

Supplementary Information: The SISAL database: a global resource to document oxygen and carbon isotope records from speleothems

Kamolphet Atsawawanunt¹, Laia Comas-Bru², Sahar Amirnezhad Mozhdehi², Michael Deininger^{2,3}, Sandy P. Harrison¹, Andy Baker⁴, Meighan Boyd⁵, Nikita Kaushal⁶, Syed Masood Ahmed⁷, Yassine Ait Brahim⁸, Monica Arienzo⁹, Petra Bajo¹⁰, Kerstin Braun¹¹, Yuval Burstyn¹², Sakonvan Chawchai¹³, Wuhui Duan¹⁴, István Gábor Hatvani¹⁵, Jun Hu¹⁶, Zoltán Kern¹⁵, Inga Labuhn¹⁷, Matthew Lachniet¹⁸, Franziska A. Lechleiter⁶, Andrew Lorrey¹⁹, Carlos Pérez-Mejías²⁰, Robyn Pickering²¹, Nick Scroton²² and SISAL Working Group Members

- 1: Centre for Past Climate Change and School of Archaeology, Geography & Environmental Sciences, Reading University, Whiteknights, Reading, RG6 6AH, UK
- 2: School of Earth Sciences, University College Dublin, Belfield, Dublin 4, Ireland.
- 3: Institute of Geosciences, Johannes-Gutenberg-University Mainz, Johann-Joachim-Becher-Weg 21, 55128 Mainz, Germany
- 4: School of Biological, Earth and Environmental Sciences, University of New South Wales, Kensington 2052, Australia
- 5: Department of Earth Sciences, Royal Holloway University of London, Egham, Surrey TW20 0EX, UK
- 6: Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, OX1 3AN, UK
- 7: National Geophysical Research Institute, Uppal Road, 500 007 Hyderabad, India
- 8: Institute of Global Environmental Change, Xi'an Jiaotong University, Xi'an, Shaanxi, China
- 9: Division of Hydrologic Sciences, Desert Research Institute, 2215 Raggio Parkway, 89512 Reno, NV, USA
- 10: The University of Melbourne, Bouverie Street, 3010 Parkville, Australia
- 11: Institute of Human Origins, Arizona State University, PO Box 874101, 85287 Tempe, Arizona, USA
- 12: Institute of Earth Science/Geology, Hebrew University of Jerusalem, Edmond J. Safra campus, Givat Ram, 91904 Jerusalem, Israel and Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501, Israel
- 13: Dept of Geology, Faculty of Sciences, Chulalongkorn University, 254 Phayathai Rd, Pathum Wan, 10330 Bangkok, Thailand
- 14: Institute of Geology and Geophysics, Chinese Academy of Sciences, University of Chinese Academy of Sciences, No.19 Beitucheng West Road, Chaoyang District, Beijing, China
- 15: Institute for Geological and Geochemical Research, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, Budaörsi út 45, 1112 Budapest, Hungary
- 16: Department of Earth Sciences, University of Southern California, 3651 Trousdale Parkway, 90089 Los Angeles, California, USA
- 17: Institute of Geography, University of Bremen, Bremen, Germany
- 18: Dept. of Geoscience, University of Nevada, Box 4010, 89154 Las Vegas, NV, USA
- 19: Climate, Atmosphere and Hazards Centre, National Institute of Water & Atmospheric Research, 41 Market Place, Central Business District, Auckland, New Zealand 1010
- 20: Department of Geoenvironmental Processes and Global Change, Pyrenean Institute of Ecology (IPE-CSIC), Avda. Montañana 1005, 50059 Zaragoza, Spain
- 21: Department of Geological Sciences, Human Evolutionary Research Institute, University of Cape Town, 7701 Rondebosch, Cape Town, South Africa
- 22: Department of Geosciences, University of Massachusetts Amherst, 611 North Pleasant Street, 01003-9297 Amherst, MA, USA

Table S1: Definition of pre-defined choice for all fields in the SISAL_v1 database

Table name	Field	Lists
d13C	iso_std	‘PDB’, ‘Vienna-PDB’
d18O	iso_std	‘PDB’, ‘Vienna-PDB’
dating	date_type	‘C14’, ‘MC-ICP-MS U/Th’, ‘ICP-MS U/Th Other’, ‘Alpha U/Th’, ‘TIMS’, ‘U/Th unspecified’, ‘Cross-dating’, ‘Multiple methods’, ‘Event; hiatus’, ‘Event; actively forming’, ‘Event; start of laminations’, ‘Event; end of laminations’, ‘unknown’
dating	material_dated	‘calcite’, ‘aragonite’, ‘organic’, ‘other’, ‘unknown’
dating	calib_used	‘INTCAL13 NH’, ‘INTCAL13 SH’, ‘INTCAL13 marine’, ‘INTCAL09’, ‘INTCAL09 marine’, ‘INTCAL04 NH’, ‘INTCAL04 SH’, ‘INTCAL98’, ‘FAIRBANKS09’, ‘not calibrated’
dating	date_used	‘yes’, ‘no’, ‘unknown’
dating	decay_constant	‘Cheng et al. 2000’, ‘Cheng et al. 2013’, ‘Edwards et al. 1987’, ‘Ivanovich & Harmon 1992’, ‘others’, ‘unknown’
entity	depth_ref	‘from top’, ‘from base’, ‘not applicable’
entity	speleothem_type	‘stalagmite’, ‘composite’, ‘stalactite’, ‘flowstone’, ‘unknown’, ‘other’
entity	drip_type	‘seepage flow’, ‘seasonal drip’, ‘fast flow’, ‘mixture’, ‘unknown’
entity	d13C	‘yes’, ‘no’, ‘unknown’
entity	d18O	‘yes’, ‘no’, ‘unknown’
entity	d18O_water_equilibrium	‘yes’, ‘no’, ‘unknown’
entity	trace_elements	‘yes’, ‘no’, ‘unknown’
entity	organics	‘yes’, ‘no’, ‘unknown’
entity	fluid_inclusions	‘yes’, ‘no’, ‘unknown’
entity	mineralogy_petrology_fabric	‘yes’, ‘no’, ‘unknown’
entity	clumped_isotopes	‘yes’, ‘no’, ‘unknown’
entity	noble_gas_temperatures	‘yes’, ‘no’, ‘unknown’
entity	C14	‘yes’, ‘no’, ‘unknown’
entity	ODL	‘yes’, ‘no’, ‘unknown’
entity	Mg_Ca	‘yes’, ‘no’, ‘unknown’
gap	gap	‘G’
hiatus	hiatus	‘H’
original_chronology	age_model_type	‘linear’, ‘linear between dates’, ‘polynomial fit’, ‘polynomial fit omitting outliers’, ‘Bayesian’, ‘Bayesian Bacon’, ‘Bayesian Bchron’, ‘StalAge’, ‘StalAge and other’, ‘Clam’, ‘COPRA’, ‘OxCal’, ‘combination of methods’, ‘unknown’, ‘other’
original_chronology	ann_lam_check	‘14C peak’, ‘14C slope’, ‘U/Th cycle’, ‘trace element cycle’, ‘assumed’, ‘not applicable’, ‘unknown’
original_chronology	dep_rate_check	‘yes’, ‘no’, ‘assumed’, ‘not applicable’, ‘unknown’
sample	mineralogy	‘calcite’, ‘secondary calcite’, ‘aragonite’, ‘vaterite’, ‘mixed’, ‘unknown’
sample	composite	‘yes’, ‘no’, ‘unknown’

sample	arag_corr	'yes', 'no', 'not applicable', 'unknown'
site	geology	'limestone', 'dolomite', 'gypsum', 'magmatic', 'marble', 'granite', 'mixed', 'other', 'unknown'
site	rock_age	'Holocene', 'Pleistocene', 'Pliocene', 'Miocene', 'Oligocene', 'Eocene', 'Palaeocene', 'Cretaceous', 'Jurassic', 'Triassic', 'Permian', 'Carboniferous', 'Devonian', 'Silurian', 'Ordovician', 'Cambrian', 'Precambrian', 'unknown'
site	monitoring	'yes', 'no', 'unknown'

Table S2: Characteristics of the site table

Field label	Definition	Format	Constraints
site_id	Unique identifier for each site, where a site is defined as a cave or cave system	Numeric	Positive integer
site_name	Site name as given by original authors or as defined by us where there was no unique name given to the site	Text	None
latitude	Latitude of the cave site, given in decimal degrees, where N is positive and S is negative	Numeric	None
longitude	Longitude of the cave site, given in decimal degrees, E is positive and W is negative	Numeric	None
elevation	Elevation of the cave, in meters above sea level (where negative values indicate elevations below sea level)	Numeric	None
geology	Description of the rock type	Text	selected from pre-defined list
rock_age	Description of age of the rock	Text	selected from pre-defined list
monitoring	Indication of whether long-term monitoring of cave conditions have been carried out	Text	selected from pre-defined list

Table S3: Characteristics of the entity table

Field	Definition	Format	Constraints
site_id	Refers to the unique identifier for each site (as given in site table)	Numeric	Positive integer
entity_id	Unique identifier for each entity, where an entity is defined as a speleothem or a speleothem composite	Numeric	Positive integer
entity_name	Entity (speleothem) name as given by the author	Text	None
depth_ref	Indication of whether the reference point is the top or base of the speleothem	Text	selected from pre-defined list
cover_thickness	Thickness of overlying bedrock above the speleothem (m)	Numeric	Positive decimal
distance_entrance	Distance of the speleothem from the cave entrance (m)	Numeric	Positive decimal
speleothem_type	Description of the speleothem type	Text	selected from pre-defined list
drip_type	Description of the drip type	Text	selected from pre-defined list
d13C	Indication of whether $\delta^{13}\text{C}$ measurements have been made of the speleothem	Text	selected from pre-defined list
d18O	Indication of whether $\delta^{18}\text{O}$ measurements have been measured	Text	selected from pre-defined list
d18O_water_equilibrium	Indication of whether studies assessing if the speleothem is precipitating in equilibrium with dripwaters have been done	Text	selected from pre-defined list
trace_elements	Indication of whether trace elements have been measured	Text	selected from pre-defined list
organics	Indication of whether organics have been measured	Text	selected from pre-defined list
fluid_inclusions	Indication of whether fluid inclusions have been measured	Text	selected from pre-defined list
mineralogy_petrology_fabric	Indication of whether fabric measurements have been made	Text	selected from pre-defined list
clumped_isotopes	Indication of whether clumped isotopes have been measured	Text	selected from pre-defined list
noble_gas_temperatures	Indication of whether noble gases have been measured	Text	selected from pre-defined list
C14	Indication of whether ^{14}C measurements have been made	Text	selected from pre-defined list
ODL	Indication of whether the optical density of luminosity measurements have been made	Text	selected from pre-defined list
Mg_Ca	Indication of whether the Mg/Ca ratio measurements have been made	Text	selected from pre-defined list
contact	Name of the person who entered	Text	None

	the data into the workbook		
data_doi_url	Digital Object Identifier (DOI) of the data or URL of the webpage from which the data can be obtained.	Text	None

Table S4: Characteristics of the sample table

Field	Description	Format	Constraints
entity_id	Refers to the unique identifier for each entity (as given in entity table)	Numeric	Positive integer
<u>sample_id</u>	Unique identifier for the sample	Numeric	Positive integer
sample_thickness	Thickness of the sample analysed (mm)	Numeric	Positive decimal
depth_sample	Distance in mm from a reference point	Numeric	Positive decimal
mineralogy	Description of the mineralogy of the sample	Text	selected from pre-defined list
arag_corr	Indication of whether the isotope measurements have been corrected in aragonite samples	Text	selected from pre-defined list

Table S5: Characteristics of the dating information table

Field	Description	Format	Constraints
dating_id	Unique identifier for each date	Numeric	Positive integer
entity_id	Refers to the unique identifier for each entity (as given in entity table)	Numeric	Positive integer
date_type	Description of the dating method used	Text	selected from pre-defined list
depth_dating	Distance in mm from a reference point	Numeric	Positive decimal
dating_thickness	Thickness of dated sample in mm	Numeric	Positive decimal
lab_num	The laboratory number of the dated sample	Text	None
material_dated	Mineralogy of the dated sample	Text	selected from pre-defined list
min_weight	Minimum weight of the dated sample in mg	Numeric	Positive decimal
max_weight	Maximum weight of the dated sample in mg	Numeric	Positive decimal
uncorr_age	Uncorrected age of the dated sample in years	Numeric	None
uncorr_age_uncert_pos	Positive uncertainty of the uncorrected age of the dated sample in years	Numeric	Positive decimal
uncorr_age_uncert_neg	Negative uncertainty of the uncorrected age of the dated sample in years	Numeric	Positive decimal
14C_correction	Percentage dead carbon present in dated sample	Numeric	Positive decimal
calib_used	Calibration method used to convert C ¹⁴ dates to calendar years	Text	selected from pre-defined list
date_used	Indication of whether the date is used in the original age model	Text	selected from pre-defined list
238U_content	²³⁸ U content of the dated sample in ppb	Numeric	None
238U_uncertainty	²³⁸ U 2-sigma uncertainty of dated sample in ppb	Numeric	None
232Th_content	²³² Th content of the dated sample in ppt	Numeric	None
232Th_uncertainty	²³² Th 2-sigma uncertainty of the dated sample in ppt	Numeric	None
230Th_content	²³⁰ Th content of the dated sample in ppt	Numeric	None
230Th_uncertainty	²³⁰ Th 2-sigma uncertainty of the dated sample in ppt	Numeric	None
230Th_232Th_ratio	²³⁰ Th/ ²³² Th activity ratio of the dated sample	Numeric	None
230Th_232Th_ratio_uncertainty	²³⁰ Th/ ²³² Th activity ratio 2-sigma uncertainty of the dated sample	Numeric	None
230Th_238U_activity	²³⁰ Th/ ²³⁸ U activity ratio of the dated sample	Numeric	None
230Th_238U_activity_uncertainty	²³⁰ Th/ ²³⁸ U activity ratio 2-sigma uncertainty of the dated sample	Numeric	None
234U_238U_activity	²³⁴ U/ ²³⁸ U activity ratio of the dated sample	Numeric	None
234U_238U_activity_u	²³⁴ U/ ²³⁸ U activity ratio 2-sigma	Numeric	None

ncertainty	uncertainty of the dated sample		
ini_230Th_232Th_ratio	Initial $^{230}\text{Th}/^{232}\text{Th}$ activity ratio for the detrital correction	Numeric	None
ini_230Th_232Th_ratio_uncertainty	Initial $^{230}\text{Th}/^{232}\text{Th}$ activity ratio uncertainty for the detrital correction	Numeric	None
decay_constant	Description of the half-life used for ^{230}Th and ^{234}U for U/Th samples	Text	selected from pre-defined list
corr_age	Corrected age of the dated sample in years	Numeric	None
corr_age_uncert_pos	Positive uncertainty of corrected age of the dated sample in years	Numeric	Positive decimal
corr_age_uncert_neg	Negative uncertainty of corrected age of the dated sample in years	Numeric	Positive decimal

Table S6: Characteristics of the lamina dating table

Field	Description	Format	Constraints
dating_lamina_id	Unique identifier for each lamina	Numeric	Positive integer
entity_id	Refers to the unique identifier for each entity (as given in entity table)	Numeric	Positive integer
depth_lam	Depth of the midpoint of the lamina in mm from a reference point	Numeric	Positive integer
lam_thickness	Thickness in mm of the sample dated	Numeric	Positive decimal
lam_age	Age in years of individual lamina	Numeric	None
lam_age_uncert_pos	Positive counting uncertainty of individual lamina in years	Numeric	Positive decimal
lam_age_uncert_neg	Negative counting uncertainty of individual lamina in years	Numeric	Positive decimal

Table S7: Characteristics of the hiatus place mark information table

Field	Description	Format	Constraints
sample_id	Refers to the unique identifier for each sample (as given in sample table)	Numeric	Positive integer
hiatus	Indication of an hiatus	Text	selected from pre-defined list

Table S8: Characteristics of the gap place mark information table

Field	Description	Format	Constraints
sample_id	Refers to the unique identifier for the sample (as given in sample table)	Numeric	Positive integer
gap	Indication of a gap	Text	selected from pre-defined list

Table S9: Characteristics of the original chronology information table

Field	Description	Format	Constraints
sample_id	Refers to the unique identifier for the sample (as given in sample table)	Numeric	Positive integer
interp_age	Calendar age of the sample in years	Numeric	Positive decimal
interp_age_uncert_pos	Positive uncertainty on the age of the sample in years	Numeric	Positive decimal
interp_age_uncert_neg	Negative uncertainty on the age of the sample in years	Numeric	Positive decimal
age_model_type	Description of the age model used in the original publication	Text	selected from pre-defined list
ann_lam_check	Indication that verification that laminae are annual, in cases where lamina counting is used to construct the age model	Text	selected from pre-defined list
dep_rate_check	Indication that verification of the deposition rate has been made	Text	selected from pre-defined list

Table S10: Characteristics of the carbon isotope data table

Field	Description	Format	Constraints
sample_id	Refers to the unique identifier for the sample (as given in sample table)	Numeric	Positive integer
d13C_measurement	Original $\delta^{13}\text{C}$ measurement	Numeric	None
d13C_precision	Laboratory precision on the $\delta^{13}\text{C}$ measurement	Numeric	None
iso_std	Description of isotopic standard used	Text	selected from pre-defined list

Table S11: Characteristics of the oxygen isotope data table

Field	Description	Format	Constraints
sample_id	Refers to the unique identifier for the sample (as given in sample table)	Numeric	Positive integer
d18O_measurement	Original $\delta^{18}\text{O}$ measurement	Numeric	None
d18O_precision	Laboratory precision on the $\delta^{18}\text{O}$ measurement	Numeric	None
iso_std	Description of isotopic standard used	Text	selected from pre-defined list

Table S12: Characteristics of the publication information table

Field	Description	Type	Constraints
ref_id	Unique identifier for the reference	Numeric	Positive integer
Citation	Full citation for the original publication	Text	None
publication_DOI	Digital Object Identifier (DOI) of publication	Text	None

Table S13: Characteristics of the link entity and publication information table

Field	Description	Format	Constraints
entity_id	Refers to the unique identifier for the entity (as given in entity table)	Numeric	Positive integer
ref_id	Refers to the unique identifier for the publication (as given in the publication information table)	Numeric	Positive integer

Table S14: Characteristics of the link composite and entity table

Field	Description	Format	Constraints
composite_entity_id	Refers to the unique identifier for a composite entity (as given in entity table)	Numeric	Positive integer
single_entity_id	Refers to the unique identifier for each single entity in the composite (as given in entity table)	Numeric	Positive integer

Table 15: Characteristics of the notes table

Field	Description	Format	Constraints
site_id	Refers to the unique identifier for each site (as given in site table)	Numeric	Positive integer
Notes	Notes and additional information about the site	Text	None