r0 is estimated, this define the step for iteration. smaller step heavily increases the computing time.
r0_min	Minimum value from which the iteration starts. Calculated from r0.
r0_max	Maximum value at which iteration ends. Calculated from r0.
prefix	A prefix in your columns e.g. ICP_La
suffix	A suffix in your columns e.g. La_ppm
Calibrate	Logical (T or F). If True, the model is calibrated using the correction factors. By default it is the reciprocal of the median REE from the work of Carrasco-Godoy and Campbell is used.
Pr_correction_fact	a number: correction factor for overestimated Pr 1/0.918
Y_correction_fact	a number: correction factor for underestimated Y. 1/0.72 by default.

Dy_correction_fact
 a number: correction factor for overestimated Dy 1/1.032

Ho_correction_fact
 a number: correction factor for Ho. 1 by default.

Er_correction_fact
 a number: correction factor for underestimated Er. 1/0.97 by default.

Tm_correction_fact
 a number: correction factor for Tm. 1 by default.

Yb_correction_fact
 a number: correction factor for underestimated Yb. 1/0.8785 by default.

Lu_correction_fact
 a number: correction factor for underestimated Lu. 1/0.8943 by default.

Nd_correction_fact
 a number: correction factor for underestimated Nd 1/0.989

Sm_correction_fact
 a number: correction factor for overestimated Sm 1/1.022

Gd_correction_fact
 a number: correction factor for overestimated Gd 1/1.033

Tb_correction_fact
 a number: correction factor for overestimated Tb 1/1.050

Value

a dataframe

See Also

Other model REE: [modelChondrite_Onuma\(\)](#), [modelChondrite_lattice\(\)](#), [modelZhong\(\)](#)

Examples

```
Ballard_et_al_Zircon %>% model_REE(prefix = 'Zr', suffix = 'ppm')
```

REE_Elements

Rare earth element list

Description

A string vector containing the elemental symbols for REE.

Usage

```
REE_Elements
```

Format

Rare earth element list

REE_plus_Y_Elements *Rare earth element list*

Description

A string vector containing the elemental symbols for REE and Y.

Usage

REE_plus_Y_Elements

Format

Rare earth element + Y list

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