World Data Service for Paleoclimatology standard format for Uranium-Thorium tables

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This document provides instructions to create a standardized Uranium-Thorium table for the Chronology section of a WDS-Paleo data contribution. The purpose of this standard is to promote interoperability and reusability. Specifically, standardized nomenclature and consistent formatting ensure datasets are human-understandable and machine-readable (i.e., capable of being read by computer code for reprocessing, etc.). All new contributions to the WDS-Paleo will adhere to this standard, and datasets already archived by the WDS-Paleo will be converted to the standard format as resources permit.

Within a formatted U-Th chronology block (**Figure 1**), there are two subsections. First is a series of standardized fields for important chronology-related metadata (e.g., Chronology_Methods, Missing_Values, etc.), as defined in **Appendix A**. Second is the tab-delimited U-Th table (Chronology_Table) that uses standardized column heading names listed in **Appendix B**.

```
#----------------------------------------
# Chronology_Information
#   Chronology: Uranium-Thorium
#     Chronology_Download_Resource: https://www.ncei.noaa.gov/pub/data/paleo/templates/noaa-wds-paleo-uth-terms.csv
#   Chronology_Download_Description: Uranium-Thorium terms and definitions.
#   Chronology_Notes:
#   Rejection_Rationale:
#   238U_Decay_Constant:
#   234U_Decay_Constant:
#   230Th_Decay_Constant:
#   Initial_230Th/232Th:
#   Initial_230Th/232Th_Method:
#   Age_Model_Method:
#   Missing_Values:
#   Chronology_Table:
# depth_top_mm→238U_ppb→238U_2s_ppb→232Th_ppt→232Th_2s_ppt→230Th_232Th_act→230Th_232Th_act_2s→
230Th_238U_act→230Th_238U_act_2s→d234U_meas_permil→d234U_meas_2s_permil→d234U_init_permil→
d234U_init_2s_permil→age_uncorr_BM→age_uncorr_2s_yr→age_corr_BM→age_corr_2s_yr→age_corr_BP1950→
age_corr_2s_yr→date_used
# 10→891.56266→0.75038→1012.46920→15.09079→247.63087→3.91033→0.09202→0.00049→158.31916→1.15778→
162.38313→1.18775→9009.64211→50.43689→8981.20877→52.38379→8914.20877→52.38379→yes
```

Figure 1. Snippet of a WDS-Paleo text dataset file, showing a standardized U-Th chronology block. Dashes demarcate the beginning and end of a chronology block. Every new line must start with #. Only standard column headings listed in Appendix B of this document may be used for the Chronology_Table (i.e., samp_id, depth_top_mm, etc.).

Appendix A. Standardized metadata tags and their uses

Above the Chronology_Table that contains the U-Th data, there are nine fields for free-text metadata information. Providing information for these fields is not required, but is recommended for proper interpretation and reuse of data. The metadata tag names should not be altered, but there is no restriction on the format of the text that follows the colon of each tag.

Metadata tag	**Use**
Chronology_Notes	Provide general information about the chronology section.
Rejection_Rationale	Explain why certain dates were not used in the age model (e.g., out of stratigraphic alignment). If dates were rejected, also include the “date_used” column in Chronology_Table to mark these dates as “no” (date not used). See Appendix B.
238U_Decay_Constant	Provide the decay constant used.
234U_Decay_Constant	Provide the decay constant used.
230Th_Decay_Constant	Provide the decay constant used.
Initial_230Th/232Th	Provide the value used for initial 230Th/232Th.
Initial_230Th/232Th_Method	Explain how the initial 230Th/232Th value was obtained (e.g., assumed, constrained using some method, measured directly).
Age_Model_Method	Provide information about how the age model was constructed from the Chronology_Table (e.g., bchron, linear interpolation).
Missing_Values	Define how missing values are denoted in Chronology_Table (e.g., NA).

Appendix B. Standardized column headings, definitions, and units

Column headings for the Chronology_Table must be selected from standard terms listed below. It is not required to use all of the column headings listed below. However, there are several required columns:

- depth (e.g., depth_top_cm, depth_top_mm)
- age corrected for initial 230Th/232Th (e.g., age_corr_BP1950, age_corr_kaBP1950)
- corresponding age uncertainty (e.g., age_corr_2s_yr, age_corr_2s_ka)
- meas_yr (if corrected ages are reported relative to measurement year rather than relative to 1950 CE)
- date_used (if some dates were not used in the final age model)

There is no particular order in which the columns need to be arranged. The term lists below are grouped into categories for organizational purposes.

Terms for sample metadata

Column heading	Definition	Units
samp_id	Sample identification	N/A
core_id	Core identification	N/A
lab_code	Code used by dating lab	N/A
depth_top_mm	Distance of sample from top	millimeters
depth_top_cm	Distance of sample from top	centimeters
depth_bot_mm	Distance of sample from bottom	millimeters
depth_bot_cm	Distance of sample from bottom	centimeters
thick_mm	Thickness of sample	millimeters
thick_cm	Thickness of sample	centimeters
material_dated	Mineralogy of material dated (e.g. calcite or aragonite)	N/A
date_type	Measurement method (e.g. TIMS or MC-ICP-MS)	N/A
weight_ug	Weight of sample	micrograms
weight_mg	Weight of sample	milligrams
weight_g	Weight of sample	grams

meas_yr	Year of sample measurement (e.g. 2015)	year CE
date_used	Indicates whether date was used in age model	N/A
IGSN	International Geo Sample Number	N/A
notes	Any additional sample information	N/A

Terms for elemental content

Column heading	Definition	Units
U_ppm	Uranium	parts per million
U_1s_ppm	One sigma uncertainty of Uranium	parts per million
U_2s_ppm	Two sigma uncertainty of Uranium	parts per million
U_ppb	Uranium	parts per billion
U_1s_ppb	One sigma uncertainty of Uranium	parts per billion
U_2s_ppb	Two sigma uncertainty of Uranium	parts per billion
Th_ppm	Thorium	parts per million
Th_1s_ppm	One sigma uncertainty of Thorium	parts per million
Th_2s_ppm	Two sigma uncertainty of Thorium	parts per million
Th_ppb	Thorium	parts per billion
Th_1s_ppb	One sigma uncertainty of Thorium	parts per billion
Th_2s_ppb	Two sigma uncertainty of Thorium	parts per billion
Th_ppt	Thorium	parts per trillion
Th_1s_ppt	One sigma uncertainty of Thorium	parts per trillion
Th_2s_ppt	Two sigma uncertainty of Thorium	parts per trillion

Terms for content of single isotope

Column heading	Definition	Units
238U_ppm	238U	parts per million
238U_1s_ppm	One sigma uncertainty of 238U	parts per million
238U_2s_ppm	Two sigma uncertainty of 238U	parts per million
238U_ppb	238U	parts per billion
238U_1s_ppb	One sigma uncertainty of 238U	parts per billion
238U_2s_ppb	Two sigma uncertainty of 238U	parts per billion
234U_ppb	234U	parts per billion
234U_1s_ppb	One sigma uncertainty of 234U	parts per billion
234U_2s_ppb	Two sigma uncertainty of 234U	parts per billion
232Th_ppb	232Th	parts per billion
232Th_1s_ppb	One sigma uncertainty of 232Th	parts per billion
232Th_2s_ppb	Two sigma uncertainty of 232Th	parts per billion
232Th_ppt	232Th	parts per trillion
232Th_1s_ppt	One sigma uncertainty of 232Th	parts per trillion
232Th_2s_ppt	Two sigma uncertainty of 232Th	parts per trillion
232Th_pmol/g	232Th	picomoles per gram
232Th_1s_pmol/g	One sigma uncertainty of 232Th	picomoles per gram
232Th_2s_pmol/g	Two sigma uncertainty of 232Th	picomoles per gram
230Th_ppb	230Th	parts per billion
230Th_1s_ppb	One sigma uncertainty of 230Th	parts per billion
230Th_2s_ppb	Two sigma uncertainty of 230Th	parts per billion
230Th_ppt	230Th	parts per trillion
230Th_1s_ppt	One sigma uncertainty of 230Th	parts per trillion
230Th_2s_ppt	Two sigma uncertainty of 230Th	parts per trillion

Terms for atomic ratios of isotopes

Column heading	Definition	Units
230Th_232Th_atom	Atomic abundance of 230Th divided by atomic abundance of 232Th	dimensionless
230Th_232Th_atom_1s	One sigma uncertainty of atomic abundance of 230Th divided by atomic abundance of 232Th	dimensionless
230Th_232Th_atom_2s	Two sigma uncertainty of atomic abundance of 230Th divided by atomic abundance of 232Th	dimensionless
230Th_232Th_atom_ppm	Atomic abundance of 230Th divided by atomic abundance of 232Th and multiplied by 10e6	parts per million
230Th_232Th_atom_1s_ppm	One sigma uncertainty of atomic abundance of 230Th divided by atomic abundance of 232Th and multiplied by 10e6	parts per million
230Th_232Th_atom_2s_ppm	Two sigma uncertainty of atomic abundance of 230Th divided by atomic abundance of 232Th and multiplied by 10e6	parts per million
232Th_230Th_atom	Atomic abundance of 232Th divided by atomic abundance of 230Th	dimensionless
232Th_230Th_atom_1s	One sigma uncertainty of atomic abundance of 232Th divided by atomic abundance of 230Th	dimensionless
232Th_230Th_atom_2s	Two sigma uncertainty of atomic abundance of 232Th divided by atomic abundance of 230Th	dimensionless

Terms for isotope activity ratios

Column heading	Definition	Units
230Th_232Th_act	230Th rate of decay divided by 232Th rate of decay	dimensionless
230Th_232Th_act_1s	One sigma uncertainty of 230Th rate of decay divided by 232Th rate of decay	dimensionless

230Th_232Th_act_2s	Two sigma uncertainty of 230Th rate of decay divided by 232Th rate of decay	dimensionless
230Th_232Th_act_init	Estimated initial 230Th rate of decay divided by 232Th rate of decay	dimensionless
230Th_232Th_act_init_1s	One sigma uncertainty of estimated initial 230Th rate of decay divided by 232Th rate of decay	dimensionless
230Th_232Th_act_init_2s	Two sigma uncertainty of estimated initial 230Th rate of decay divided by 232Th rate of decay	dimensionless
230Th_234U_act	230Th rate of decay divided by 234U rate of decay	dimensionless
230Th_234U_act_1s	One sigma uncertainty of 230Th rate of decay divided by 234U rate of decay	dimensionless
230Th_234U_act_2s	Two sigma uncertainty of 230Th rate of decay divided by 234U rate of decay	dimensionless
230Th_238U_act	230Th rate of decay divided by 238U rate of decay	dimensionless
230Th_238U_act_1s	One sigma uncertainty of 230Th rate of decay divided by 238U rate of decay	dimensionless
230Th_238U_act_2s	Two sigma uncertainty of 230Th rate of decay divided by 238U rate of decay	dimensionless
232Th_238U_act	232Th rate of decay divided by 238U rate of decay	dimensionless
232Th_238U_act_1s	One sigma uncertainty of 232Th rate of decay divided by 238U rate of decay	dimensionless
232Th_238U_act_2s	Two sigma uncertainty of 232Th rate of decay divided by 238U rate of decay	dimensionless
234U_232Th_act	234U rate of decay divided by 232Th rate of decay	dimensionless
234U_232Th_act_1s	One sigma uncertainty of 234U rate of decay divided by 232Th rate of decay	dimensionless
234U_232Th_act_2s	Two sigma uncertainty of 234U rate of decay divided by 232Th rate of decay	dimensionless
234U_238U_act	234U rate of decay divided by 238U rate of decay	dimensionless

234U_238U_act_1s	One sigma uncertainty of 234U rate of decay divided by 238U rate of decay	dimensionless
234U_238U_act_2s	Two sigma uncertainty of 234U rate of decay divided by 238U rate of decay	dimensionless
234U_238U_act_init	Calculated initial 234U rate of decay divided by 238U rate of decay	dimensionless
234U_238U_act_init_1s	One sigma uncertainty of calculated initial 234U rate of decay divided by 238U rate of decay	dimensionless
234U_238U_act_init_2s	Two sigma uncertainty of calculated initial 234U rate of decay divided by 238U rate of decay	dimensionless
234U_238U_act_init_pos1s	Positive one sigma uncertainty of calculated initial 234U rate of decay divided by 238U rate of decay	dimensionless
234U_238U_act_init_neg1s	Negative one sigma uncertainty of calculated initial 234U rate of decay divided by 238U rate of decay	dimensionless
234U_238U_act_init_pos2s	Positive two sigma uncertainty of calculated initial 234U rate of decay divided by 238U rate of decay	dimensionless
234U_238U_act_init_neg2s	Negative two sigma uncertainty of calculated initial 234U rate of decay divided by 238U rate of decay	dimensionless
238U_232Th_act	238U rate of decay divided by 232Th rate of decay	dimensionless

Terms for isotopic ratios in delta notation

Column heading	Definition	Units
d234U_meas_permil	Measured present 234U/238U activity ratio expressed as a deviation from secular equilibrium and multiplied by 1000	per mil
d234U_meas_1s_permil	One sigma uncertainty of measured present 234U/238U activity ratio expressed as a deviation from secular equilibrium and multiplied by 1000	per mil

d234U_meas_2s_permil	Two sigma uncertainty of measured present 234U/238U activity ratio expressed as a deviation from secular equilibrium and multiplied by 1000	per mil
d234U_init_permil	Calculated initial 234U/238U activity ratio expressed as a deviation from secular equilibrium and multiplied by 1000	per mil
d234U_init_1s_permil	One sigma uncertainty of calculated initial 234U/238U activity ratio expressed as a deviation from secular equilibrium and multiplied by 1000	per mil
d234U_init_2s_permil	Two sigma uncertainty of calculated initial 234U/238U activity ratio expressed as a deviation from secular equilibrium and multiplied by 1000	per mil

Terms for uncorrected ages

Column heading	Definition	Units
age_uncorr_BM	Uncorrected age	years before sample measurement where measurement date is defined by “meas_yr”
age_uncorr_BP1950	Uncorrected age	years before 1950 CE
age_uncorr_pos1s_yr	Positive one sigma uncertainty of uncorrected age	years
age_uncorr_neg1s_yr	Negative one sigma uncertainty of uncorrected age	years
age_uncorr_pos2s_yr	Positive two sigma uncertainty of uncorrected age	years
age_uncorr_neg2s_yr	Negative two sigma uncertainty of uncorrected age	years
age_uncorr_1s_yr	Positive and negative one sigma uncertainty of uncorrected age	years
age_uncorr_2s_yr	Positive and negative two sigma uncertainty of uncorrected age	years
age_uncorr_kaBM	Uncorrected age	kiloyears before sample measurement where measurement date is

		defined by “meas_yr”
age_uncorr_kaBP1950	Uncorrected age	kiloyears before 1950 CE
age_uncorr_pos1s_ka	Positive one sigma uncertainty of corrected age	kiloyears
age_uncorr_neg1s_ka	Negative one sigma uncertainty of uncorrected age	kiloyears
age_uncorr_pos2s_ka	Positive two sigma uncertainty of uncorrected age	kiloyears
age_uncorr_neg2s_ka	Negative two sigma uncertainty of uncorrected age	kiloyears
age_uncorr_1s_ka	Positive and negative one sigma uncertainty of uncorrected age	kiloyears
age_uncorr_2s_ka	Positive and negative two sigma uncertainty of uncorrected age	kiloyears

Terms for corrected ages

Column heading	Definition	Units
age_corr_BM	Corrected age	years before sample measurement where measurement date is defined by “meas_yr”
age_corr_CE	Corrected age	years Common Era
age_corr_BP1950	Corrected age	years before 1950 CE
age_corr_pos1s_yr	Positive one sigma uncertainty of corrected age	years
age_corr_neg1s_yr	Negative one sigma uncertainty of corrected age	years
age_corr_pos2s_yr	Positive two sigma uncertainty of corrected age	years
age_corr_neg2s_yr	Negative two sigma uncertainty of corrected age	years
age_corr_1s_yr	Positive and negative one sigma	years

	uncertainty for corrected age	
age_corr_2s_yr	Positive and negative two sigma uncertainty for corrected age	years
age_corr_kaBM	Corrected age	kiloyears before sample measurement where date of measurement is defined by “meas_yr”
age_corr_kaBP1950	Corrected age	kiloyears before 1950 CE
age_corr_pos1s_ka	Positive one sigma uncertainty of corrected age	kiloyears
age_corr_neg1s_ka	Negative one sigma uncertainty of corrected age	kiloyears
age_corr_pos2s_ka	Positive two sigma uncertainty of corrected age	kiloyears
age_corr_neg2s_ka	Negative two sigma uncertainty of corrected age	kiloyears
age_corr_1s_ka	Positive and negative one sigma uncertainty of corrected age	kiloyears
age_corr_2s_ka	Positive and negative two sigma uncertainty of corrected age	kiloyears

Terms for modeled ages

Column heading	Definition	Units
age_model_BP1950	Age inferred from an age-depth model	years before 1950 CE
age_model_pos1s_yr	Positive one sigma uncertainty of age inferred from an age-depth model	years
age_model_neg1s_yr	Negative one sigma uncertainty of age inferred from an age-depth model	years
age_model_pos2s_yr	Positive two sigma uncertainty of age inferred from an age-depth model	years
age_model_neg2s_yr	Negative two sigma uncertainty of age inferred from an age-depth model	years

age_model_1s_yr	Positive and negative one sigma uncertainty for age inferred from an age-depth model	years
age_model_2s_yr	Positive and negative two sigma uncertainty for age inferred from an age-depth model	years
age_model_pos1s_BP1950	One sigma upper range of age inferred from an age-depth model	years before 1950 CE
age_model_neg1s_BP1950	One sigma lower range of age inferred from an age-depth model	years before 1950 CE
age_model_pos2s_BP1950	Two sigma upper range of age inferred from an age-depth model	years before 1950 CE
age_model_neg2s_BP1950	Two sigma lower range of age inferred from an age-depth model	years before 1950 CE