

Knowledge graphs for global and regional geologic time scales

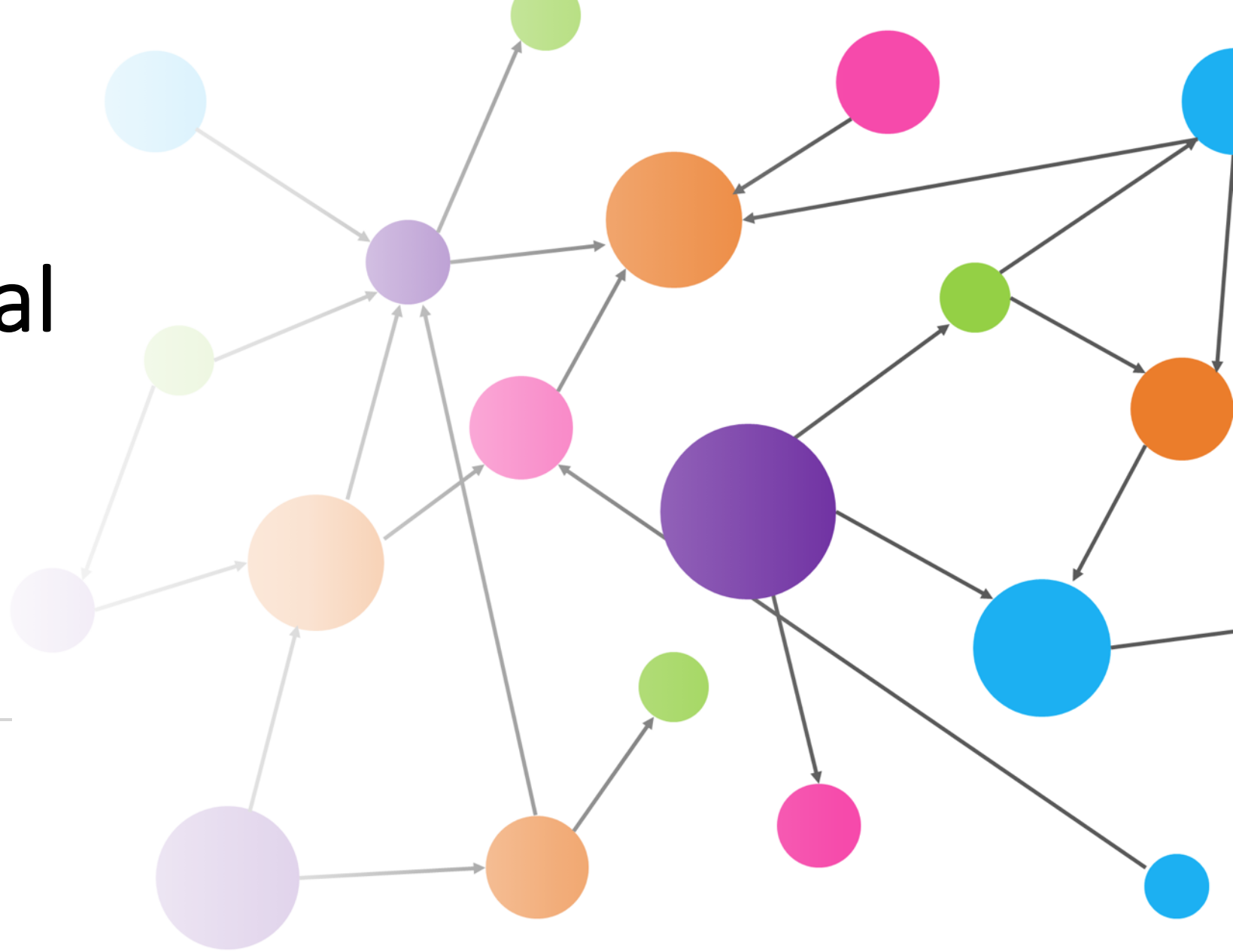
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University of Idaho

IDEA Lab



Outline

- 1. Introduction
- 2. Deep time knowledge base
- 3. R package
- 4. Summary



Knowledge graph?

A knowledge graph acquires and integrates information into an ontology and applies a reasoner to derive new knowledge.

About 254,000,000 results (1.10 seconds)

www.uidaho.edu

University of Idaho - Offering top-ranked programs in the ...

The **University of Idaho**, based in the Northwest, is a leading research school, providing majors and degrees for graduate and undergraduate students.

Results from uidaho.edu

University of Idaho - Offering ...

The University of Idaho, based in the Northwest, is a leading ...

Academics

Degree Finder - College of Engineering - Graduate Studies

Admissions

Academics - Value - Request Information - Graduate Programs

Current Students

Vandal students have many opportunities to get involved ...

Faculty & Staff

The resources below will support your efforts as faculty and staff ...

University of Idaho Library

As Idaho's flagship research library, the University of Idaho Library ...

People also ask

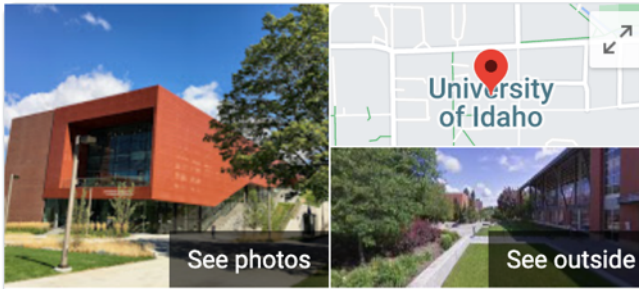
Is University of Idaho a Division 1 school?

How do I apply to University of Idaho?

What is University of Idaho known for?

https://www.google.com/search?q=university+of+idaho&ne...

Google knowledge graph supported



University of Idaho

Website Directions Save Call

Public land grant university in Moscow, Idaho

The University of Idaho is a public land-grant research university in Moscow, Idaho. It is the state's land-grant and primary research university, and the lead university in the Idaho Space Grant Consortium. [Wikipedia](#)

Avg cost after aid	Graduation rate	Acceptance rate
\$15K	56%	77%

Graduation rate is for first-time, full-time undergraduate [more](#) [v](#)
Source: US Dept of Education · [Learn more](#)

Address: 875 Perimeter Dr, Moscow, ID 83844

Phone: (208) 885-6111

Undergraduate enrollment: 7,528 (2018–19)

• Google Search

These infoboxes were added to Google's search engine in May 2012

Geologic time scale (GTS)?

a system of chronological dating that classifies geological strata (stratigraphy) in time.

Basic element in geoscientific problem.

Eonothem / Eon Erathem / Era System / Period	Series / Epoch	Stage / Age	GSSP	numerical age (Ma)
Phanerozoic	Cenozoic	Quaternary	Holocene	present
			Meghalayan	0.0042
			Northgrippian	0.0082
			Greenlandian	0.0117
			Upper	0.129
		Pleistocene	Chibanian	0.774
			Calabrian	1.80
			Gelasian	2.58
			Piacenzian	3.600
		Pliocene	Zanclean	5.333
			Messinian	7.246
		Miocene	Tortonian	11.63
			Serravallian	13.82
			Langhian	15.97
			Burdigalian	20.44
			Aquitania	23.03
		Oligocene	Chattian	27.82
			Rupelian	33.9
		Eocene	Priabonian	37.71
			Bartonian	41.2
			Lutetian	47.8
			Ypresian	56.0
		Paleocene	Thanetian	59.2
			Selandian	61.6
			Danian	66.0
	Mesozoic	Upper	Maastrichtian	72.1 ± 0.2
			Campanian	83.6 ± 0.2
			Santonian	86.3 ± 0.5
			Coniacian	89.8 ± 0.3
			Turonian	93.9
			Cenomanian	100.5
			Albian	~ 113.0
			Aptian	~ 125.0
		Lower	Barremian	~ 129.4
			Hauterivian	~ 132.6
			Valanginian	~ 139.8
			Berriasian	~ 145.0
		Cretaceous		
		Paleocene		
		Eocene		
		Oligocene		
		Miocene		
		Pliocene		
		Quaternary		

Eonothem / Eon Erathem / Era System / Period	Series / Epoch	Stage / Age	GSSP	numerical age (Ma)
Phanerozoic	Mesozoic	Upper	Tithonian	152.1 ± 0.9
			Kimmeridgian	157.3 ± 1.0
			Oxfordian	163.5 ± 1.0
			Callovian	166.1 ± 1.2
			Bathonian	168.3 ± 1.3
		Middle	Bajocian	170.3 ± 1.4
			Aalenian	174.1 ± 1.0
			Toarcian	182.7 ± 0.7
		Lower	Pliensbachian	190.8 ± 1.0
			Sinemurian	199.3 ± 0.3
			Hettangian	201.3 ± 0.2
			Rhaetian	~ 208.5
		Upper	Norian	~ 227
			Carnian	~ 237
			Ladinian	~ 242
		Middle	Anisian	247.2
			Olenekian	251.2
		Lower	Induan	251.902 ± 0.024
			Changhsingian	254.14 ± 0.07
	Paleozoic	Lopingian	Wuchiapingian	259.1 ± 0.5
			Capitanian	265.1 ± 0.4
			Wordian	268.8 ± 0.5
		Guadalupian	Roadian	272.95 ± 0.11
			Kungurian	283.5 ± 0.6
			Artinskian	290.1 ± 0.26
		Cisuralian	Sakmarian	293.52 ± 0.17
			Asselian	298.9 ± 0.15
			Gzhelian	303.7 ± 0.1
			Kasimovian	307.0 ± 0.1
		Upper	Moscovian	315.2 ± 0.2
			Bashkirian	323.2 ± 0.4
		Middle	Serpukhovian	330.9 ± 0.2
			Visean	346.7 ± 0.4
		Lower	Tournaisian	358.9 ± 0.4
		Carboniferous		
		Pennsylvanian		
		Mississippian		
		Permian		
		Triassic		
		Jurassic		
		Cretaceous		
		Paleocene		
		Eocene		
		Oligocene		
		Miocene		
		Pliocene		
		Quaternary		

Eonothem / Eon Erathem / Era System / Period	Series / Epoch	Stage / Age	GSSP	numerical age (Ma)
Phanerozoic	Paleozoic	Upper	Famennian	372.2 ± 1.6
			Frasnian	382.7 ± 1.6
			Givetian	387.7 ± 0.8
			Eifelian	393.3 ± 1.2
			Emsian	407.6 ± 2.6
		Middle	Pragian	410.8 ± 2.8
			Lochkovian	419.2 ± 3.2
			Pridoli	423.0 ± 2.3
		Lower	Ludfordian	425.6 ± 0.9
			Gorstian	427.4 ± 0.5
			Homerian	430.5 ± 0.7
			Sheinwoodian	433.4 ± 0.8
		Silurian	Telychian	438.5 ± 1.1
			Aeronian	440.8 ± 1.2
			Rhuddanian	443.8 ± 1.5
	Mesozoic	Upper	Hirnantian	445.2 ± 1.4
			Katian	453.0 ± 0.7
			Sandbian	458.4 ± 0.9
		Middle	Darriwilian	467.3 ± 1.1
			Dapingian	470.0 ± 1.4
			Floian	477.7 ± 1.4
		Lower	Tremadocian	485.4 ± 1.9
			Stage 10	~ 489.5
			Jiangshanian	~ 494
		Furongian	Paibian	~ 497
			Guzhangian	~ 500.5
			Drumian	~ 504.5
		Miaolingian	Wuliuan	~ 509
			Stage 4	~ 514
			Stage 3	~ 521
		Terreneuvian	Stage 2	~ 529
			Fortunian	541.0 ± 1.0
		Cambrian		
		Ordovician		
		Silurian		
		Devonian		
		Carboniferous		
		Permian		
		Triassic		
		Jurassic		
		Cretaceous		
		Paleocene		
		Eocene		
		Oligocene		
		Miocene		
		Pliocene		
		Quaternary		



Issue in data-driven discovery related to GTS:

1. Heterogeneity of geologic time scale concept
2. Machine readability and reasoning



**Knowledge graphs for geologic time scales
(international and regional)**

+ services

+ an R package

Knowledge graphs for geologic time scales

**(15 international versions and 16
regions)**

International versions	Regions
2020/01	East Avalonian
2019/05	West Europe
2018/08	California
2018/07	British
2017/02	Iberian-Morocco
2016/10	Baltoscandia
2016/04	Boreal
2015/01	South China
2014/10	North China
2014/02	Russia Platform
2013/01	N-E Siberia
2012	Japan
2010	Kazakhstan
2009	Australia
2008	Tethyan
	New Zealand

- Database hosted on the server of the Northwest Knowledge Network (NKN)
- Queryable through SPARQL end point
- Shared at Github

Virtuoso SPARQL Query Editor

[About](#) | [Namespace Prefixes](#) | [Inference rules](#) | [RDF views](#) | [iSPARQL](#)

Default Data Set Name (Graph IRI)

Query Text

```
select distinct ?Concept where {[ ] a ?Concept} LIMIT 100
```

(Security restrictions of this server do not allow you to retrieve remote RDF data, see [details](#).)

Results Format:


Execution timeout: milliseconds (values less than 1000 are ignored)

Options:

- ☒ Strict checking of void variables
- ☐ Log debug info at the end of output (has no effect on some queries and output formats)
- ☐ Generate SPARQL compilation report (instead of executing the query)

(The result can only be sent back to browser, not saved on the server, see [details](#))

<http://virtuoso.nkn.uidaho.edu:8890/sparql/>



github.com/xgmachina/DeepTimeKB

xgmachina / DeepTimeKB

<> Code | Issues | Pull requests | Actions | Projects | Wiki | Security | Insights

master | 2 branches | 1 tag

Go to file | Add file | Code

Commit	Message	Time
f46180b	Demerara update gts and gts help	4 days ago 124 commits
	Documents: Delete 4_GTS_Ogg_2016.svg	6 months ago
	Notebooks: small change to file name	3 months ago
	Notebooks_python: Add python examples	11 days ago
	Paper_Materials: Update 3. code.R	2 months ago
	Presentations: Create 202006_DDE_meeting.pptx	5 months ago
	RDF_Code: Update tsnorthamerica_20191107.ttl	5 months ago
	R_Functions: Update ex.R	13 days ago
	R_pkg: update gts and gts help	4 days ago
	LICENSE: Create LICENSE	5 months ago
	README.md: Update README.md	5 months ago

SPARQL query

```
prefix dc: <http://purl.org/dc/elements/1.1/>
prefix gts: <http://resource.geosciml.org/ontology/timescale/gts#>
prefix skos: <http://www.w3.org/2004/02/skos/core#>
prefix time: <http://www.w3.org/2006/time#>
prefix ts: <http://resource.geosciml.org/vocabulary/timescale/>

SELECT DISTINCT ?schemeID str(?label) AS ?geoConcpet ?begTimeValue ?endTimeValue
WHERE
{
  GRAPH <http://deeptimekb.org/iscallnew>
  {
    ?tconcept a gts:GeochronologicEra ;
    rdfs:label ?label ;
    skos:inScheme ?schemeID.
    FILTER (lang(?label) = "en")
    FILTER strstarts(?label, "Jurassic")
    ?tconcept time:hasBeginning ?beg ;
    time:hasEnd ?end .
    ?beg time:inTemporalPosition ?begTime .
    ?end time:inTemporalPosition ?endTime .
    ?begTime time:numericPosition ?begTimeValue .
    ?endTime time:numericPosition ?endTimeValue .
  }
  UNION
  {
    ?tconcept a gts:GeochronologicEra ;
    rdfs:label ?label .
    FILTER (lang(?label) = "en")
    FILTER strstarts(?label, "Jurassic")
    ?tconcept dc:description
    [time:hasBeginning ?beg ;
    time:hasEnd ?end ;
    skos:inScheme ?schemeID].
    ?beg time:inTemporalPosition ?begTime .
    ?end time:inTemporalPosition ?endTime .
    ?begTime dc:description
    [time:numericPosition ?begTimeValue ;
    skos:inScheme ?schemeID].
    ?endTime dc:description
    [time:numericPosition ?endTimeValue ;
    skos:inScheme ?schemeID].
    FILTER regex(?schemeID, "2005").
  }
}
ORDER BY DESC (?schemeID)
```

schemeID	geoConcpet	begTimeValue	endTimeValue
http://resource.geosciml.org/vocabulary/timescale/isc2005-12	Jurassic Period	199.6	145.5



```
> gts.range(geoConcept = "Jurassic", iscVersion = 2005)
```

	schemeID	geoConcpet	begTimeValue	endTimeValue	duration
15	isc2005-12	Jurassic Period	199.6	145.5	54.1



An R package: *deeptimeKB*

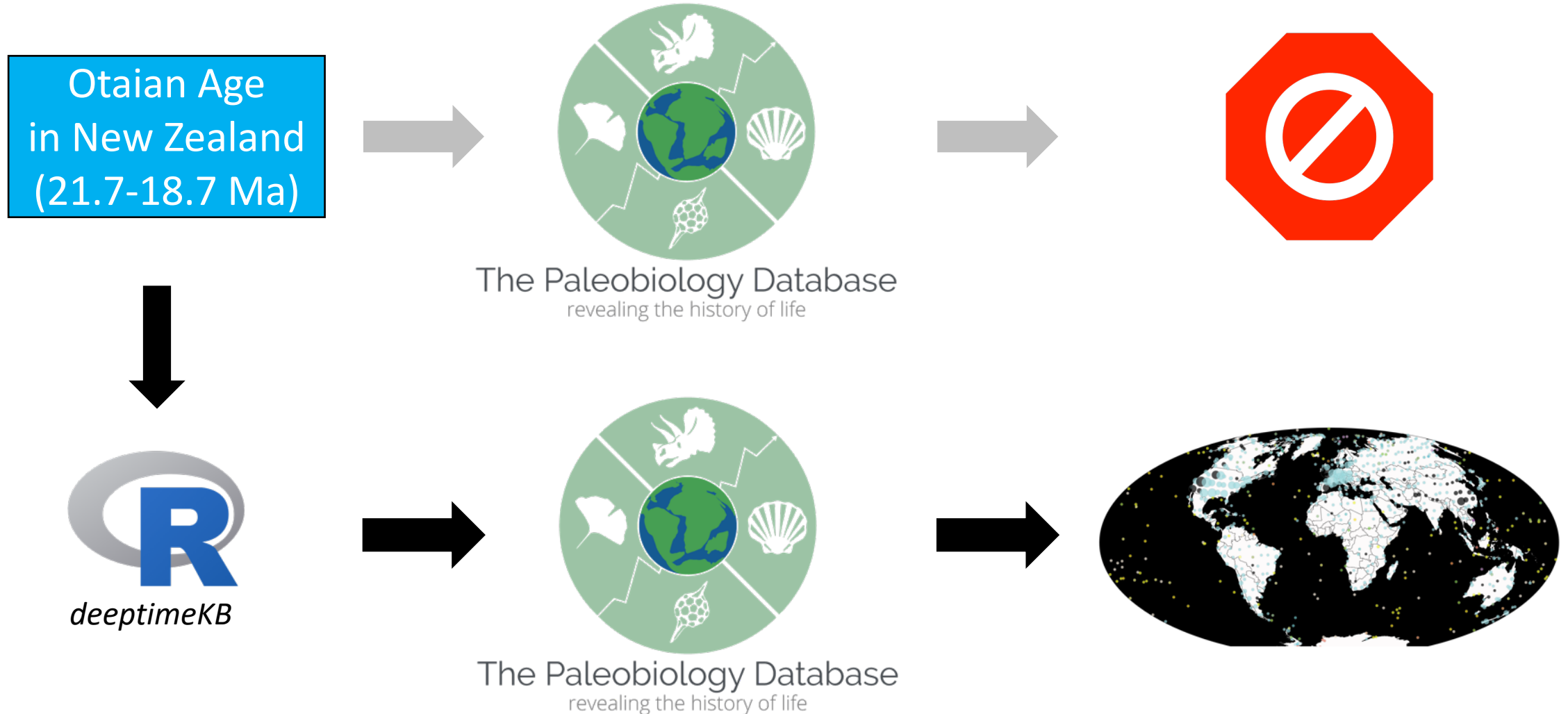
12 functions

installation from Github:

```
devtools::install_github("xgmachina/DeepTimeKB/R_pkg")
```

Functions	Description
<code>gssp.map</code>	Plot the locations of the Global Boundary Stratotype Section and Point (GSSP) on the world map
<code>gts</code>	Get all the properties of one geological time concept in the database
<code>gts.gssp</code>	Query the GSSP data
<code>gts.hierarchy</code>	Get the broader and narrower concept of one geological time concept in database
<code>gts.iscSchemes</code>	Function querying start time, end time and duration of a specific geological time concept
<code>gts.level</code>	Get the level of the geological time concept
<code>gts.list</code>	Function querying the geological time concept of a region or the international geological time concept
<code>gts.listRegion</code>	Function querying the geological time concept of a region or the international geological time concept
<code>gts.point</code>	Function querying all the geological time concepts that include the specified time point
<code>gts.range</code>	Function querying start time, end time, and duration of a specific geological time concept
<code>gts.topo</code>	Topology of two geological time concepts
<code>gts.within</code>	Function querying all geological time concepts within a time interval

Deep time knowledge base interacts with other databases



Summary

- Created a knowledge database that covers multiple versions of international geologic time scale and regional ones.
- A SPARQL end point is created for online services.
- An R package is built to facilitate knowledge exploration.
- Prepare to publish the R package to CRAN.
- Our work improves the data interoperability and machine readability.

