Taming the chronology of South Gaulish Samian found at Hadrian's Wall and the German Limes using Linked Open Data

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Archaeological databases usually include a lot of…

…"hidden archaeological assumptions"
in their relational
data models.

Especially short cutted relative chronological information and its dependencies are not modelled using transparent methods.

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The aim of our project is to make these hidden assumptions in archaeology visible…

…and provide them as Linked Open Data to establish reproducible research as a fundament for Open Science.

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In particular, the Samian Research database at the RGZM offers nearly 250'000 identified potter stamps from Europe, …

http://www.rgzm.de/samian

… which are traditionally dated in a short cutted way.

In Roman archaeology this is usually expressed by establishing "absolute dates" in well known "from-to" tables, …

http://www.rgzm.de/samian

… whereas in reality, the situation is much more diffuse.

Datings are mainly derived from Limes parts. But the only absolute dated Limes part is Hadrian's Wall (122+ AD)...
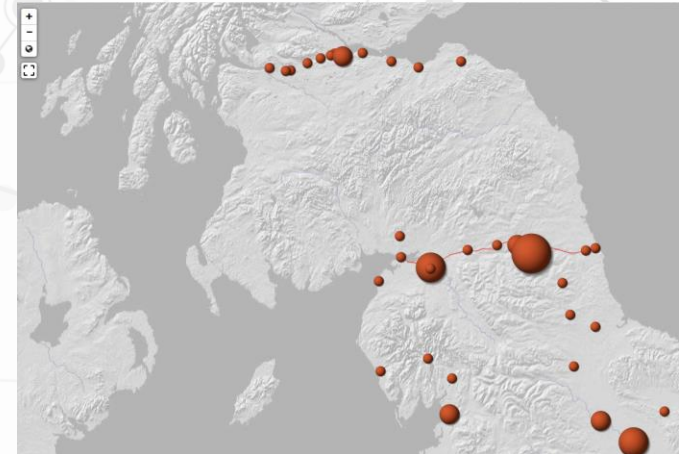

Phil Champion / Hadrian's wall at Cuddy's Crags and Housesteads Crags CC BY-SA 2.0
https://commons.wikimedia.org/wiki
/File:Hadrian%27s_wall_at_Cuddy%27s_Crags_and_Housesteads_Crags_-_geograph.org.uk_-_404992.jpg

... which is good for dating the Samian found at Hadrian's Wall ...

© RGZM, NAVIS3, https://www1.rgzm.de/Navis3/Large/41442A00L.gif

"And so, having reformed the army quite in the manner of a monarch, he set out for Britain, and there he corrected many abuses and was the first to construct a wall, eighty miles in length, which was to separate the barbarians from the Romans. "
- SHA, Hadrian, 11.2

http://www.rgzm.de/samian (Distribution of Cinnamus ii on Hadrian's Wall)

The german Alb Limes, Neckar Limes, Elisabethenstraße and Wetterau Limes do <u>not</u> have absolute starting dates.

However, due to the progressing occupation, Limes phases have a relative chronology.

How to date these Limes phases?

Wetterau Limes
ca. 110 AD ?

Elisabethenstraße
ca. 74 AD ?

Neckar Limes
ca. 115 AD ?

Alb Limes
ca. 110 AD ?
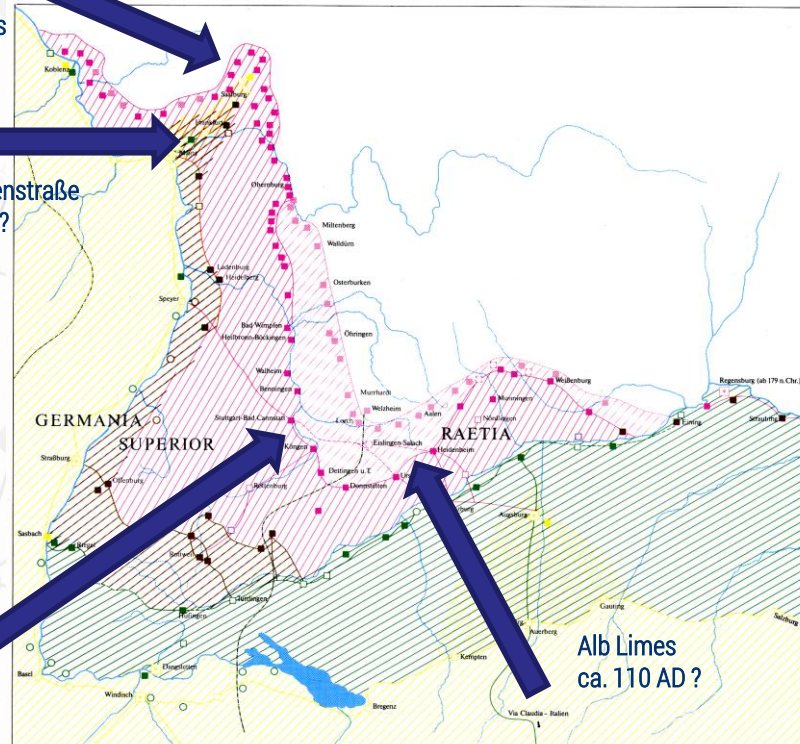
Kuhnen 1992, 79, Taf. 1

Who is right? There are diverging average Coin dating curves and Samian dating curves of german Limes parts.

based on http://rgzm.de/samian

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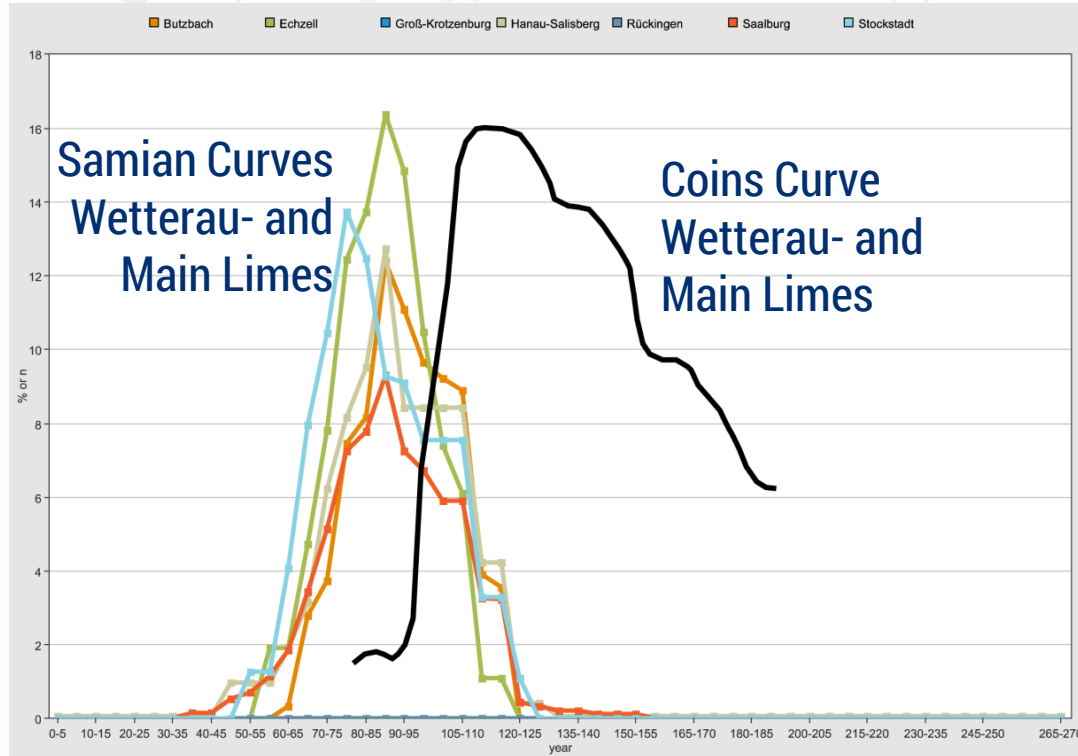
To achieve a chronology in Samian dating we use the horseshoe paradigma in Correspondence Analysis (CA).

early ➝ late

based on Madsen 1988, 25, Fig. 11.
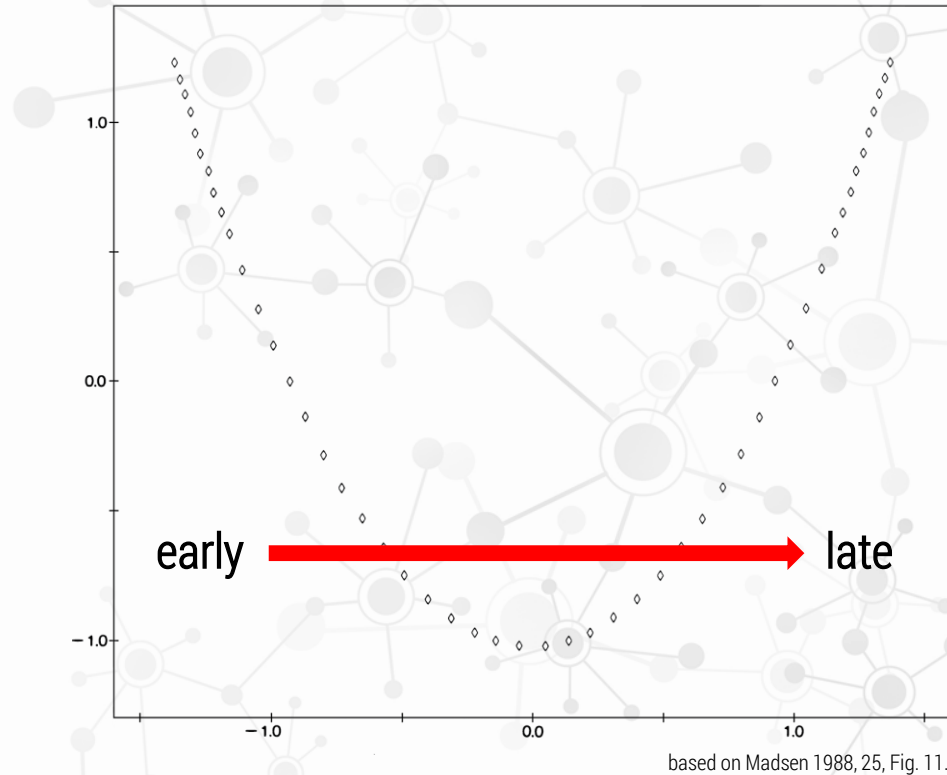
The easy accessible web based Correspondence Analyses at the RGZM ADP research tool only needs a CSV input file.

LimesPotters.csv used in http://rgzm.de/adp

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The amount of <u>time-overlap</u> between the Limes parts can be defined by the number of potters they have in common.
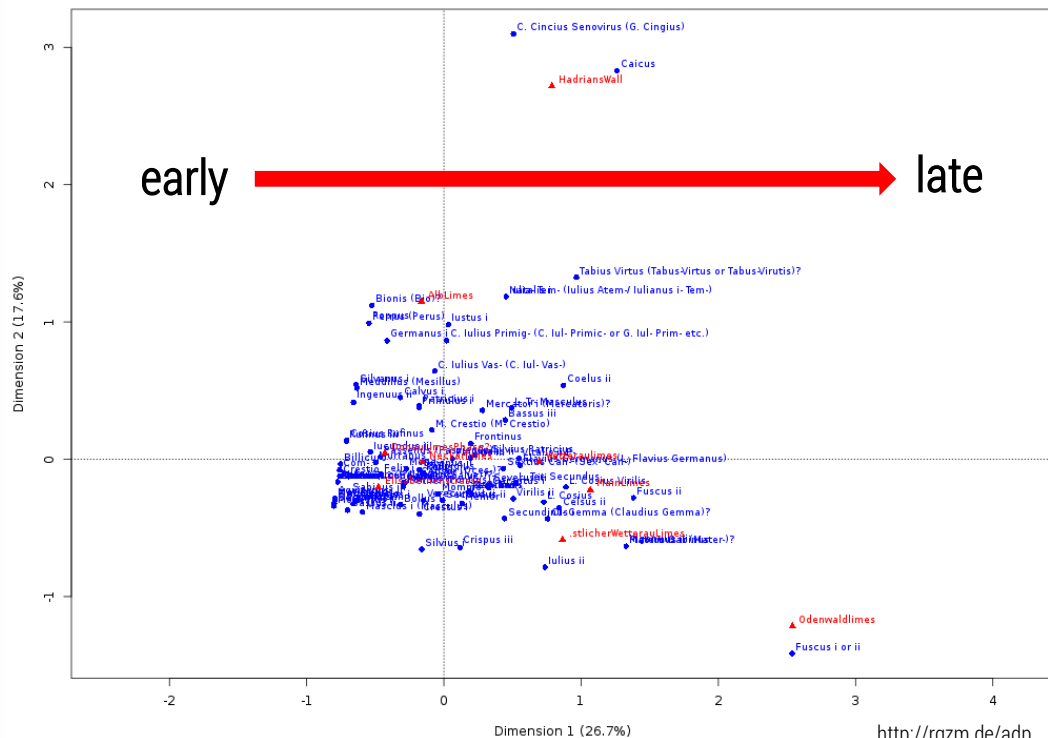
potter	limes	count
Abitus (Habitus)	Elisabethenstrasse	2
Acutus i	Elisabethenstrasse	1
Aemilius i	Elisabethenstrasse	1
Aemilius i	Wetteraulimes	1
Albanus ii	DonauLimesPhase2	1
Albanus ii	Elisabethenstrasse	1
Amandus ii	AlbLimes	1
Amandus ii	Elisabethenstrasse	2
Amandus iii (Amandinus)?	Elisabethenstrasse	1
Aper i	DonauLimesPhase2	2
Aper i	Elisabethenstrasse	2
Apro (Apro-)?	DonauLimesPhase2	1
Apro (Apro-)?	Elisabethenstrasse	1
Aquitanus	DonauLimesPhase2	7
Aquitanus	Elisabethenstrasse	19
Ardacus ii	Elisabethenstrasse	3
Ardanus	Elisabethenstrasse	2
Astaurus (Asaurus or Tastaurus?)	Wetteraulimes	1
Atticus i	AlbLimes	2
Auro (Aro)?	DonauLimesPhase2	1
Ave (i) or Avetu or Ave tu or Ave Vale etc.	Elisabethenstrasse	2
Aveus ii/Avevus?	Elisabethenstrasse	1
Avitus ii	Elisabethenstrasse	2
Balbus i	Elisabethenstrasse	1
Bamsinus or Bamasinus?	Elisabethenstrasse	1
Bassinus i	AlbLimes	2
Bassus ii	DonauLimesPhase2	4
Bassus ii	Elisabethenstrasse	18
Bassus ii	ÖstlicherWetterauLimes	1
Bassus ii-Coelus	Elisabethenstrasse	7
Bassus iii	AlbLimes	2
Bassus iii	Elisabethenstrasse	2
Bassus iii	Wetteraulimes	4
Bassus iii	ÖstlicherWetterauLimes	1
Bellicus i	Elisabethenstrasse	1
Bilicatus (Bilicatos)	Elisabethenstrasse	3
Billicuro	DonauLimesPhase2	3
Billicuro	Elisabethenstrasse	1
Bionis (Bio)?	AlbLimes	2

http://rgzm.de/adp

excerpt of LimesPotters.csv

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A deeper look into the relative chronological relationships of the Limes fortresses: the more to the right, the later.
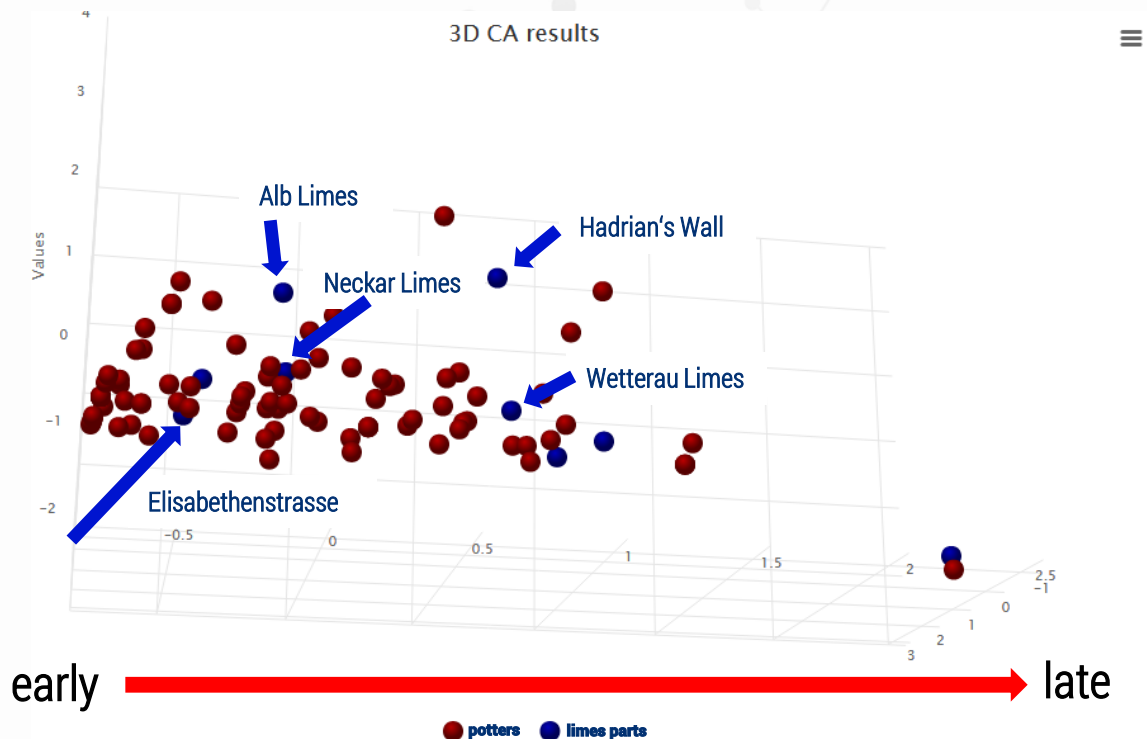
The horizontal CA dimension axis defines the amount of overlap between the limes parts.

http://rgzm.de/adp

Calculating / dating Limes intervals using a Correspondence Analysis causes challenges, which have to be solved…

	A	B	C	D	E	F	G
1	name	x	y	z	start	end	fixed
2	AlbLimes	-0.162	1.149	-0.519	97	260	fixed
3	DonauLimesPhase2	-0.43	0.046	-0.372	70	260	fixed
4	Elisabethenstrasse	-0.479	-0.204	0.270	74	104	fixed
5	HadriansWall	0.787	2.717	2.279	122	230	fixed
6	MainLimes	1.067	-0.223	0.273	0	0	floating
7	Neckarlimes	-0.155	-0.021	-0.973	117	260	fixed
8	Odenwaldlimes	2.540	-1.215	1.228	0	0	floating
9	Wetteraulimes	0.695	-0.019	-0.092	110	260	fixed
10	ÖstlicherWetterauLimes	0.864	-0.585	-0.103	105	260	fixed

LimesPotters.tsv

… some Limes parts have a *terminus post quem* point (derived from a historical source)
… some Limes parts have a *terminus ante quem* point (derived from dendrodates)
… some Limes parts have *no* datings and are floating between other fixed parts

>122 AD **Hadrian's Wall**

? >117 AD **Neckar Limes**

? **Main Limes** **?**

based on https://github.com/RGZM/alligator

... but to resolve them, one can use the *Alligator Method* used in the *Alligator Tool* developed by RGZM Scientific IT department.

The Output of Alligator is a RDF representation of the calculation defined in an the *Alligator Ontology* as OWL.

http://www.visualdataweb.de/webvowl/#iri=https://raw.githubusercontent.com/RGZM/alligator/master/docs/vocab/alligator.rdf

ALLIGATOR VOCABULARY

Authors: Florian Thiery (Römisch-Germanisches Zentralmuseum Mainz)

Version: Vättern Edition

Date: 2018-08-19

Abstract: A vocabulary for Alligator.

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About this Document: This document is based on the GEOJSON-LD VOCABULARY by Sean Gillies (Mapbox) with a CC BY 4.0 license.

https://rgzm.github.io/alligator/vocab/
https://raw.githubusercontent.com/RGZM/alligator/master/docs/vocab/alligator.rdf
https://doi.org/10.5281/zenodo.1436351

The Alligator method consists of a chain of steps to calculate and date the floating limes parts…

- **Step 1**: All 3D distances between the CA time periods are calculated
- **Step 2**: The nearest 3D CA neighbours for start and end years of the floating intervals towards intervals with fixed values are located
- **Step 3**: the result is stored as a "calculated virtual fuzzy year"
- **Step 4**: the intermediate result of the fixed and floating time intervals is stored as a list of "virtual fuzzy start and end years"

Our aim is to date the "Main Limes" and "Odenwald Limes" to get the "virtual fuzzy start and end years"…

	A	B	C	D	E	F	G
1	name	x	y	z	start	end	fixed
2	AlbLimes	−0.162	1.149	−0.519	97	260	fixed
3	DonauLimesPhase2	−0.43	0.046	−0.372	70	260	fixed
4	Elisabethenstrasse	−0.479	−0.204	0.270	74	104	fixed
5	HadriansWall	0.787	2.717	2.279	122	230	fixed
6	MainLimes	1.067	−0.223	0.273	0	0	floating
7	Neckarlimes	−0.155	−0.021	−0.973	117	260	fixed
8	Odenwaldlimes	2.540	−1.215	1.228	0	0	floating
9	Wetteraulimes	0.695	−0.019	−0.092	110	260	fixed
10	ÖstlicherWetterauLimes	0.864	−0.585	−0.103	105	260	fixed

LimesPotters.tsv

… here as an estimated result of Main Limes 100 – 260 AD and Odenwald Limes 105 – 260 AD…

	name	x	y	z	start	end	fixed
2	AlbLimes	−0.162	1.149	−0.519	97	260	fixed
3	DonauLimesPhase2	−0.43	0.046	−0.372	70	260	fixed
4	Elisabethenstrasse	−0.479	−0.204	0.270	74	104	fixed
5	HadriansWall	0.787	2.717	2.279	122	230	fixed
6	MainLimes	1.067	−0.223	0.273	**110**	**260**	floating
7	Neckarlimes	−0.155	−0.021	−0.973	117	260	fixed
8	Odenwaldlimes	2.540	−1.215	1.228	**105**	**260**	floating
9	Wetteraulimes	0.695	−0.019	−0.092	110	260	fixed
10	ÖstlicherWetterauLimes	0.864	−0.585	−0.103	105	260	fixed

LimesPotters.tsv

… as well as the intermediate result: the fixed and floating limes parts intervals as full list of „virtual fuzzy start and end years".

	name	x	y	z	start	end	fixed
2	AlbLimes	−0.162	1.149	−0.519	97	260	fixed
3	DonauLimesPhase2	−0.43	0.046	−0.372	70	260	fixed
4	Elisabethenstrasse	−0.479	−0.204	0.270	74	104	fixed
5	HadriansWall	0.787	2.717	2.279	122	230	fixed
6	MainLimes	1.067	−0.223	0.273	**110**	**260**	floating
7	Neckarlimes	−0.155	−0.021	−0.973	117	260	fixed
8	Odenwaldlimes	2.540	−1.215	1.228	**105**	**260**	floating
9	Wetteraulimes	0.695	−0.019	−0.092	110	260	fixed
10	ÖstlicherWetterauLimes	0.864	−0.585	−0.103	105	260	fixed

LimesPotters.tsv

The „virtual fuzzy start and end years" of the limes party can be visualised for example in a "virtual timeline".

	A	B	C	D	E	F	G
1	name	x	y	z	start	end	fixed
2	AlbLimes	-0.162	1.149	-0.519	97	260	fixed
3	DonauLimesPhase2	-0.43	0.046	-0.372	70	260	fixed
4	Elisabethenstrasse	-0.479	-0.204	0.270	74	104	fixed
5	HadriansWall	0.787	2.717	2.279	122	230	fixed
6	MainLimes	1.067	-0.223	0.273	110	260	floating
7	Neckarlimes	-0.155	-0.021	-0.973	117	260	fixed
8	Odenwaldlimes	2.540	-1.215	1.228	105	260	floating
9	Wetteraulimes	0.695	-0.019	-0.092	110	260	fixed
10	ÖstlicherWetterauLimes	0.864	-0.585	-0.103	105	260	fixed

Alligator calculation and visualisation of LimesPotters.tsv

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The Alligator method needs some more steps to establish a relative chronology based on Allen's interval algebra.

- **Step 5**: the "virtual fuzzy years" are transformed to relative time intervals using Allen interval algebra

- **Step 6**: create a RDF representation in order to achieve a representation of the state of knowledge concerning the temporal sequences of time intervals, which is transparent, interoperable, semantically described and machine readable

- **Step 7**: visualisation of the results

- **Step 8**: look for contradictions

- **Step 9**: resolve them and start with step 1

Modelling a relative chronology can be based on Allen's interval algebra to apply temporal reasoning…

based on Freksa (1992), Figure 3
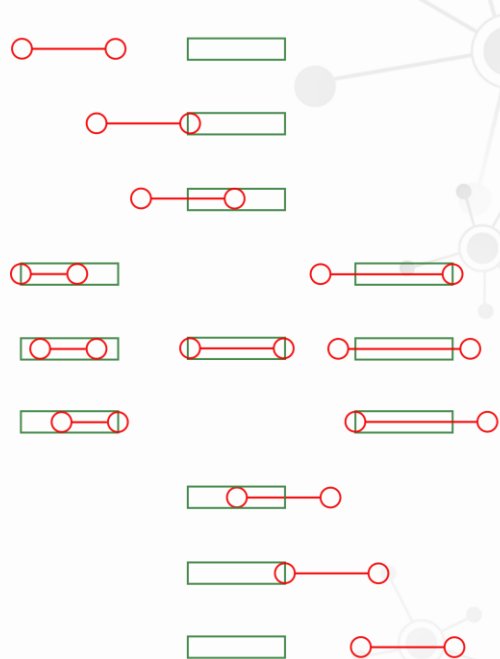
< before
> after
d during
di contains
o overlaps
oi overlapped-by
m meets
mi met-by
s starts
si started-by
f finishes
fi finished-by
= equals

The time intervals with fixed "virtual fuzzy" datings are used to establish a relative chronology according to Allen's Algebra...

	AL	DL2	ES	HW	ML	NL	OL	WL	ÖWL
AL	e	f	oi	di	fi	fi	fi	fi	fi
DL2	fi	e	di	di	fi	fi	fi	fi	fi
ES	o	d	e	b	b	b	b	b	b
HW	d	d	a	e	d	d	d	d	d
ML	f	f	a	di	e	fi	f	e	f
NL	f	f	a	di	f	e	f	f	f
OL	f	f	a	di	fi	fi	e	fi	e
WL	f	f	a	di	e	fi	f	e	f
ÖWL	f	f	a	di	fi	fi	e	fi	e

AlbLimes
DonauLimesPhase2
Elisabethenstrasse
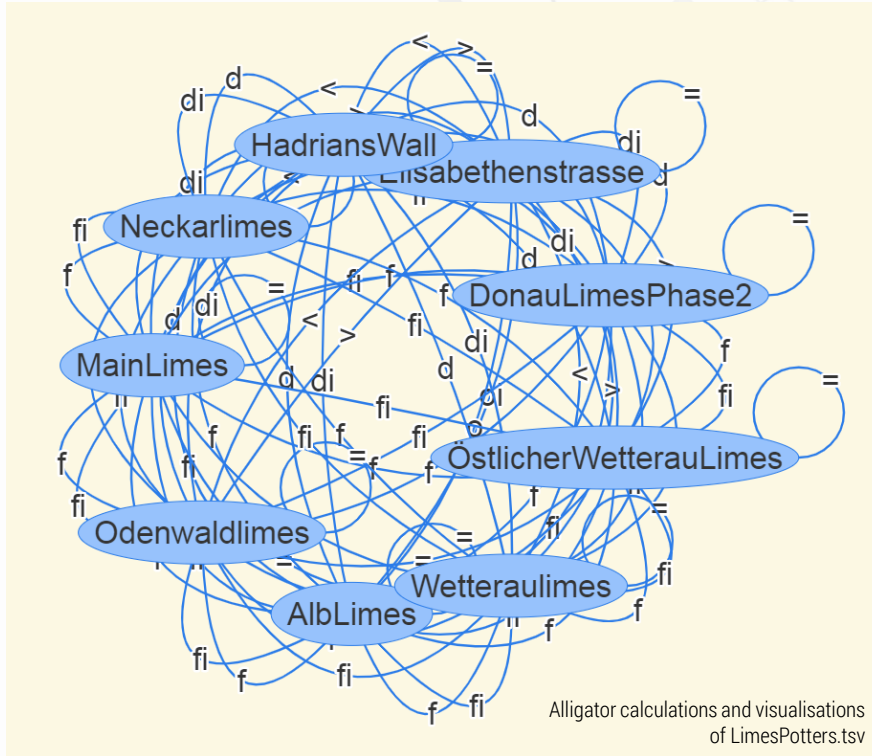HadriansWall
MainLimes
Neckarlimes
Odenwaldlimes
Wetteraulimes
ÖstlicherWetterauLimes

Alligator calculation and visualisation of LimesPotters.tsv

And as an RDF for a transparent, interoperable, semantically described and machine readable graph representation.

Alligator calculations and visualisations
of LimesPotters.tsv

```
ae:VNAxbY a alligator:Event .
ae:VNAxbY dc:identifier "VNAxbY" .
ae:VNAxbY alligator:eventname "Neckarlimes" .
ae:VNAxbY alligator:estimatedstart "117.0" .
ae:VNAxbY alligator:estimatedend "260.0" .
ae:VNAxbY alligator:cax "-0.155" .
ae:VNAxbY alligator:cay "-0.021" .
ae:VNAxbY alligator:caz "-0.973" .
ae:VNAxbY alligator:startfixed "true" .
ae:VNAxbY alligator:endfixed "true" .

ae:OGad4x a alligator:Event .
ae:OGad4x dc:identifier "OGad4x" .
ae:OGad4x alligator:eventname "Odenwaldlimes" .
ae:OGad4x alligator:estimatedstart "105.0" .
ae:OGad4x alligator:estimatedend "260.0" .
ae:OGad4x alligator:cax "2.54" .
ae:OGad4x alligator:cay "-1.215" .
ae:OGad4x alligator:caz "1.228" .
ae:OGad4x alligator:startfixed "false" .
ae:OGad4x alligator:endfixed "false" .
ae:OGad4x alligator:nfsn "ÖstlicherWetterauLimes" .
ae:OGad4x alligator:nfen "ÖstlicherWetterauLimes" .
ae:OGad4x alligator:nfsn ae:JDDMPg .
ae:OGad4x alligator:nfen ae:JDDMPg .
```

The degree of connection between Limes parts can be described with the Pearson correlation coefficient (range: [0;1]).

|	AL	DL2	ES	HW	ML	NL	OL	WL	ÖWL
AL	1,000	0,791	0,786	0,679	0,584	0,637	0,303	0,769	0,679
DL2	0,791	1,000	0,884	0,601	0,655	0,808	0,229	0,792	0,739
ES	0,786	0,884	1,000	0,607	0,686	0,780	0,329	0,780	0,758
HW	0,679	0,601	0,607	1,000	0,561	0,473	0,356	0,762	0,525
ML	0,584	0,655	0,686	0,561	1,000	0,640	0,596	0,761	0,728
NL	0,637	0,808	0,780	0,473	0,640	1,000	0,172	0,762	0,653
OL	0,303	0,229	0,329	0,356	0,596	0,172	1,000	0,413	0,549
WL	0,769	0,792	0,780	0,762	0,761	0,762	0,413	1,000	0,804
ÖWL	0,679	0,739	0,758	0,525	0,728	0,653	0,549	0,804	1,000

AlbLimes

DonauLimesPhase2

Elisabethenstrasse

HadriansWall

MainLimes

Neckarlimes

Odenwaldlimes

Wetteraulimes

ÖstlicherWetterauLimes

For creating inferred conclusions (=reasoning) of Allen Interval Algebra including a degree of connection, AMT can be used.

Academic Meta Tool
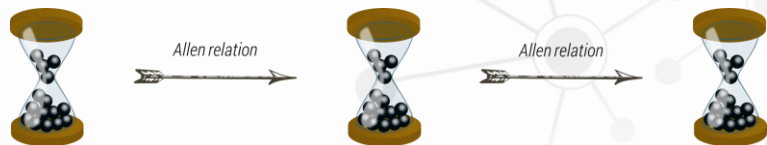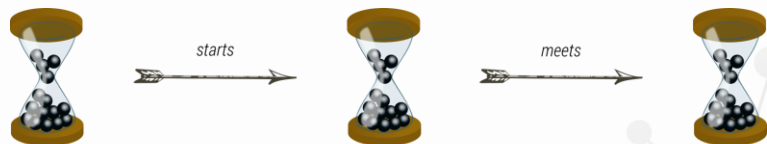
http://academic-meta-tool.xyz
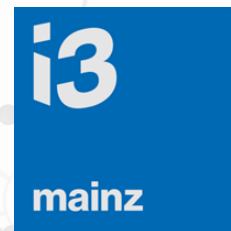
created by
mainzed, i3mainz and RGZM

with ideas from
Martin Unold M.Sc. & Florian Thiery M.Sc.

The temporal reasoning for getting conclusions can be done using the Role-Chain-Axioms within the Academic Meta Tool.

based on http://academic-meta-tool.xyz/ontology, amt:RoleChainAxiom

based on Freksa (1992), Figure 6

The Academic Meta Tool is defined in a Web Ontology Language Ontology (OWL) and available on the World Wide Web.

Academic Meta Tool

http://www.visualdataweb.de/webvowl/
#iri=http://academic-meta-
tool.xyz/amt.rdf

ACADEMIC META TOOL VOCABULARY

Authors: Florian Thiery (i3mainz, RGZM) & Martin Unold (i3mainz)

Version: Penny Edition

Date: 2018-01-19

Abstract: A vocabulary for Academic Meta Tool.

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About this Document: This document is based on the GEOJSON-LD VOCABULARY by Sean Gillies (Mapbox) with a CC BY 4.0 license.

http://academic-meta-tool.xyz/vocab/
http://academic-meta-tool.xyz/amt.rdf
https://doi.org/10.5281/zenodo.1342530

This "Limes Part Ontology" is based on the AMT ontology and contains specific axioms for temporal reasoning.

http://academic-meta-tool.xyz/ontology/ontologyviewer.htm

ACADEMIC META TOOL ONTOLOGY

Authors: Florian Thiery (i3mainz, RGZM) & Martin Unold (i3mainz)

Version: Leonard Edition

Date: 2018-01-19

Abstract: The Academic Meta Tool ontology / datamodel.

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http://academic-meta-tool.xyz/ontology/
http://academic-meta-tool.xyz/ontology/ontologyviewer.htm
https://doi.org/10.5281/zenodo.1342536

We use Concepts and Roles for creating a relative time ontology using Allen's interval algebra rules.

RGZM

Leibniz
Leibniz-Gemeinschaft

mainzed

concepts

roles

weight

Limes Part

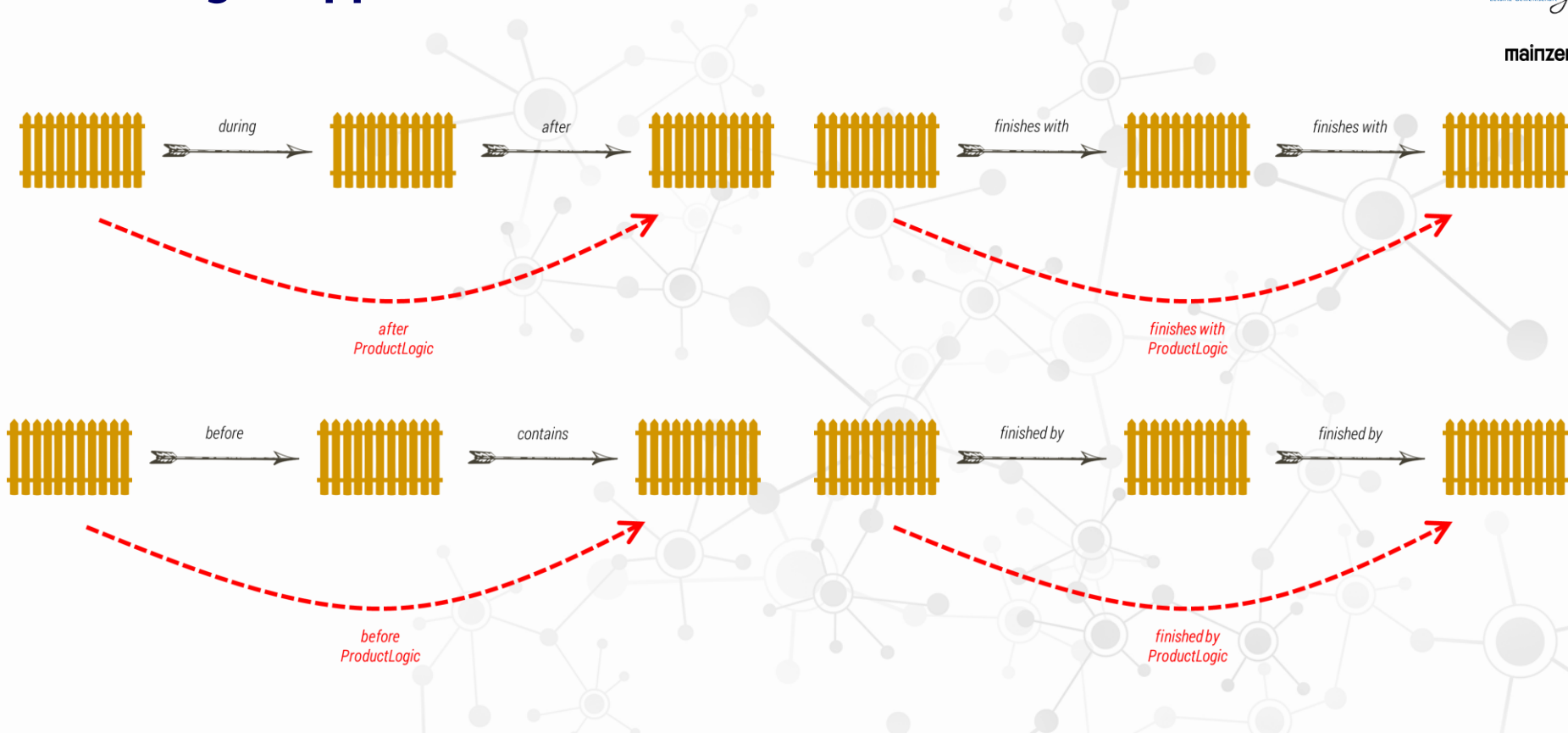$= < > m \; mi \; o \; oi$

$p\%$

$s \; si \; f \; fi \; d \; di$

$p\%$

While using Role-Chain-Axioms to calculate the inferred results, reasoning is applied and visualised in a web viewer.

Hadrian's Wall and Pearson coefficient with other Limes parts and the inferred reasoning results using AMT.

result of
AMT reasoning

http://academic-meta-tool.xyz/caauk2018/

The data and reasoning results can be exported as reproducible Linked Open Data in so called 'quadruples'.

rdf:subject

rdf:predicate

rdf:object

amt:weight

during

„0.89"

during - 0.89
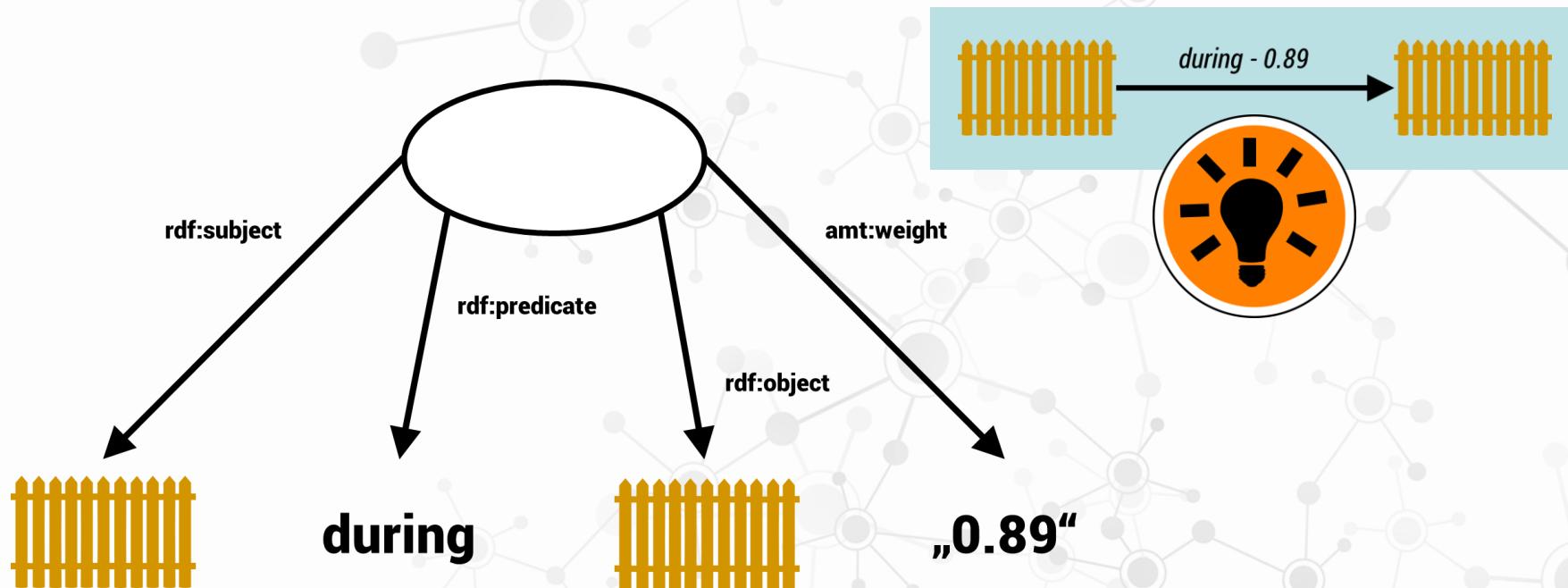
And the RDF as an archaeological result can visualise the chronological order of the Limes construction phases.

for R1:
∅ Pearson 63 of HW->NL, HW->WL, HW->AL
Reasoning Result 51

for R2:
∅ Pearson 78 of NL->ES, AL->ES, WL->ES
Reasoning Result 40
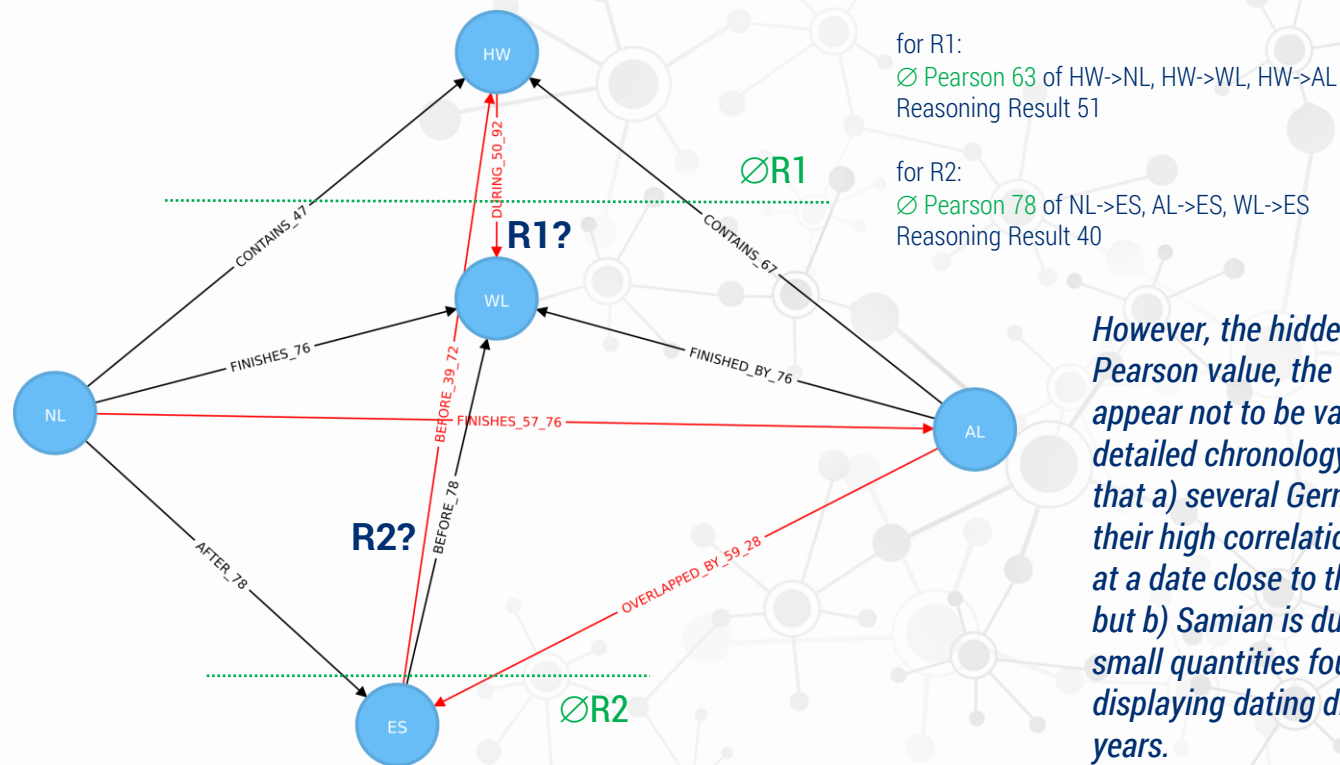
However, the hidden assumption: the lower the Pearson value, the earlier/later the Limes part is, does appear not to be valid in detail when it comes to detailed chronology. The Reasoning result suggests, that a) several German Limes parts were indeed, due to their high correlations with Hadrian's Wall, constructed at a date close to the construction of Hadrian's Wall, but b) Samian is due to its volatility and the relative small quantities found at Hadrian's Wall not capable of displaying dating differences more precisely than 10 years.

Taming the chronology of South Gaulish Samian found at Hadrian's Wall and the German Limes using Linked Open Data

thiery@rgzm.de & mees@rgzm.de

online references

- ## GitHub Repository
  - http://rgzm.github.io/amt-caauk2018/

- ## Academic Meta Tool Live Demo
  - http://academic-meta-tool.xyz/caauk2018

- ## RGZM Samian Online-Database
  - http://rgzm.de/samian

- ## Alligator
  - https://github.com/RGZM/alligator | https://rgzm.github.io/alligator

- ## RGZM Archaeological Data Processing Web Service (ADP)
  - http://rgzm.de/adp

- ## Academic Meta Tool
  - http://academic-meta-tool.xyz/
  - http://academic-meta-tool.xyz/vocab/
  - http://academic-meta-tool.xyz/ontology/

RGZM

Leibniz
Leibniz-Gemeinschaft

mainzed

publications

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