

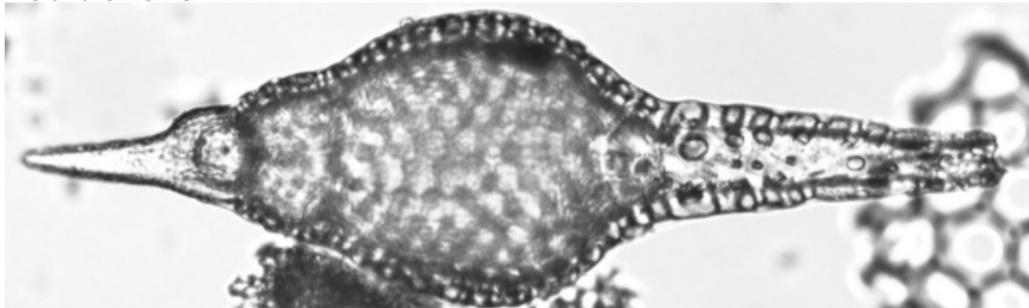
Neptune (NSB): working with a legacy database

Johan Renaudie
Museum für Naturkunde
2023-05-17

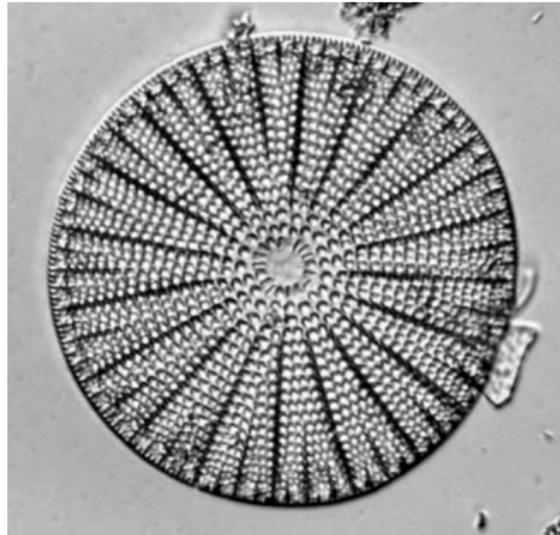


The microfossil record

Radiolarians



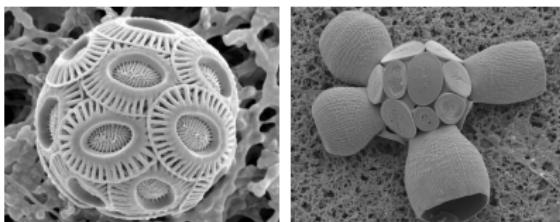
Diatoms



Planktonic Foraminifera

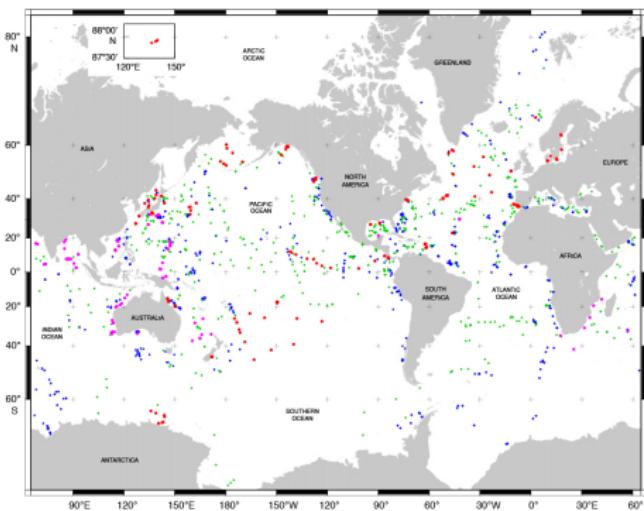


Calcareous Nannofossils



Deep-sea drilling projects

- DSDP (1966–1983), ODP (1983–2003) and IODP (2003–2013; 2013–2024)
- >1500 deep-sea sites drilled in all world's ocean
- In situ, mostly undisturbed marine sediments from late Jurassic to the Present
- Most deep-sea sites primarily composed on microfossils in a context of continuous sedimentation



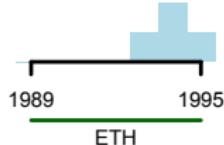
The history of the Neptune Database

The 1990s: ETH Zürich

Goal: Mobilize the remarkable fossil record from DSDP-ODP into an occurrence database to test hypotheses on macroevolution.

- Micropaleontology group at the ETH in Zürich including H. Thierstein, C. Cervato, D. Lazarus.
- Technical limitation of the time (RAM 4Mb; HD < 100Mb) drives DB design (no place for metadata!).
- Programmed in 4th Dimension. Available only offline.
- Content: 100 sites including ca. 300k occurrences.

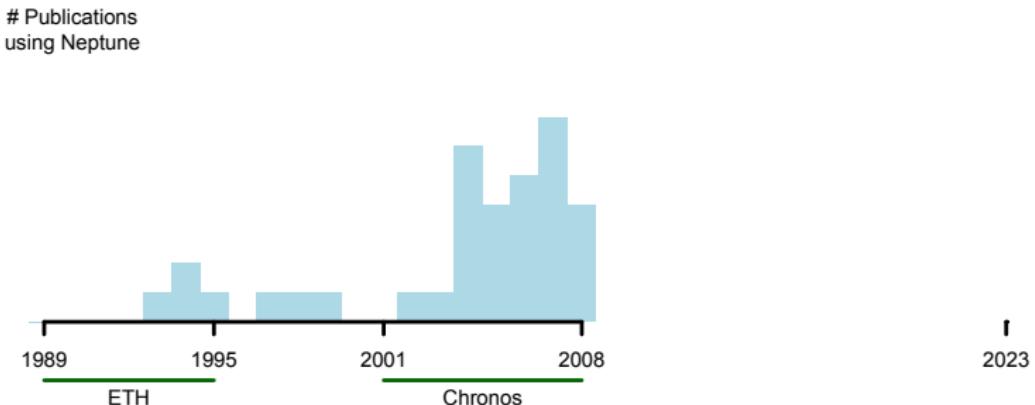
Publications
using Neptune



The history of the Neptune Database

The 2000s: NSF-CHRONOS

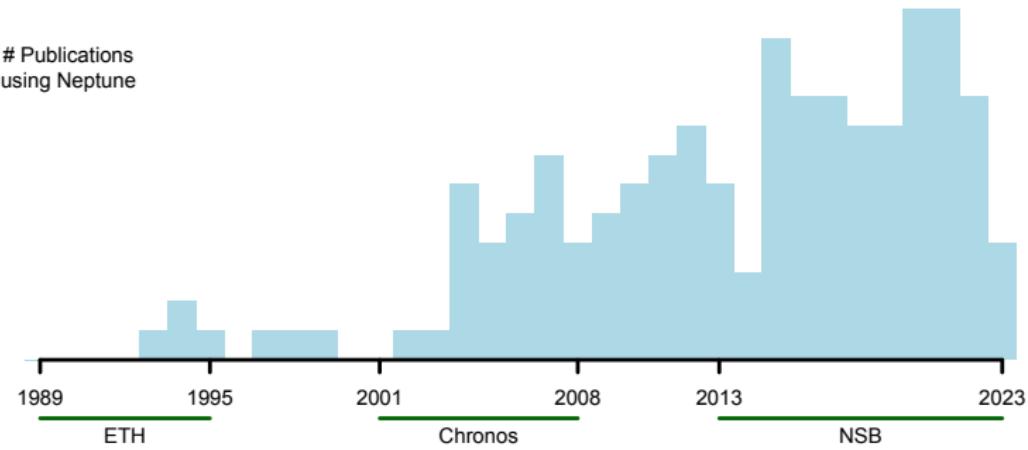
- Moved to Iowa thanks to NSF grant of Chronos project
- Development team including C. Cervato, P. Diver, D. Fils, B. Huber, M. Leckie, ...
- Moved to PostgreSQL. First online front-end.
- Content: ca. 500k occurrences.
- Funding stopped in 2008 and project was more or less abandoned.



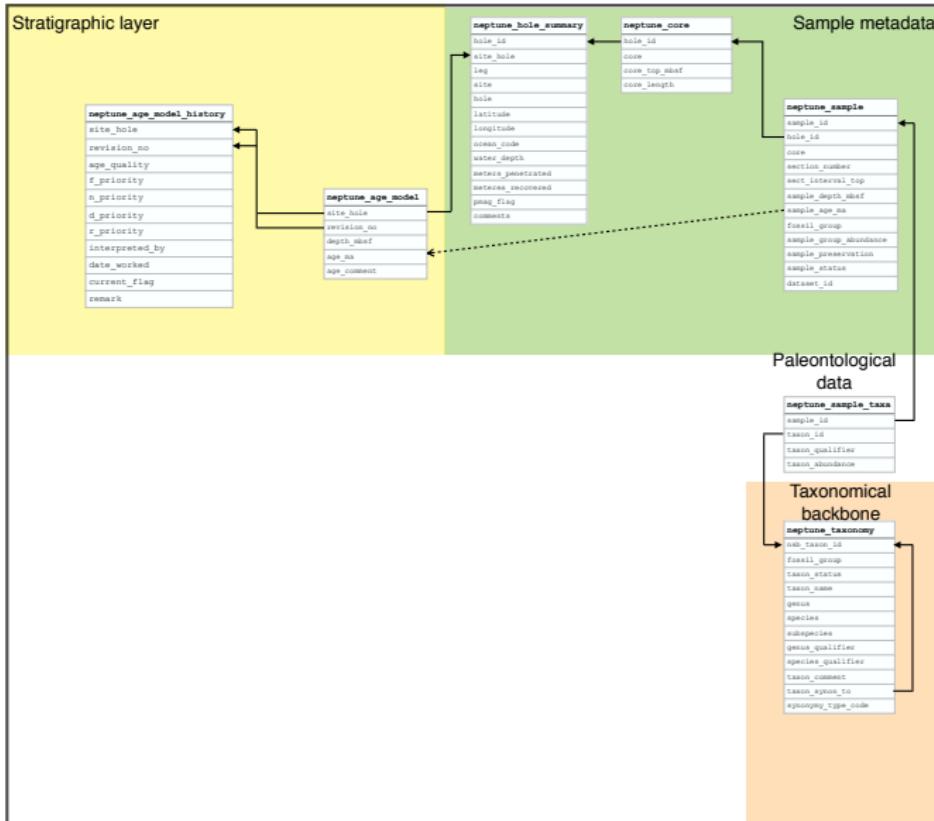
The history of the Neptune Database

The 2010s: Neptune Sandbox Berlin

- Moved to Berlin thanks to CEES funding (L. Liow and N. Stenseth).
- Expansion funded through EARTHTIME-EU ESF project (H. Pälike).
- Development team including D. Lazarus, P. Diver and me.
- New online presence (using python's Django module).
- Significant overhaul of structure to put back the metadata in the DB.
- Content: ca. 500 sites and ca. 750k occurrences.

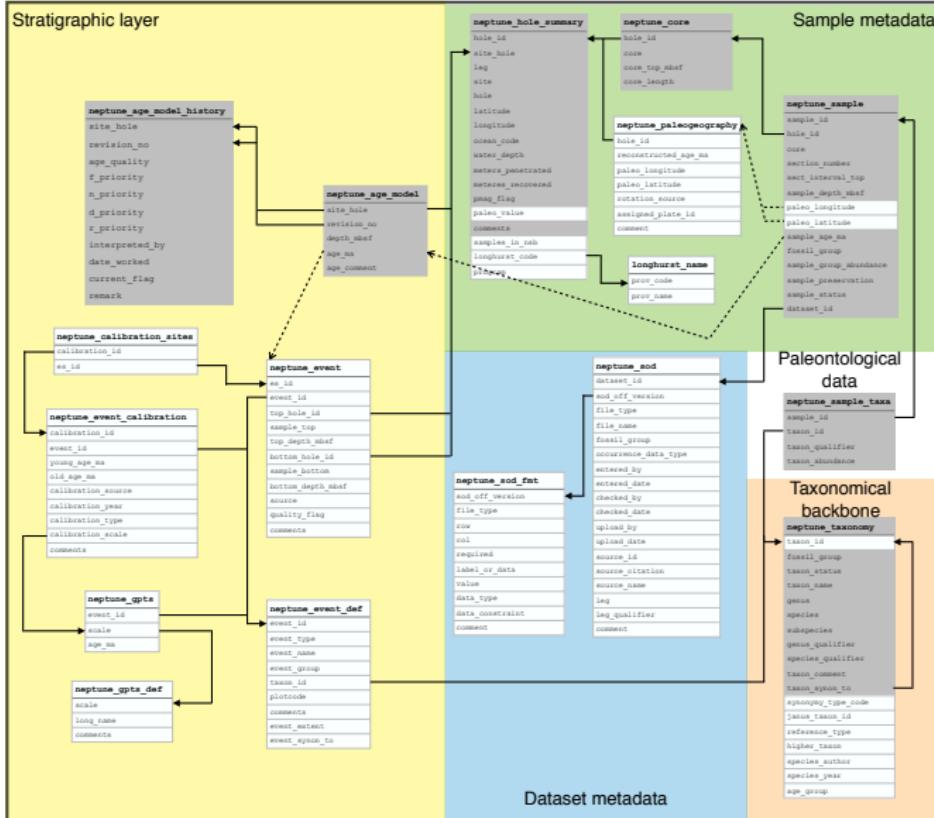


NSB Structure

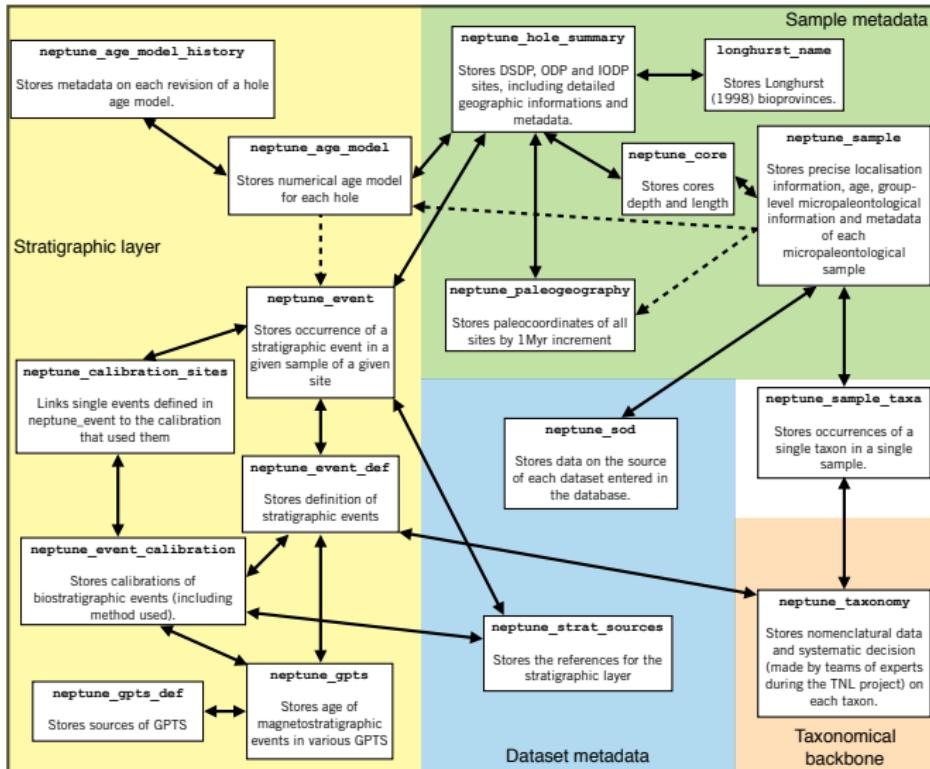


Neptune
prior to
NSB

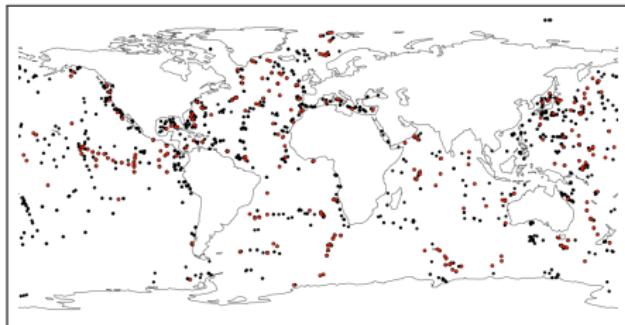
NSB Structure



NSB Structure



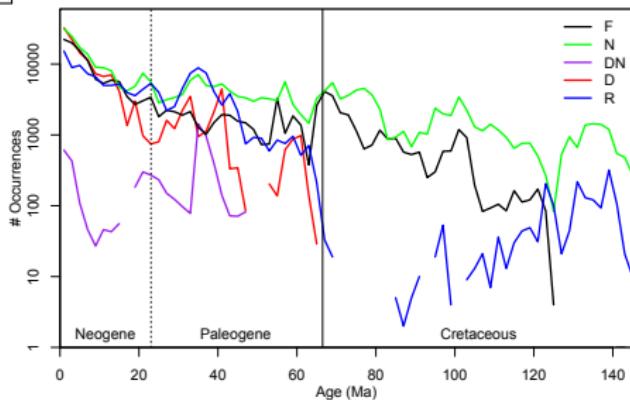
NSB Content



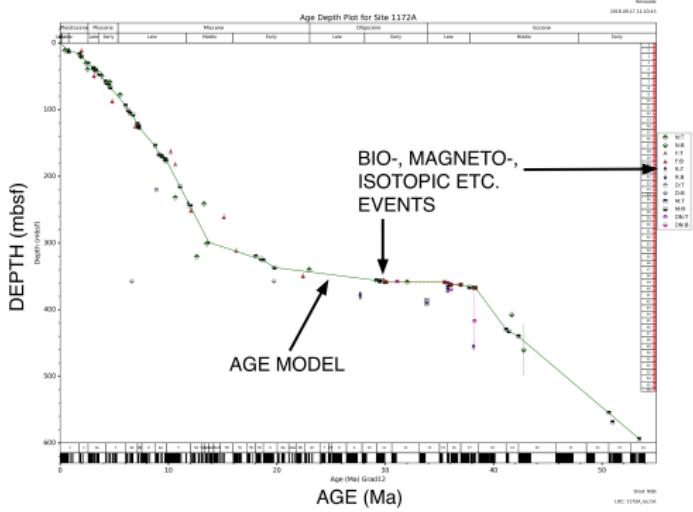
18 859 taxa names
for 5 microfossil groups
(R, D, PF, N, DN).

Synonymy resolved using TNL:
international effort from IODP
Paleontology Coordination Group.

768 057 occurrences.
502 deep-sea drilling holes.
Mostly Cenozoic, but significant
Cretaceous.
More carbonate than siliceous
fossil data so far.

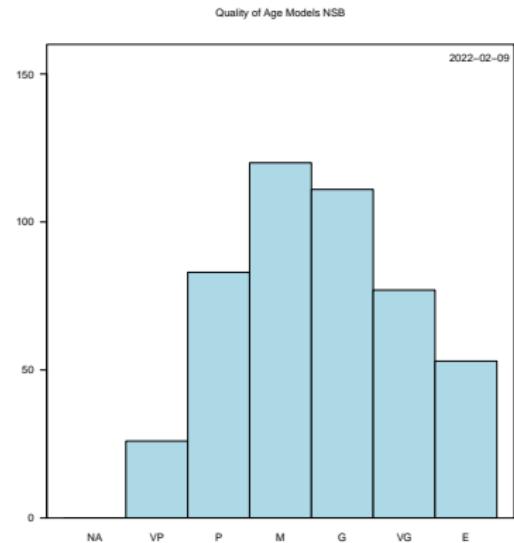


NSB Content



Continuous age vs depth functions
(age models) for each section

28 774 stratigraphic events
(including 5 130 calibrations for
them)
Age models for 483 DSDP, ODP or
IODP holes.



Age model quality vary but most "above average".

Website option to ignore poor age models set by default.

Neptune Sandbox Berlin

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About

NSB is the current implementation of the Neptune database (Lazarus, 1994; Spencer-Cervato, 1999). It holds hundreds of thousands of occurrence records for thousands of marine plankton microfossil species from hundreds of deep-sea ocean drilling sections; a taxonomic name management list; age models for all sections; and the geochronologic data used to create these age models. NSB serves several distinct groups of users including microfossil taxonomists, evolutionary (paleo)biologists, and paleoceanographers. A selection of papers that have used Neptune/NSB data is given below, and a full list of all papers using, describing or mentioning the database is given [here](#).

NSB also provides data services to the [Mikrotax](#) community catalog of microfossils and to the [Geobiodiversity Database](#) (GBDB).

NSB is free to use. User accounts are employed to maintain database security and provide feedback on user needs, and can be obtained simply with an email to one of NSB's managers ([see here](#)). The only obligation is to cite the database properly ([references here](#)) in any publications or public presentations.

Twenty selected papers using NSB

- Lazarus, D. 1994. Neptune: a marine micropaleontology database. *Mathematical Geology*, 26(7):817-832.
Spencer-Cervato, C., Thierstein, H. R., Lazarus, D. B., and Beckmann, J. P. 1994. How synchronous are Neogene marine plankton events? *Paleoceanography*, 9:739-763.
Finkel, Z. V., Katz, M. E., Wright, J. D., Schofield, O., and Falkowski, P. 2005. Climatically driven macroevolutionary patterns in the size of marine diatoms over the Cenozoic. *Proceedings of the National Academy of Sciences of the United States of America*, 102(25):8927-8932.
Allen, A. P., Gillooly, J. F., Savage, V. M., and Brown, J. H. 2006. Kinetic effects of temperature on rates of genetic divergence and speciation. *Proceedings of the National Academy of Sciences of the United States of America*, 103(24):9150-9155.
Liow, L. H. and Stenseth, N. C. 2007. The rise and fall of species: implications for macroevolutionary and macroecological studies. *Proceedings of the Royal Society B*, 274(1626):2745-2752.
Muttniak, G. and Kent, D. 2007. Widespread formation of cherts during the early Eocene climatic optimum. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 253(3-4):348-362.
Rabosky, D. L. and Sorhannus, U. 2009. Diversity dynamics of marine planktonic diatoms across the Cenozoic. *Nature*, 467:183-187.
Cermeño, P., and Falkowski, P. G. 2009. Controls on diatom biogeography in the ocean. *Science*, 325:1539-1541.
Filis, D., Cervato, C., Reed, J., Diver, P., Tang, X., Bohling, G., and Greer, D. 2009. CHRONOS architecture: Experiences with an open-source services-oriented architecture for geoinformatics. *Computers and Geosciences*, 35(6):778-789.

Occurrence search

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Leibniz



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stratigraphic events

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event calibrations

Search for occurrences

Fossil group

Diatoms

Time span

5

to

0

Ma

Ocean

Southern Ocean

Genus

Longitude

to

0

°

Leg

Species

Latitude

to

0

°

Site

Ecological Province

Hole

Options

- Resolve taxonomy using TNL.
- Filter out questionable identifications and taxa invalidly included in the fossil group.
- Filter out open-nomenclature taxa.
- Filter out problematic samples/occurrences (reworking, ...)

Choose Age Scale: Gradstein et al. 2012

Filter out sites with age quality less than Good

Perform pacman trimming (top : 0 % ; bottom : 0 %).

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Web portal: nsb.mfn-berlin.de

Taxonomy explorer

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Search the database

Genus

Species

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Fossil Group	Taxon ID	Taxon Name	Taxon Status	Taxon Synonym to	Synonymy type	Author	Year	ID in Janus DB	Old NSB ID
R	2100165	Plannapus hornibrooki	V			O'Connor	1999		
R	2100166	Plannapus mauricei	V			O'Connor	1999		
R	2100167	Plannapus microcephalus	V			O'Connor	1999		
R	2003804	Plannapus microcephala	S	2100167		(Haeckel) O'Connor	1997		
R	2001115	Dicolocapsa microcephala	S	2100167	OBJECTIVE	Haeckel	1887/2740		RDIC00020
R	2100452	Plannapus sp. A	G						
R	2100052	Dicolocapsa microcephala (q)	Q	2001115					RDIC00021

Web portal: nsb.mfn-berlin.de

Age models

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Hole

1338A

Scale

Gradstein et al. 2012

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Revision 0

Interpreted
by

Renaudie

Date

April 13, 2015

Age
Quality

G

Currently used in NSB

Y

Remarks

Qest by dbl 6.2.17. Excellent model now avail: Backman et al. 2016 IODP Leg SR vol online. JR (2015): uses IR magneto; M disagrees with biostrat between 200 and 300 mbsf

Hole	Age (Ma)	Depth (mbsf)	Comment
1338A	0.000000	0.000	None
1338A	0.782725	8.276	None
1338A	1.109405	11.971	None
1338A	1.762765	21.207	None
1338A	2.579465	31.368	None
1338A	3.118487	37.833	None
1338A	3.330829	40.142	None
1338A	3.608507	43.837	None
1338A	4.180197	51.688	None
1338A	4.376205	54.459	None
1770A	5.020551	66.020	None

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Event calibrations

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Linbnyz



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Search an event calibration

Event

Scale

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Event ID	Calib. ID	Type	Event Name	Group	Age min	Age max	Geographical Extent	Source	Calibration Type	Original Scale	Comments
1073	1210	B01	Emilia nia huxleyi	N	0.3		global	Berggren et al. 1985	M	Berg85	ODP Technical Note 24
1073	174	B01	Emilia nia huxleyi	N	0.29		global	Backman et al. 2012	O	Grad04	

All ages given here on Gradstein et al. 2012 scale.

This event has been found in the following sites:

Event ID	TOP			BOTTOM			Source event	Comment	
	Hole	Sample	Depth (mbst)	Age (mbst) (*)	Hole	Sample	Depth (mbst)	Age (mbst) (*)	
1073	101_626C	5-1.40	38.90		101_626B	5-CC	48.01		626C_fn_bstrat95
1073	104_642B	2-6.85	13.15		104_642B	3-2.87	16.67		Donally 1989
1073	104_643A	1-2.50	2.00	0.278	104_643A	1-3.50	3.50	0.31	Donally 1989
1073	104_644A	4-1.50	26.20		104_644A	4-2.50	27.70		644A_mfr_bstrat95
1073	105_646A	2-5.102	12.02	0.184 105_646A	2-6.104	13.54	0.207		Baldau et al 1989
1073	105_646B	12.03	0.182 105_646B				13.55	0.2	Baldau et al 1989
1073	105_647A	1-6.130	8.80	0.275 105_647A	1-7.14	9.14	0.285	647A_mfn_bstrat95	
1073	107_651A	8-CC	64.42		107_651A	9-1.69	69.49		651A_mn_bstrat95
									Used for calibration of the event (see calibration No 174).
1073	107_653A	3-2.60	15.30		107_653A	3-2.120	15.90		Rio et al. 1990
									Used for calibration of the event (see calibration No 174).
1073	107_653A		15.60		107_653A		15.60		Glacon et al 1990
1073	107_655A	1-2.20	1.70		107_655A	1-2.120	2.70		Müller 1990
1073	108_657A	0.90			108_657A		3.30		657A_fn_bstrat95
1073	108_658A	34.20	0.275 108_658A				43.70	0.318	Manivit 1989
1073	108_658A	34.20	0.275 108_658A				43.70	0.318	658A_mfn_bstrat95
1073	108_659A	1-5.130	7.30	0.241 108_659A	2-1.38	8.10	0.27		Manivit 1989

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Search for events in sections

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Hole

320-1333A

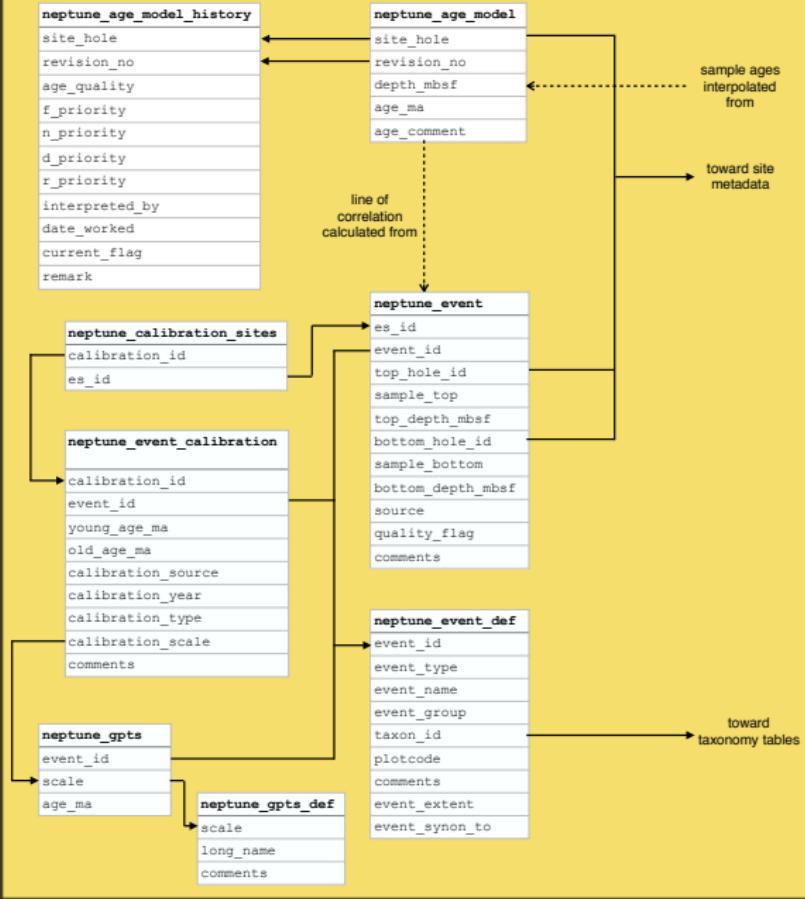
Scale

Gradstein et al. 2012

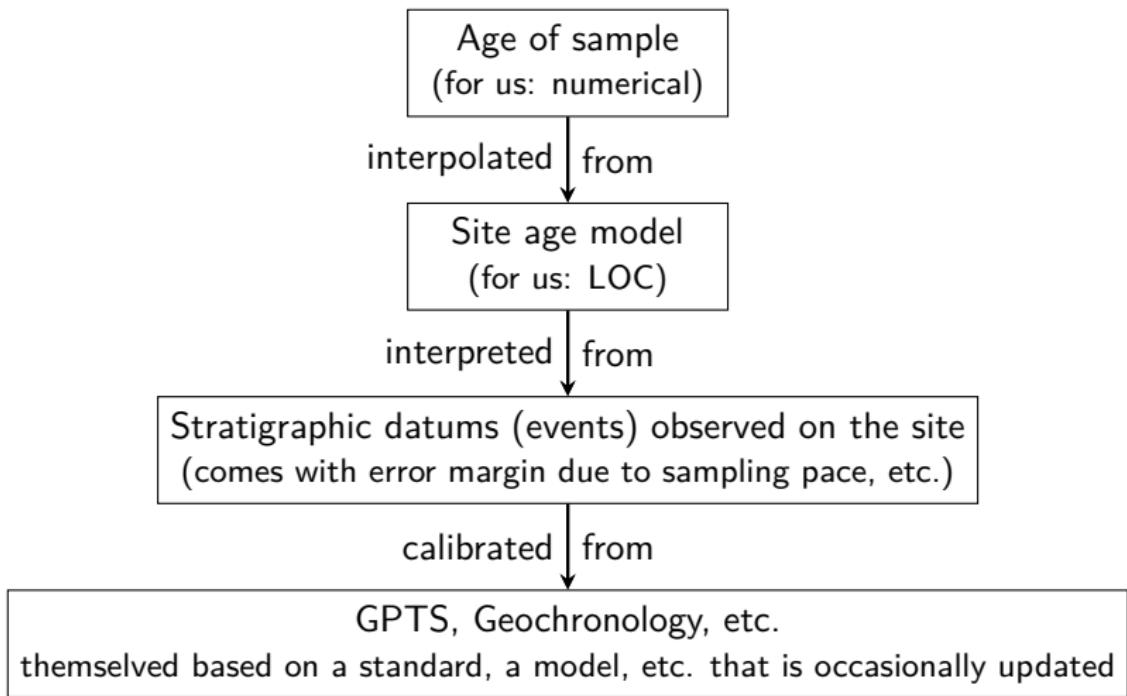
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Type	Event Name	Sample (Top)	Sample (Bottom)	Depth mbsf (Top)	Depth mbsf (Bottom)	Age min	Age max	Source event	Source calibration	Comment
M TOP	C6An.1n	320_1333A-1-1,55	320_1333A-1-1,65	0.55	0.65	20.04		Expedition 320/321 Scientists, 2010	Gradstein et al. 2012	
M BOT	C6An.1n	320_1333A-1-1,10	320_1333A-1-1,15	1.10	1.15	20.21		Expedition 320/321 Scientists, 2010	Gradstein et al. 2012	
M TOP	C6An.2n	320_1333A-1-2,50	320_1333A-1-2,60	2.00	2.10	20.44		Expedition 320/321 Scientists, 2010	Gradstein et al. 2012	
R BOT	Stichocorys delmontensis	320_1333A-1-2,104	320_1333A-1-4,104	2.54	5.54	20.6		Expedition 320/321 Scientists, 2010	Kamikuri et al. 2012	Used for age model revision 0

Stratigraphic layer



Keeping track of stratigraphic information



Age comes with lots of baggage as a whole chain of metadata: any link in the chain can (and will) change, and the changes need to ripple to the end product.

Dealing with legacy data

Quality Control over Data Acquisition

- Elimination of duplicates

How to identify duplicates based solely on site + fossil group info?

Dealing with legacy data

Quality Control over Data Acquisition

- Elimination of duplicates
 - Finding old faulty entries due to manual entry

Difficult to find errors when original source is not known
Errors frequent due to manual entry

Scientific Results, Volume 120, Chapter 41

Index	Sample Name	Abundance	Phenotype
1	1	1	C. sativus
2	2	1	S. cereale
3	3	1	E. spigulis
4	4	1	S. griseola
5	5	1	A. alternata
6	6	1	A. aculeata
7	7	1	A. cylindrospora
8	8	1	P. italicum
9	9	1	C. demarzae
10	10	1	L. corylophaga
11	11	1	E. kuhneana
12	12	1	H. sativa
13	13	1	D. sporophagae
14	14	1	P. italicum
15	15	1	L. sativa
16	16	1	P. sativus
17	17	1	T. aestivum
18	18	1	S. cereale var. "Wadsworth"
19	19	1	S. cereale
20	20	1	S. durum
21	21	1	A. triticoides
22	22	1	A. speltoides
23	23	1	A. farinosa
24	24	1	A. spelta
25	25	1	A. spelta
26	26	1	A. spelta
27	27	1	A. spelta
28	28	1	A. spelta
29	29	1	A. spelta
30	30	1	A. spelta
31	31	1	A. spelta
32	32	1	A. spelta
33	33	1	A. spelta
34	34	1	A. spelta
35	35	1	A. spelta
36	36	1	A. spelta
37	37	1	A. spelta
38	38	1	A. spelta
39	39	1	A. spelta
40	40	1	A. spelta
41	41	1	A. spelta
42	42	1	A. spelta
43	43	1	A. spelta
44	44	1	A. spelta
45	45	1	A. spelta
46	46	1	A. spelta
47	47	1	A. spelta
48	48	1	A. spelta
49	49	1	A. spelta
50	50	1	A. spelta
51	51	1	A. spelta
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186	186	1	A. spelta
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189	189	1	A. spelta
190	190	1	A. spelta
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Dealing with legacy data

Quality Control over Data Acquisition

- Elimination of duplicates
- Finding old faulty entries due to manual entry
- Dealing with design choices linked to past technological restrictions

No space on HD = no metadata

Arbitrary field restrictions (e. g. Core Numbers, Codes that used to be unambiguous but are not anymore, etc.)

Changing standards (e. g. coded absence)

Dealing with legacy data

Quality Control over Data Acquisition

- Elimination of duplicates
- Finding old faulty entries due to manual entry
- Dealing with design choices linked to past technological restrictions
- Updating outdated taxonomy and stratigraphy

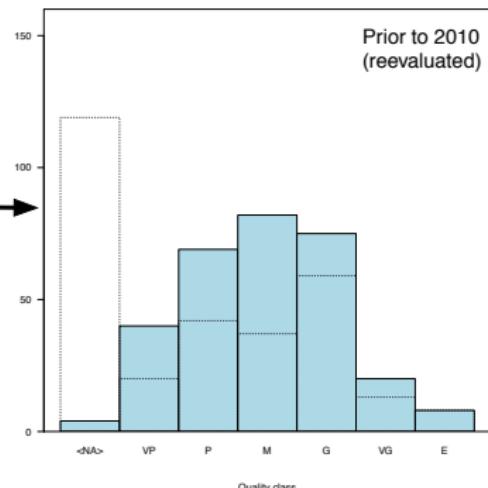
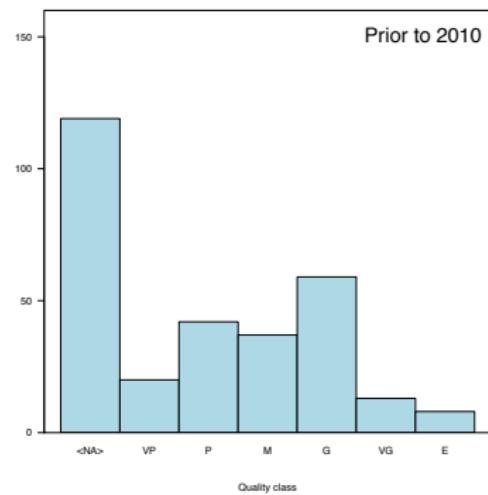
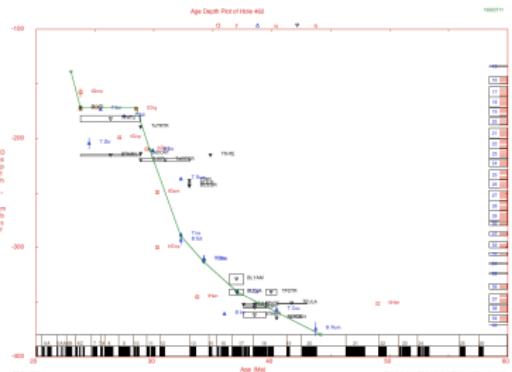
For taxonomy: TNL (see Lazarus et al. 2015 Zootaxa)

For stratigraphy: update GPTS ... and then redo all the age models

Quality Control

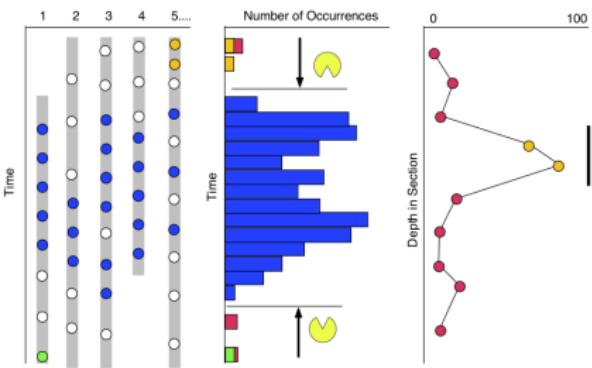
Age model assessment

- New quality assessment of old Chronos-era age models

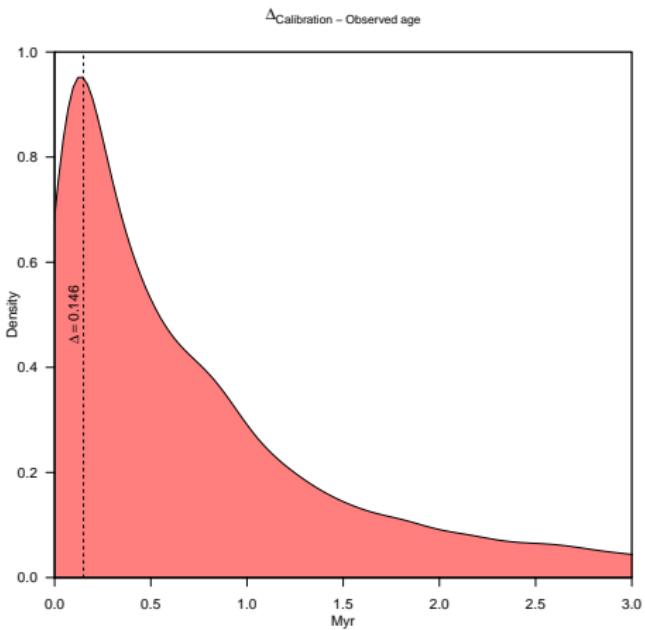
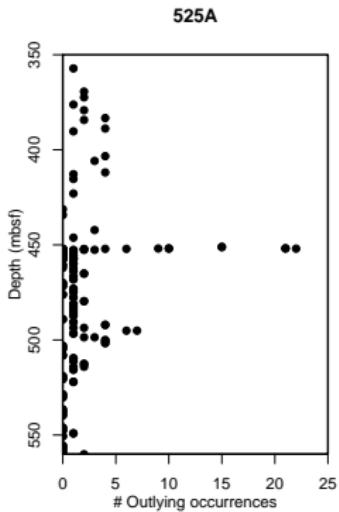


Quality Control

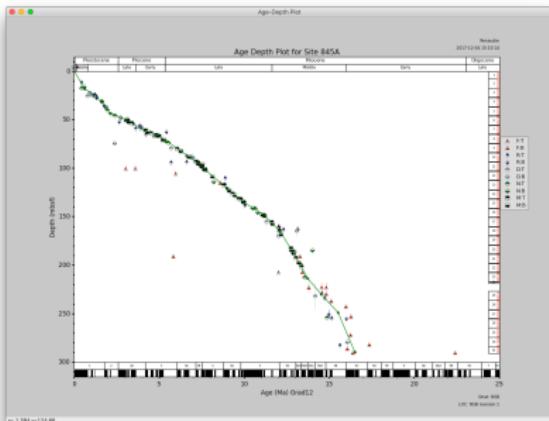
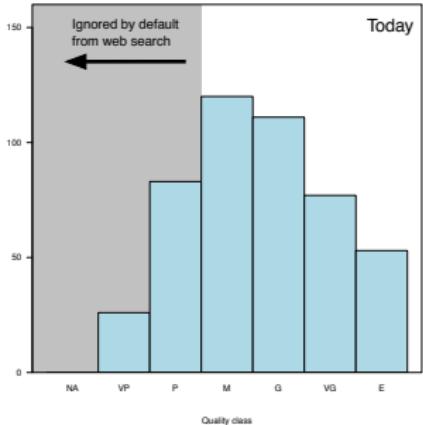
Pacman



- New quality assessment of old Chronos-era age models
- Outlier detection using e. g. PacMan analysis (Lazarus et al. 2012)



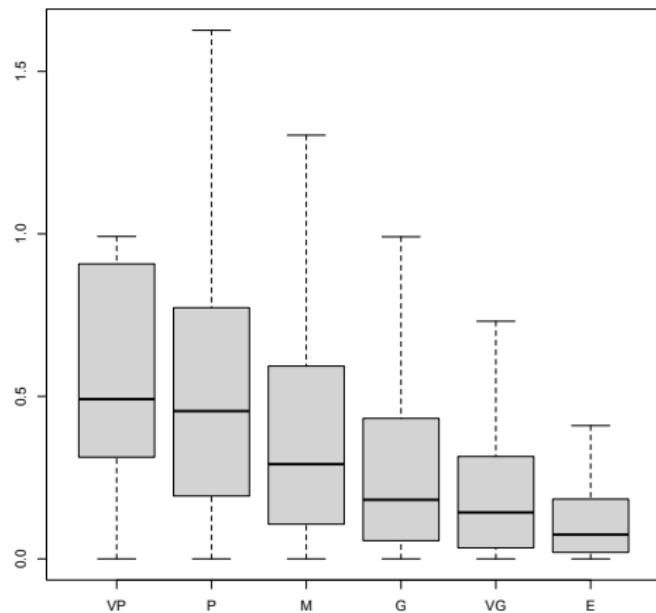
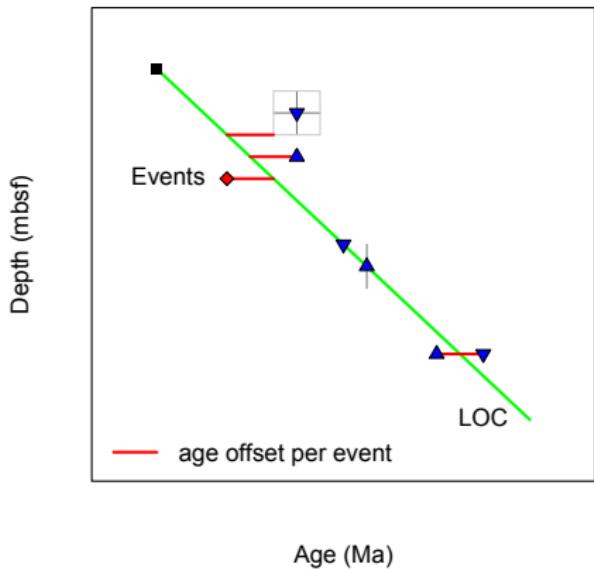
Quality Control



- New quality assessment of old Chronos-era age models
- Outlier detection using e. g. PacMan analysis (Lazarus et al. 2012)
- Selected undated holes containing the larger amount of samples
- Re-did main offenders by using modern calibrations and newly published statigraphic events (including astrochronology)
- Ported legacy software ADP (Age-Depth Plot) from Basic and Java to Python to facilitate workflow
- >350 new/revised age models since 2014; including >150 since 2020.

Error estimates on age models

Stratigraphic age
standard error distribution
per age model quality



Age model quality estimate qualitative but match quantitative estimates: **VP**: LOC poorly constrained; **P**: median error ca. ± 0.45 Myr; **M**: ca. ± 0.30 Myr; **G**: ca. ± 0.20 Myr; **VG**: ca. ± 0.15 Myr; **E**: ca. ± 0.075 Myr.

Other related projects

Mikrotax



www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores

Berlin Weather Google Amazon.de News Apple Berlin External science sites Rad sites MNF sites Professional MNF webmail

About Nannotax Live & Cenozoic Mesozoic Calc-dinos+ Farinacci Comments Tools Links

taxon search

Suppress fossils

Cenozoic and Modern Coccolithophores

Ancestry: Coccolithophores

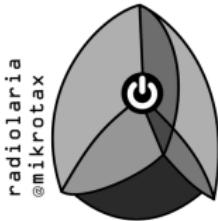
Sister taxa: >>

Short diagnosis: Extant coccolithophores and Cenozoic calcareous nannofossils - Mesozoic nannofossils are in a separate module

Daughter taxa (blue --> in age window 0-300Ma)				Granddaughter taxa	
Retivalveolate	Reticularis	Tectocyclina	Isochrysis	Heterococcoliths ISOCHRYSIDALES Motile phases with vestigial haptonema. Heterococcoliths mostly placoliths with R-unit dominant	NOELAERHABIDAE PINACEAE ISOCHRYSIDAE
Globotruncana	Calcidiscus	Calcidiscoides	Coccilithoides	COCCOLITHALES Mostly placolith heterococcoliths, with V-unit forming the distal shield; R-unit the proximal shield.	COCCOLITHACEAE CALCIDISCACEAE HYMENOMONADACEAE PLEUROCHYDIAEAE
Heliophaths	Zygospores	Heteroproteiform	Zygooids	ZYGOISCALES Heterococcoliths with V-units forming upper/outer cycle of imbricated elements and R-units forming basal plate and central mass of irregular elements	HELICOSPHERACEAE PONTOSPHERACEAE ZYGOSSCAEAE

Other related projects

Mikrotax



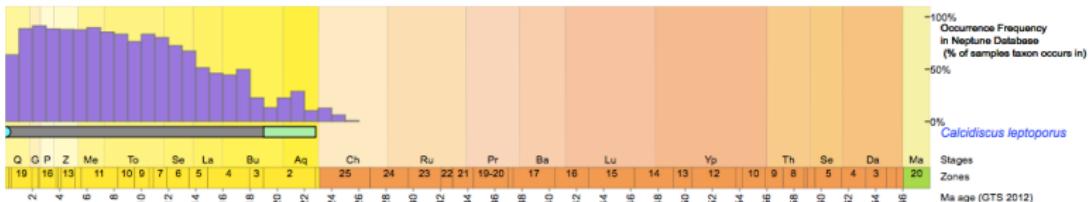
Geological Range:

Last occurrence (top): Extant Data source: present in the plankton (Young et al. 2003)

First occurrence (base): within NN2 zone (19.00-22.82Ma, base in Aquitanian stage). Data source: Young (1998)

Plot of occurrence data:

- Range-bar - range as quoted above, pink interval top occurs in, green interval base occurs in.
- Triangles indicate an event for which a precise placement has been suggested
- Histogram - Neptune occurrence data from DSDP and ODP proceedings. Interpret with caution & [read these notes](#)
- Taxon plotted: *Calcidiscus leptoporus*, synonyms included - *Calcidiscus leptoporus*; *Calcidiscus leptoporus f. rigidus*; *Calcidiscus leptoporus hol*; *Calcidiscus leptoporus* subsp. *centrovalvis*; *Calcidiscus quadrifarius*; *Coccospheira leptopora*; *Cyclococcolithina leptopora*; *Cyclococcolithus leptoporus*; Parent: *C. leptoporus* group



References:

- Bäckman, J., (1980). Miocene-Pliocene nannofossils and sedimentation rates in the Hatton-Rockall Basin, NE Atlantic Ocean. *Stockholm Contributions in Geology*, **36**: 1-91.
- Bartolini, C. & Pirini, C., (1969). *Découverte de nannoplanton calcaire dans les grès de Ponsano, Miocene Moyen, Toscane, Italie*. In: Brönnimann, P. and Renz, H.H. (Editors), *Proceedings of the First International conference on Planktonic Microfossils*, Geneva 1967. E. J. Brill, Geneva, pp. 81-88.
- de Kaenel, E. & Villa, G., (1996). Oligocene-Miocene calcareous nannofossil biostratigraphy and paleoecology from the Iberian Abyssal Plain. *Proceedings of the Ocean Drilling Program. Scientific Results*, **149**: 79-145.
- Gartner, S., (1967). Nannofossil species related to *Cyclococcolithus leptoporus* (Murray and Blackman). *University of Kansas Paleontological Contributions, Paper 28*: 1-4.

-v-more-v-



Calcidiscus leptoporus compiled by Jeremy R. Young, Paul R. Bown, Jacqueline A. Lees viewed: 22-10-2017

Taxon Search: Submit Advanced Search

AphiaID: 235923 Nomenclatural data on WoRMS

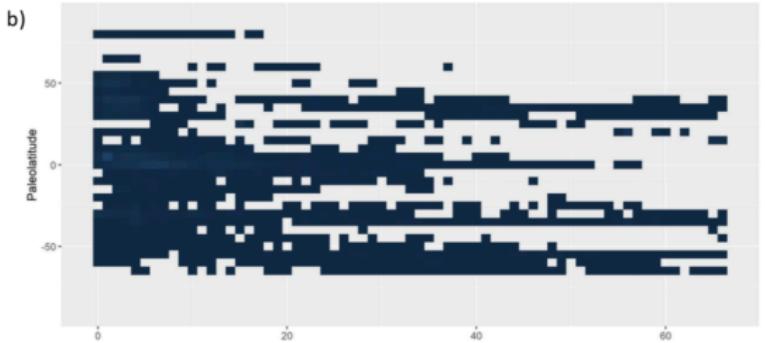
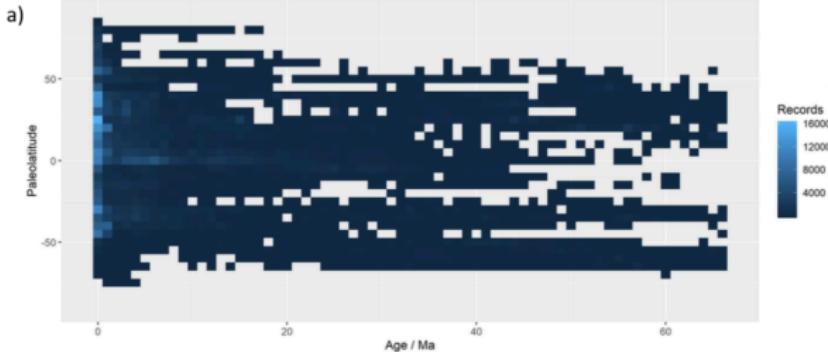
TRITON

Fenton, I.S., Woodhouse, A.,
Aze, T., Lazarus, D.B.,
Renaudie, J., Dunhill, A.M.,
Young, J.R., Saupe, E.E.
(2021) Triton, a New
Species-Level Database of
Cenozoic Planktonic
Foraminiferal Occurrences.
Scientific Data 8.

Other related projects

Triton

Database of Cenozoic Planktonic Foraminifera.
NSB + Land Sections + Surface sediments + ...
New ML-generated age models
500k records of PF (=4x NSB content)



Example of studies using NSB

To date, 152 publications using Neptune

Include micropaleontology case studies, paleobiology, theoretical biology, paleoceanography, marine geology, etc.

Thermal niches of planktonic foraminifera are static throughout glacial–interglacial climate change

Gwen S. Antell^{a,b}, Isabel S. Fenton^{b,c}, Paul J. Valdes^b, and Erin E. Saupe^{a,b}

^aDepartment of Earth Sciences, University of Oxford, OX1 3AN Oxford, United Kingdom, and ^bSchool of Geographical Sciences, University of Bristol, BS8 1SS Bristol, United Kingdom

Edited by Nils Chr. Stenseth, University of Oslo, Oslo, Norway, and approved March 12, 2021; received for review August 12, 2020

Out of the extratropics: the evolution of the latitudinal diversity gradient of Cenozoic marine plankton

Nussaibah B. Raja and Wolfgang Kiessling

GeoZentrum Nordbayern, Department of Geography and Geosciences, Friedrich-Alexander University Erlangen-Nürnberg, Loewenichstr. 28, 91054 Erlangen, Germany

 NBR, 0000-0002-0000-3944; WK, 0000-0002-1088-2014

Article

Neogene burial of organic carbon in the global ocean

<https://doi.org/10.1038/s41586-022-05413-6>

Ziyi Li^{a,b,2}, Yi Ge Zhang^{2,3}, Mark Torres^a & Benjamin J. W. Mills^b

Received: 14 February 2022

SCIENCE ADVANCES | RESEARCH ARTICLE

ECOLOGY

Diversity dependence is a ubiquitous phenomenon across Phanerozoic oceans

Valentin Rineau^{1*}, Jan Smyčka¹, David Storch^{1,2}



Palaeontology

The Palaeontological Association
www.palass.org

[Palaeontology, 2022, e12615]

Diversity dynamics of microfossils from the Cretaceous to the Neogene show mixed responses to events

by KATIE M. JAMSON^{1,3,*}, BENJAMIN C. MOON¹ and ANDREW J. FRAASS^{1,2,3}

¹Palaeobiology Research Group, School of Earth Sciences, University of Bristol, Wills Memorial Building, Queens Road, Bristol, BS8 1RJ, UK; ²katie.jamson@bris.ac.uk

³The Academy of Natural Sciences of Drexel University, 1000 Benjamin Franklin Parkway, Philadelphia, PA 19103, USA

*Corresponding address: School of Earth & Ocean Sciences, University of Victoria, Bob Wright Centre A465, Victoria, BC V8W 2Y2, Canada

^{*}Corresponding author

TypeScript received 10 May 2021; accepted in revised form 14 March 2022

Geochemistry, Geophysics, Geosystems[®]

RESEARCH ARTICLE

10.1029/2022GO010667

Key Points:

- Carbonate carbon flux and storage has been computed for the Atlantic Ocean spanning the entire Cenozoic at 0.5 m.y. intervals

The History of Cenozoic Carbonate Flux in the Atlantic Ocean Constrained by Multiple Regional Carbonate Compensation Depth Reconstructions

Adriana Dutkiewicz¹ and R. Dietmar Müller²

¹EarthByte Group, School of Geosciences, University of Sydney, Sydney, Australia

AGU ADVANCING EARTH AND SPACE SCIENCE



To-Do list

- Rest API – allow easy automated remobilization of database content. Current Beta API limited to age models.
- Benthic Microfossils (benthic forams and ostracods for instance) – need taxonomic experts for synonymies.
- Land Sections: some time period are under represented in in situ deep sea sediments for some of the microfossils (e. g. Paleocene and Early Eocene diatoms) but present in land sections.
- Mirror site & database
- Versioning of DB through Adam's chronoverse package?

Additional information

Access to the Database:

Website: <http://nsb.mfn-berlin.de>

NSBcompanion, R package: <http://github.com/plannapus/NSBcompanion>

NSB_ADP_wx: http://github.com/plannapus/nsb_adp_wx/releases

Renaudie, J., Lazarus, D.B., Diver, P. (2020) NSB (Neptune Sandbox Berlin): an expanded and improved database of marine planktonic microfossil data and deep-sea stratigraphy.
Palaeontologia Electronica, 23(1):a11.