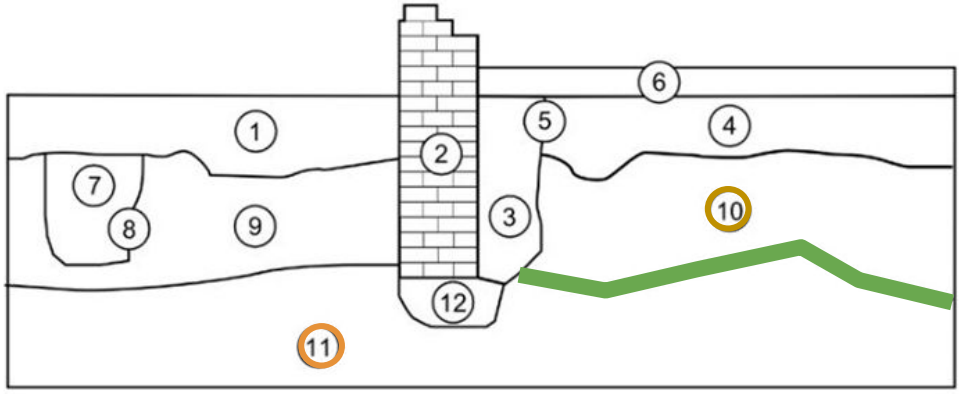
Spatio-Temporal Reasoning on Stratigraphic Data in Archaeology:

Formalization of the Harris Laws as Inferences Using CIDOC CRM

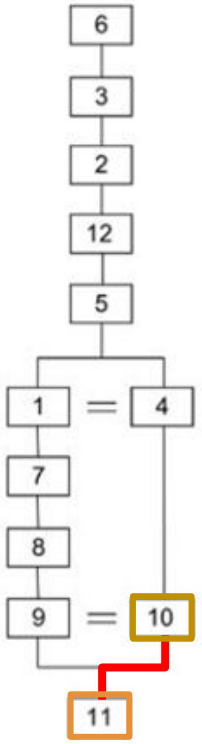


Guillem Anaïs

Van Ruymbeke Muriel

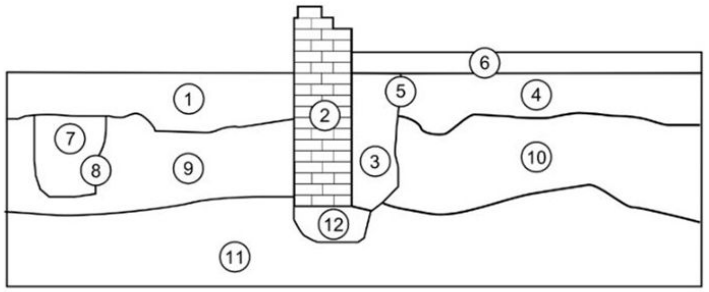
Eide Øyvind

De Luca Livio

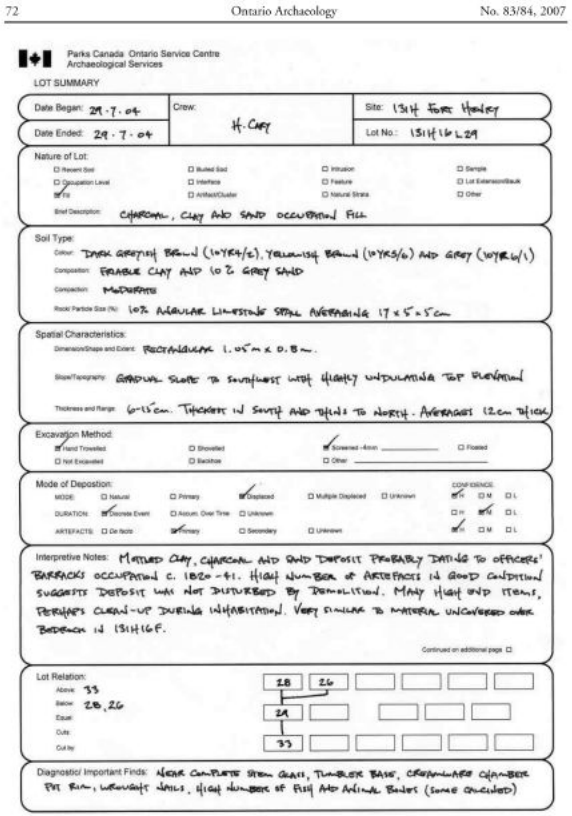


30-31 October 2024
SWODCH'24:
International Workshop on Semantic Web and Ontology Design for Cultural Heritage 2024,
Maison des Sciences de l'Homme Val de Loire, Tours, France

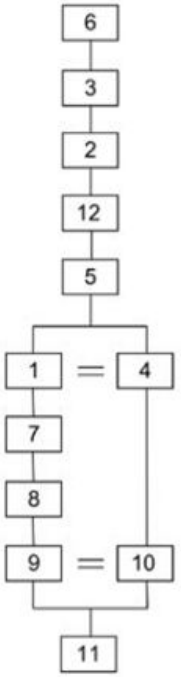
[3]



[1]



[2]



[1]

[1]
Mantegari, Glauco, Alessandro Mosca, and Maurizio Cattani. 2007. Formal Knowledge Representation and Automated Reasoning for the Study of Archaeological Stratigraphy.
[2]
Cary, Henry C, and Joseph H Last. “For the Record: The What, How and When of Stratigraphy.” For the Record, no. 83 (2007).
[3]
https://www.images-archeologie.fr/Accueil/Recherche/p-3-lg0-notice-IMAGE-Deux-archeologues-relevent-une-coupe-stratigraphique-du-fosse-de-l-enceinte..htm?&notice_id=3906

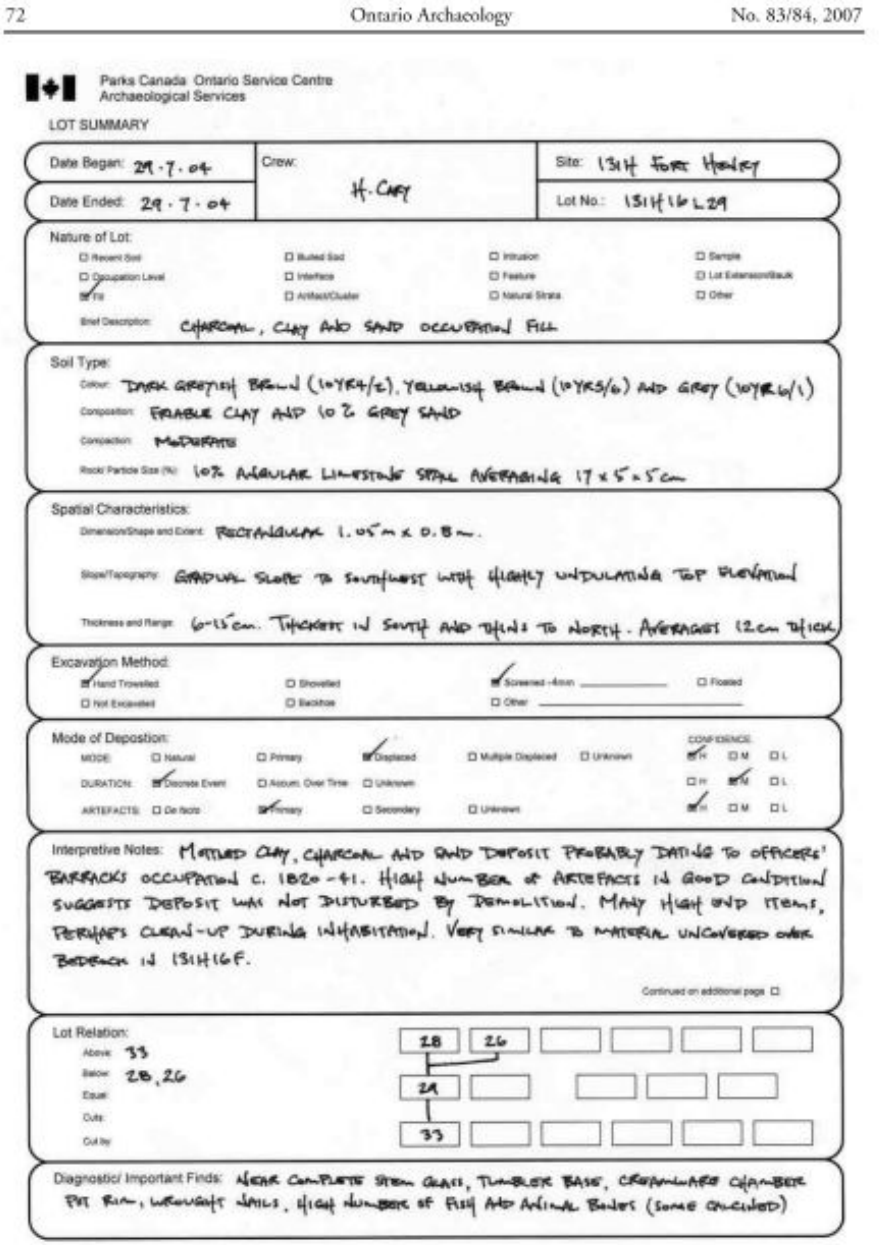
Onsite excavation documentation of a stratigraphic unit:
example of stratigraphic unit form

Pros:

- A long tradition of documentation practice in the field
- Methodology
- Normalized documentation

Cons:

- semantic modeling and data sharing are not yet common place in archaeology
- granularity of documentation



72 Ontario Archaeology No. 83/84, 2007

Parks Canada Ontario Service Centre
Archaeological Services

LOT SUMMARY

Date Began: 29-7-04 | Crew: H. Cary | Site: 1514 Fort Henry
Date Ended: 29-7-04 | Lot No.: 1514 16 L29

Nature of Lot:
Brief Description: CHARCOAL, CLAY AND SAND OCCUPATION FILL

Soil Type:
Colour: DARK GREYISH BROWN (10YR4/2), YELLOWISH BROWN (10YR5/6) AND GREY (10YR6/1)
Composition: FRIABLE CLAY AND 10% GREY SAND
Compaction: MODERATE
Rock/ Particle Size (%): 10% ANGULAR LIMESTONE SPALL AVERAGING 17 x 5 x 5 cm

Spatial Characteristics:
Dimension/Shape and Extent: RECTANGULAR 1.05m x 0.8m.
Slope/Topography: GRADUAL SLOPE TO SOUTHWEST WITH HIGHLY UNDULATING TOP ELEVATION
Thickness and Range: 6-15cm. THICKEST IN SOUTH AND THINS TO NORTH. AVERAGES 12cm THICK

Excavation Method:

Mode of Deposition:

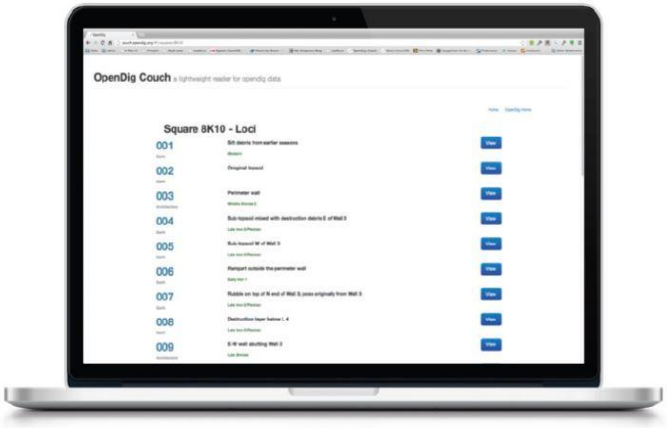
Interpretive Notes: MOTTLED CLAY, CHARCOAL AND SAND DEPOSIT PROBABLY DATING TO OFFICERS' BARRACKS OCCUPATION C. 1820-41. HIGH NUMBER OF ARTEFACTS IN GOOD CONDITION SUGGESTS DEPOSIT WAS NOT DISTURBED BY DEMOLITION. MANY HIGH END ITEMS, PERHAPS CLEAN-UP DURING INHABITATION. VERY SIMILAR TO MATERIAL UNCOVERED OVER BEDROCK IN 1514 16F.

Lot Relation:
Above: 33
Below: 28, 26
Equal:
Cuts:
Cut by:

Diagnostic/ Important Finds: NEAR COMPLETE STEM GLASS, TUMBLER BASE, CREAMWARE CHAMBER POT RIM, WROUGHT NAILS, HIGH NUMBER OF FISH AND ANIMAL BONES (SOME CALCINED)

Cary, Henry C, and Joseph H Last. “For the Record: The What, How and When of Stratigraphy.” For the Record, no. 83 (2007).

Recording excavation data: OpenDig [1], Syslat [2], AIR [3]…



Portable OpenDig Field Server

OpenDig field-recording application for iOS

[1] Vincent, Matthew L., Falko Kuester, and Thomas E. Levy. 2013. “OpenDig: In-Field Data Recording for Archaeology and Cultural Heritage.” In 2013 Digital Heritage International Congress (DigitalHeritage), 2:539–42. IEEE. https://ieeexplore.ieee.org/abstract/document/6744823/?casa_token=pXxjxJqTga4AAAAA:DAWlGdisIdVKOETmQQ2USAJ4VMSsGXbEVsvU0j7Croepgd1_E2Ze7UI-U0B7sao61HnxK90OpHs.

[2] Roure, Réjane, Sébastien Munos, Hakima Manseri, and Michel Py. 2021. “Towards an Archaeological Information System: The Evolution of Syslat, an Archaeological Data Management Software.” In Big Data and Archaeology. Proceedings of the XVIII UISPP World Congress (4-9 June 2018, Paris, France), edited by François Djindjian and Paola Moscati, 15:62–70. Archaeopress. https://hal.science/hal-04228247.

[3] Derudas, P., Nurra, F., & Svensson, A. (2023). New AIR for the Archaeological Process? The use of 3D web Semantic for Publishing Archaeological Reports. ACM Journal on Computing and Cultural Heritage, 16(3), 1-23.

Archiving excavation data: example of OpenContext:

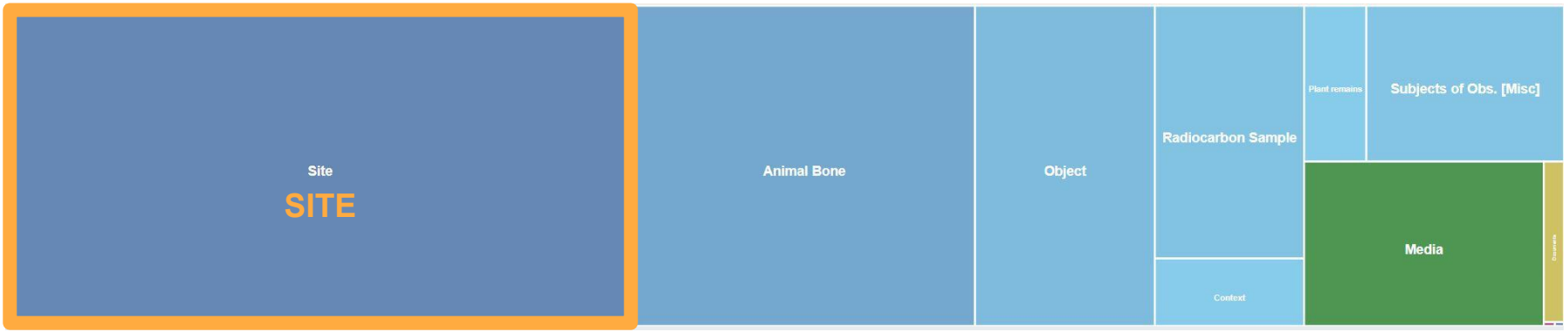


Fig.: relative proportion of different types of content published by Open Context.

Example of Ariadne: https://portal.ariadne-infrastructure.eu/search?q=stratigraphy%20site

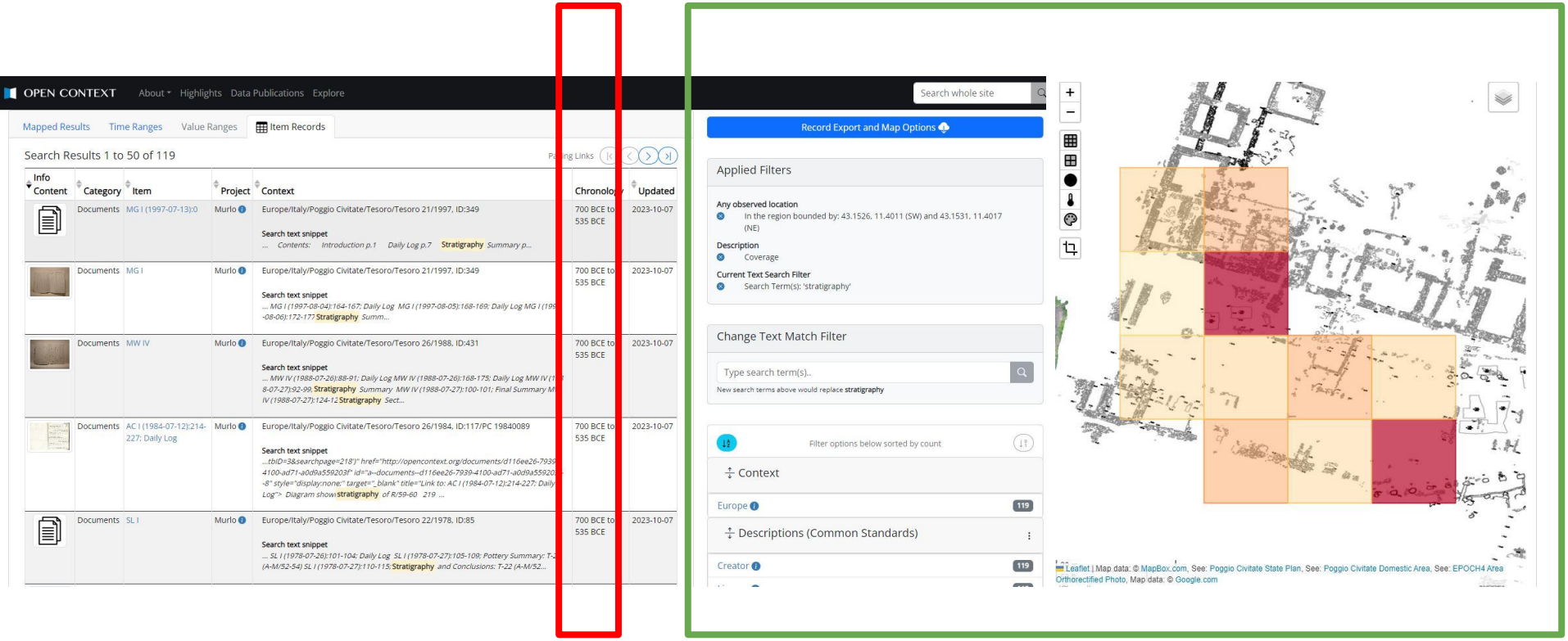
Example of OpenArcheo:

[Talk on SPARNATURAL, a knowledge graph visual query system, and its use in OpenArchaeo, a portal of archaeological knowledge graphs by Thomas FRANCART (SPARNA) and Florian HIVERT (Université de Tours/MSH), 30/10/2324, SWODCH'24]

Identified problem: uncorrelated temporal and spatial information

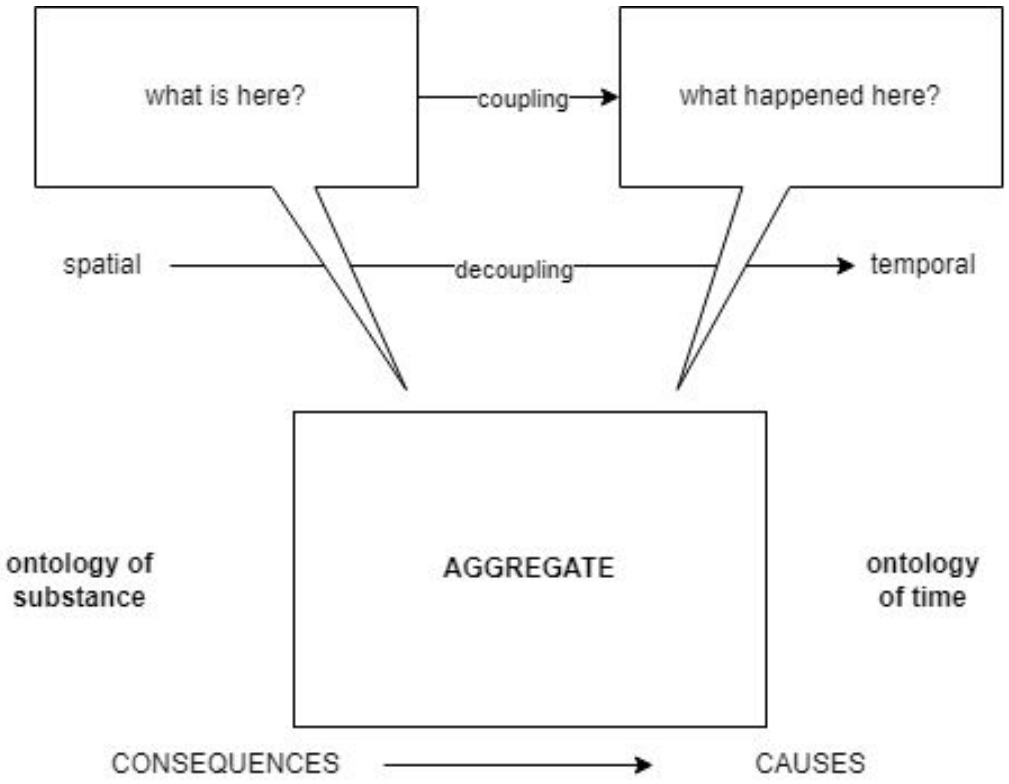
temporal information

place and spatial information



https://opencontext.org/query/?allevent-geotile=1202320222213033100&prop=dc-terms-coverage&q=stratigraphy#tab=3/ovgrd=oc/zm=20/lat=43.15285/lng=11.40141/ov=sqr

Archaeological theory of aggregate: Reasoning about space and time



How to apply a consistent modeling and reasoning to the decoupling spatial/temporal?

[Boissinot, Philippe. 2015. Qu'est-ce qu'un fait archéologique? Éditions EHESS. translation authors]

Archaeological stratigraphy

- Archaeological stratigraphy is the study of layered deposits or strata for understanding the chronological sequence of past human activity.

- A Harris Matrix is a stratification diagram used in archaeology to express the sequence of deposition of contexts, reflecting relative chronology rather than absolute time, and aiding in the interpretation of site development and material culture analysis.

[Harris, The Principles of Archaeological Stratigraphy, 1979, fig.2, p.12]

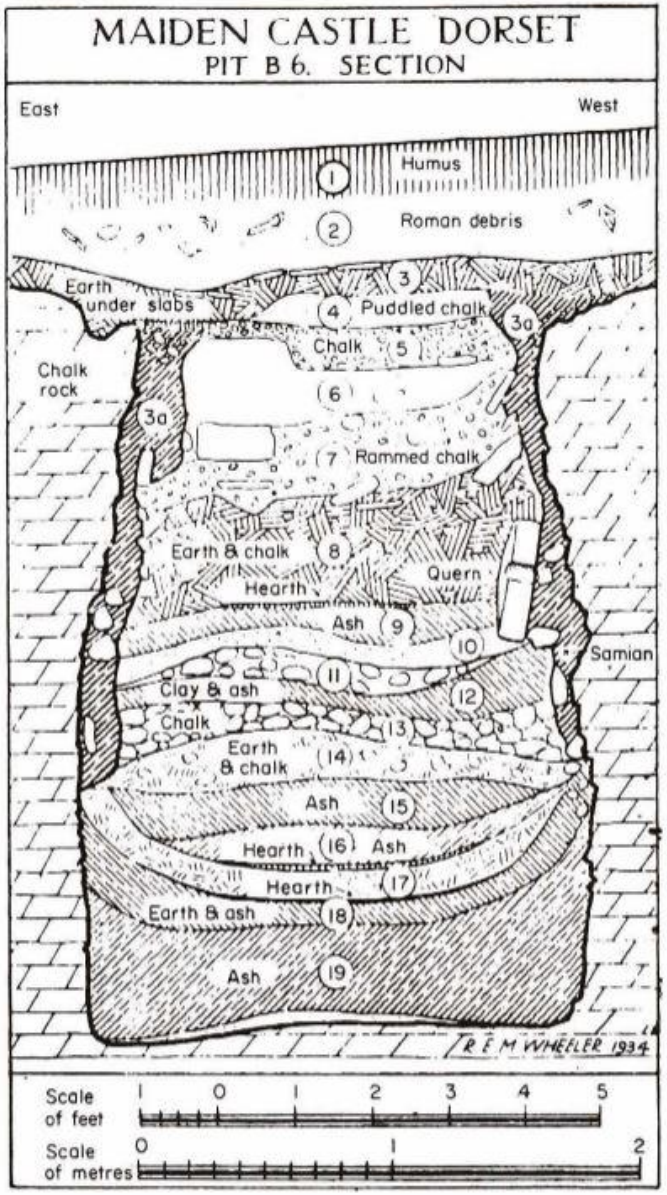
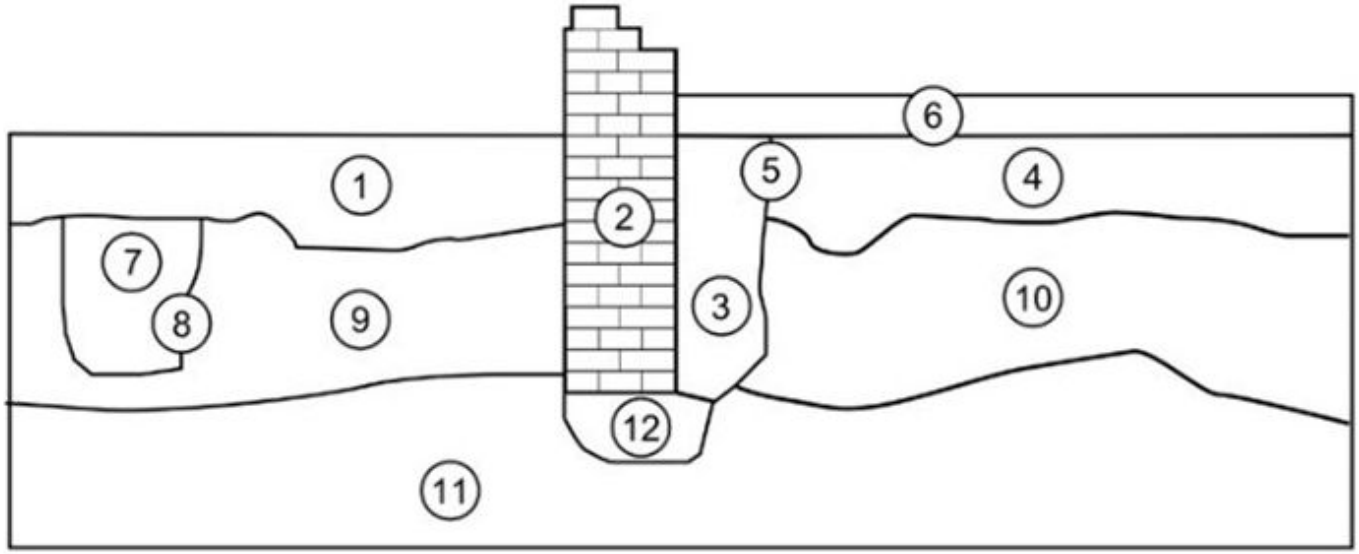
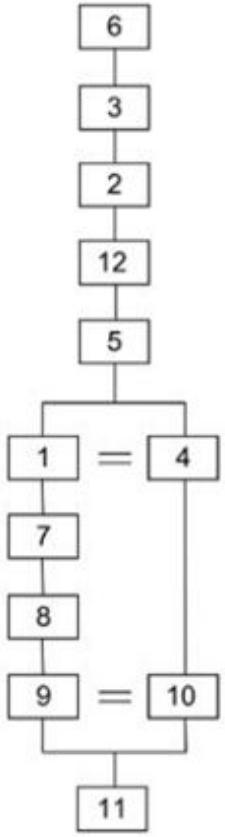


Fig. 2 This section drawing, made by Mortimer Wheeler in 1934, is one of the earliest to contain 'layer numbers' (from Wheeler 1943: fig. 10; courtesy of the Society of Antiquaries of London).

Theoretical example of stratigraphy analysis and Harris matrix





#a: hypothetical excavation section drawing
#b: resulting Harris matrix

#a #b

[Mantegari, Glauco, Alessandro Mosca, and Maurizio Cattani. 2007. Formal Knowledge Representation and Automated Reasoning for the Study of Archaeological Stratigraphy.]

State-of-the-art: Mantegari et al. [17]

Modelling of stratigraphy using knowledge representation and performing automated reasoning on spatial and temporal aspects of archaeological data.
AnsProlog to define prolog rules

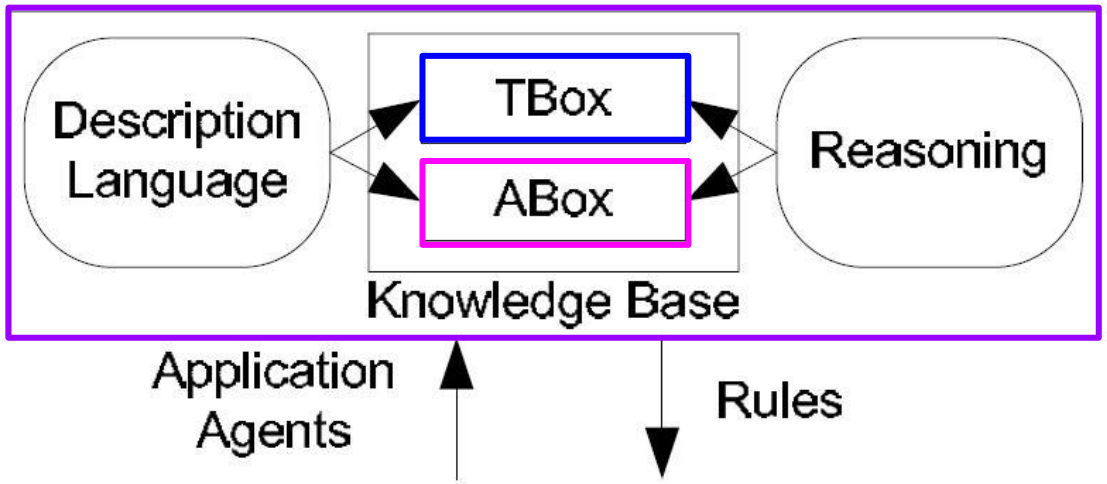
- Description of primitive spatial relations: cover, cut, fill, leanOn, attachTo, equalTo (covered, cutBy, filledBy, isLeanedOn).
- A second set of rules is defined for the primitive temporal relations: directly posterior to (dirPostTo), directly anterior to (dirAntTo), posteriorTo, anteriorTo, contemporary(X,Y).

The approach proposes to map the first set with the second, using a third set of rules to translate the topological relationship into a temporal one.
This preliminary work concludes with the need to represent the rules defined by Harris in a formal way to compute the models accordingly, and to test the approach on large datasets.

[Mantegari, Glauco, Alessandro Mosca, and Maurizio Cattani. 2007. Formal Knowledge Representation and Automated Reasoning for the Study of Archaeological Stratigraphy.]

Ontologies and knowledge domain

- general domain knowledge: **TBox** (ontology) made of a finite set of axioms
- factual knowledge about particular individuals: **ABox** (data) made of a finite set of assertions C(a),r(a, b) (C concept, r role, a, b inds)
- **DL Knowledge Base (KB)** = **TBox** (ontology) + **ABox** (data)



[Patrón, Pedro, Emilio Miguelañez, and Yvan R. Petillot. 2011. Embedded Knowledge and Autonomous Planning: The Path towards Permanent Presence of Underwater Networks. INTECH Open Access Publisher. p.205, fig.4: Knowledge Base representation system including the TBox, ABox, the description language and the reasoning components. Its interface is made of orientation rules and agent queries. (figure modified by the authors)]

State-of-the-art: CRMarchaeo, v2.1.1, p.18

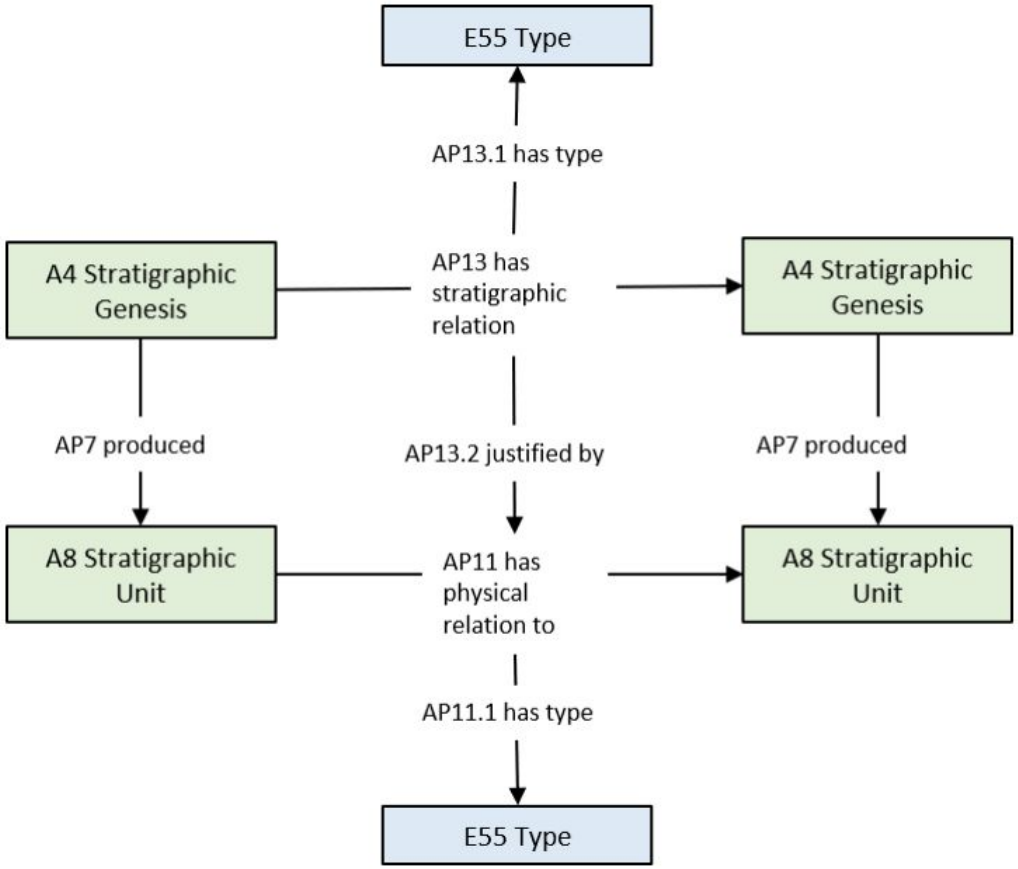


Figure 5: CRMarchaeo conceptualisation to represent stratigraphic relationships contained in Harris Matrix, being justified by physical relationships.

State-of-the-art:
Documenting time periods with CRM, SKOS, owl-time

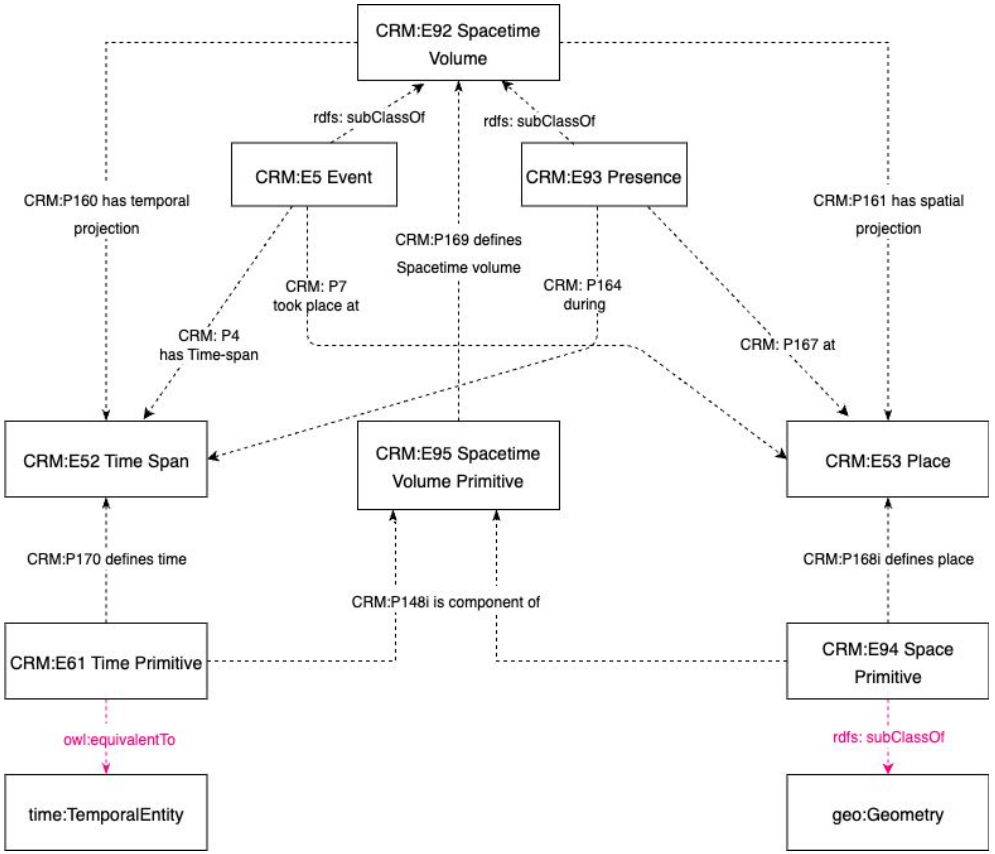
Table 1 relationships between time periods, with their associated inverse property

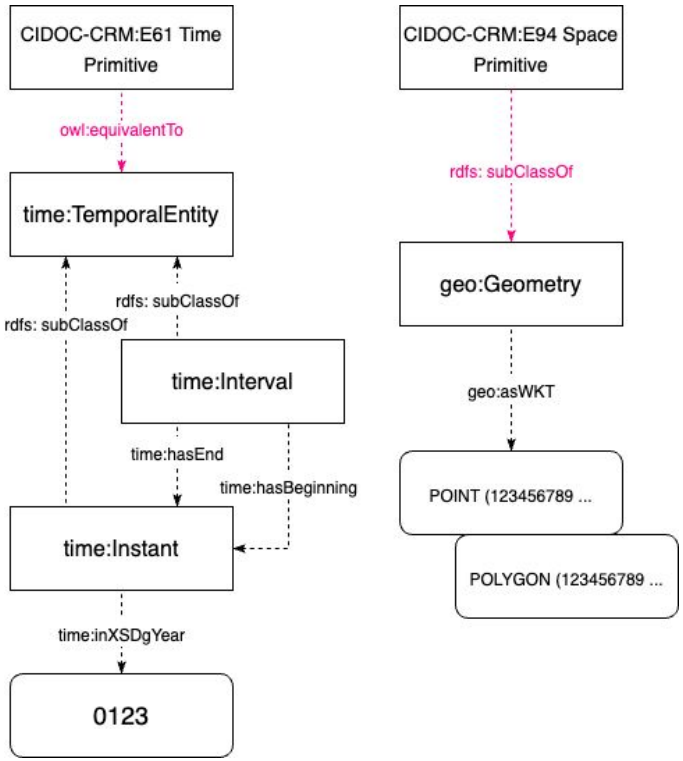
CIDOC CRM Property	OWL-Time Property	Transitive?
P114F.is_equal_in_time_to	intervalEquals	✓
P115F.finishes P115B.is_finished_by	intervalFinishes intervalFinishedBy	✓
P116F.starts P116B.is_started_by	intervalStarts intervalStartedBy	✓
P117F.occurs_during P117B.includes	intervalDuring intervalContains	✓
P118F.overlaps_in_time_with P118B.is_overlapped_in_time_by	intervalOverlaps intervalOverlappedBy	×
P119F.meets_in_time_with P119B.is_met_in_time_by	intervalMeets intervalMetBy	×
P120F.occurs_before P120B.occurs_after	intervalBefore intervalAfter	✓

Note: *transitive*[1] in **Table 1** refers to relationships that are logically transitive; transitivity is not formally stated for the interval relations in the RDF implementations of CIDOC CRM and OWL-Time (the latter does however include separate transitive versions of the *before* and *after* properties). **Fig. 2** shows how each of these formal relationships between periods can be deduced based on start/end dates.

[Binding, Ceri. 2010. “Implementing Archaeological Time Periods Using CIDOC CRM and SKOS.” In , 273–87. https://doi.org/10.1007/978-3-642-13486-9.]

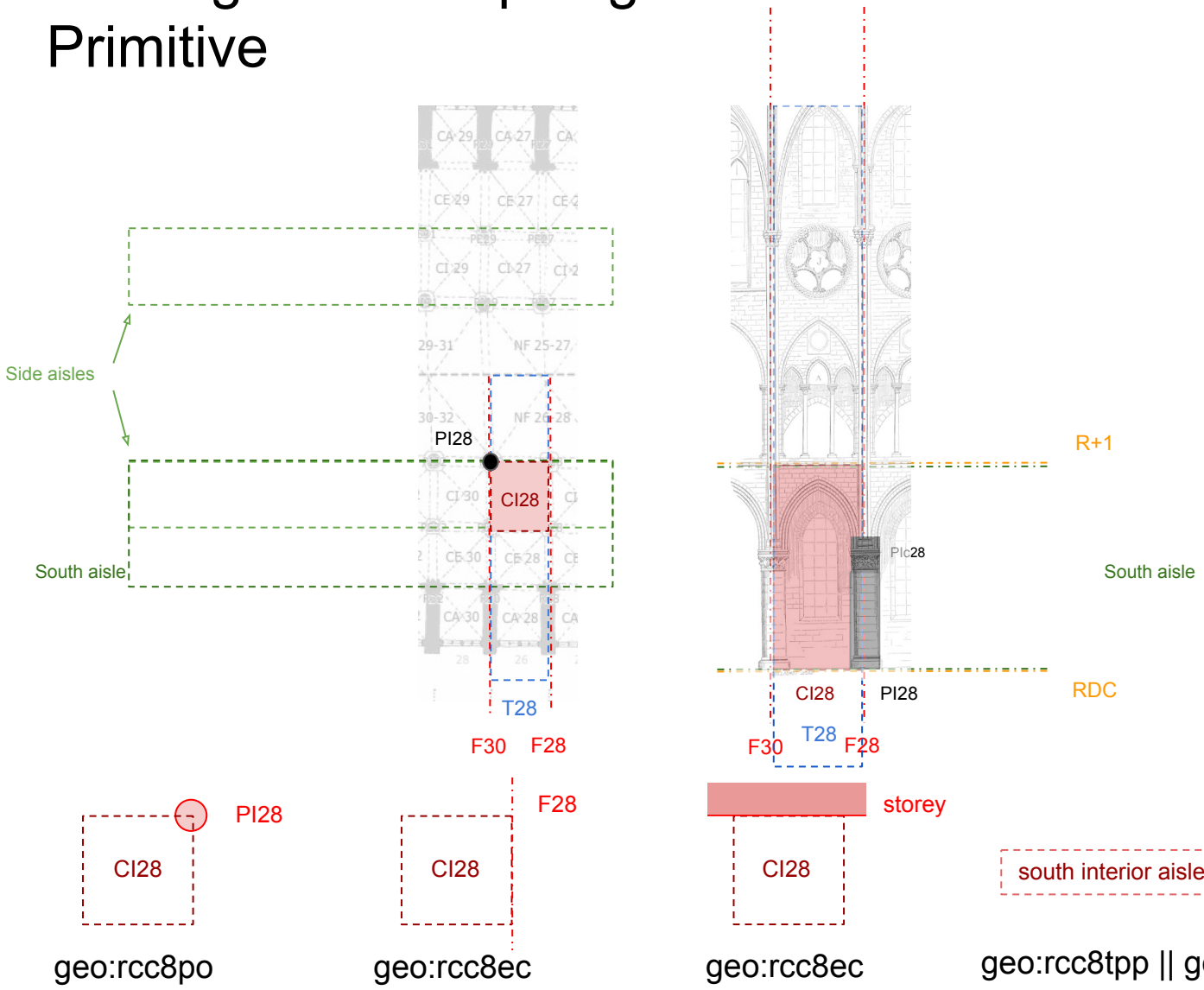
State-of-the-art: Nys et al., 2018 / Van Ruymbeke, 2021

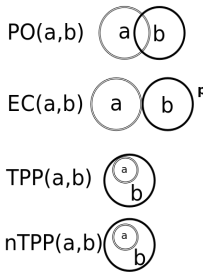




[Van Ruymbeke, 2021]

State-of-the-art: documenting and reasoning about heterogeneous topological relations: Place - Object/Spatial Primitive





Implementation of RCC8 in Geosparql: http://www.opengis.net/def/function/geosparql

[Guillem et al._2023] RCC8 for CIDOC CRM: semantic modeling of mereological and topological spatial relations in Notre-Dame de Paris, A.Guillem, A.Gros, K.Reby ; V.Abergel, L.De Luca, SWODCH 2023]

Competency questions (1)

CQ#0.1 What is the excavation and stratigraphy documentation accessible (section drawings, SU inventory)?

CQ#0.2: Is there a Harris matrix for the considered excavation?

CQ#0.3: Is the reasoning about stratigraphy documented somehow?

CQ#0.4: How does the reasoning about spatio-temporal relationships of SUs applies Harris laws?

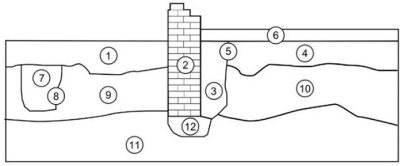
CQ#0.5: What are the Harris laws used for?

CQ#0.6: How many SUs are documented in the considered use case? what is the list of the SUs?

First level of mapping with CIDOC CRM and CRMinf

input

Excavation documentation: #a: hypothetical excavation section drawing



inf:J1_used_as_premise

inf:I5_Reasoning about spatial-temporal relationships of SU

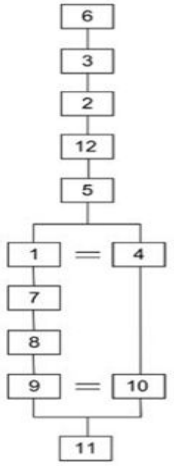
inf:J2_concluded

inf:J3_applies

inf:I3_Inference Logic: **Harris laws**

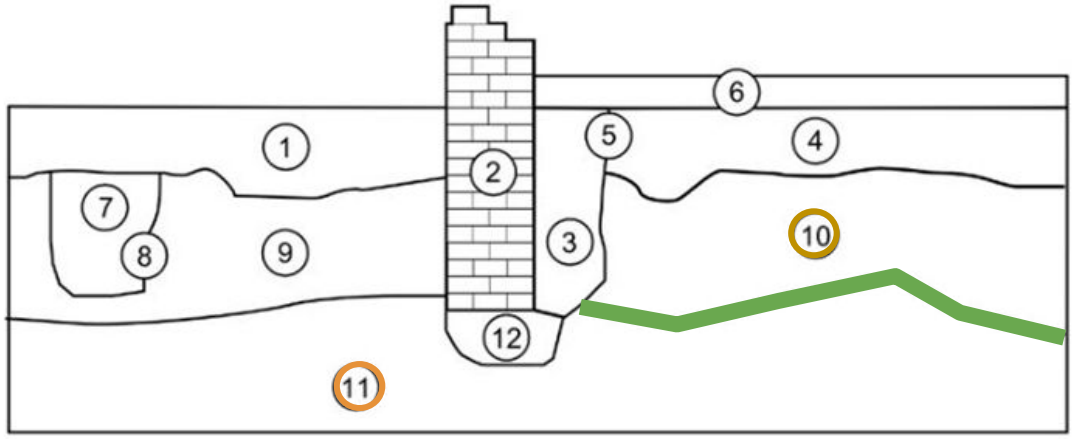
outcome

Synthesis Document: #b: resulting Harris matrix

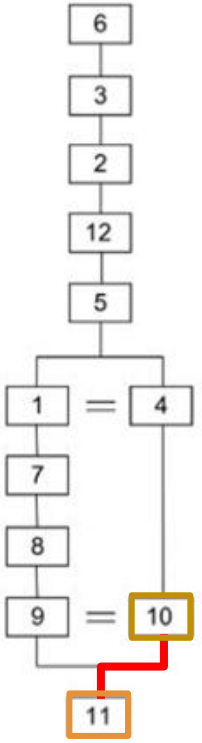


PREFIX:
archaeo: CIDOC CRM archaeo
inf: CIDOC CRM inf

Demonstration and use case



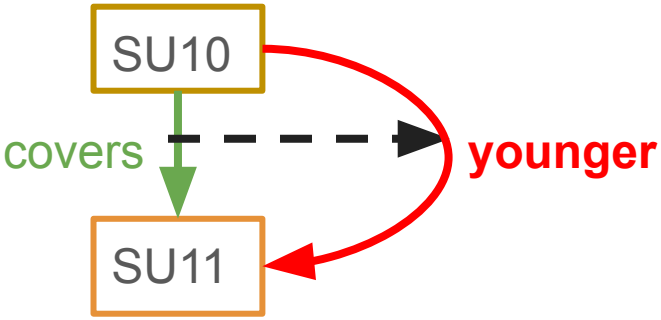
law of superposition



Harris law #1: law of superposition

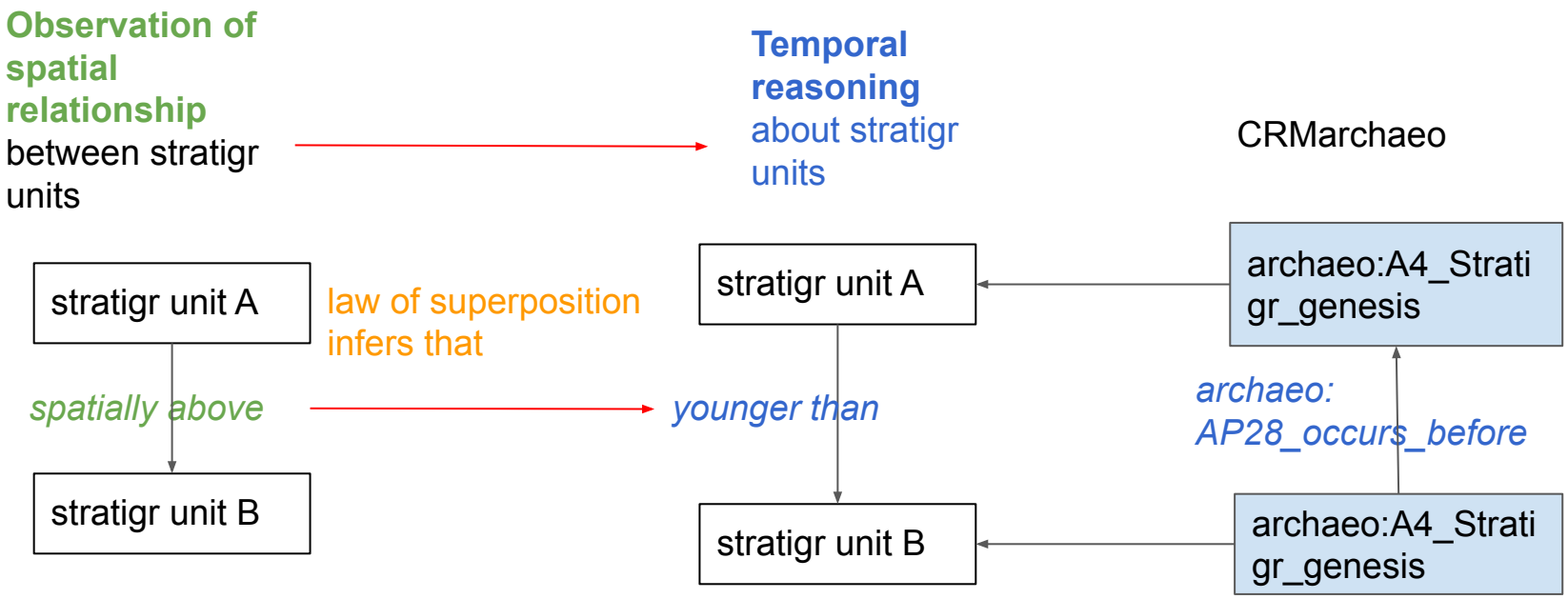
How to model the law of superposition as an inference using the competency questions and the existing ontologies?

Use case example:

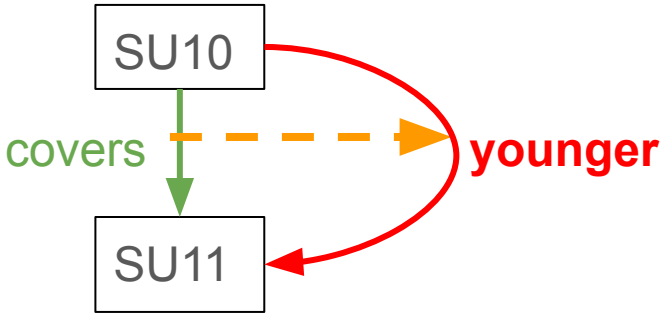


Harris matrix -
1-Law of superposition

Formulation of the law of superposition:
The law of superposition states that, in a series of layers, the upper units of stratification are younger and the lower are older, for each must have been deposited on, or created by the removal of, a pre-existing mass of archaeological stratification.



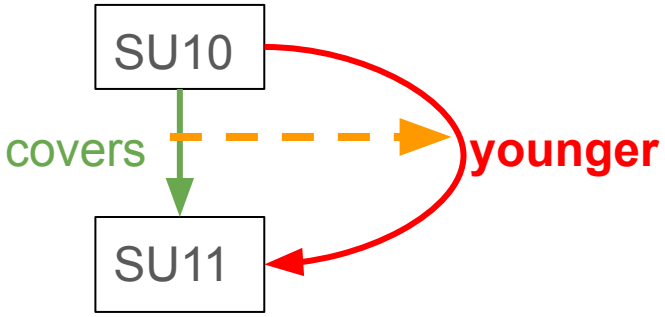
Harris matrix -
1-Law of superposition: competency questions



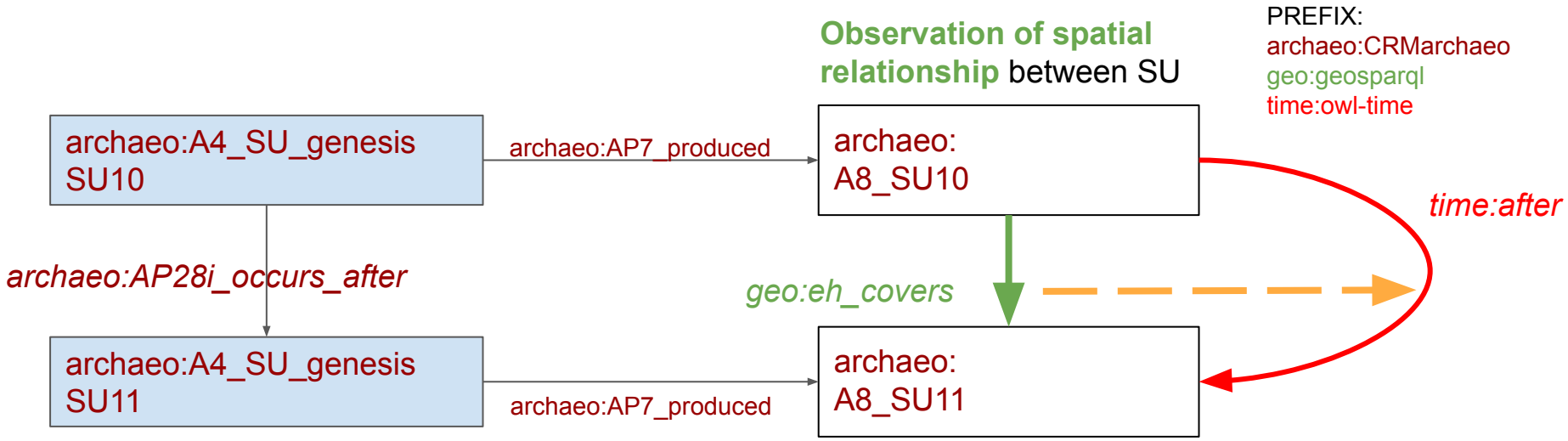
CQ#1.4: If SUx covers SUy, then according to the law of superposition, one can postulate that SUx should be after SUy unless proven otherwise.

- CQ#1.1 In which use case, does the law of superposition apply?
- CQ#1.2 In which use case, does the law of superposition not apply?
- CQ#1.3 What is the law of superposition?
- **CQ#1.4** If SUx covers SUy, then according to the law of superposition, one can postulate that SUx should be after SUy unless proven otherwise.

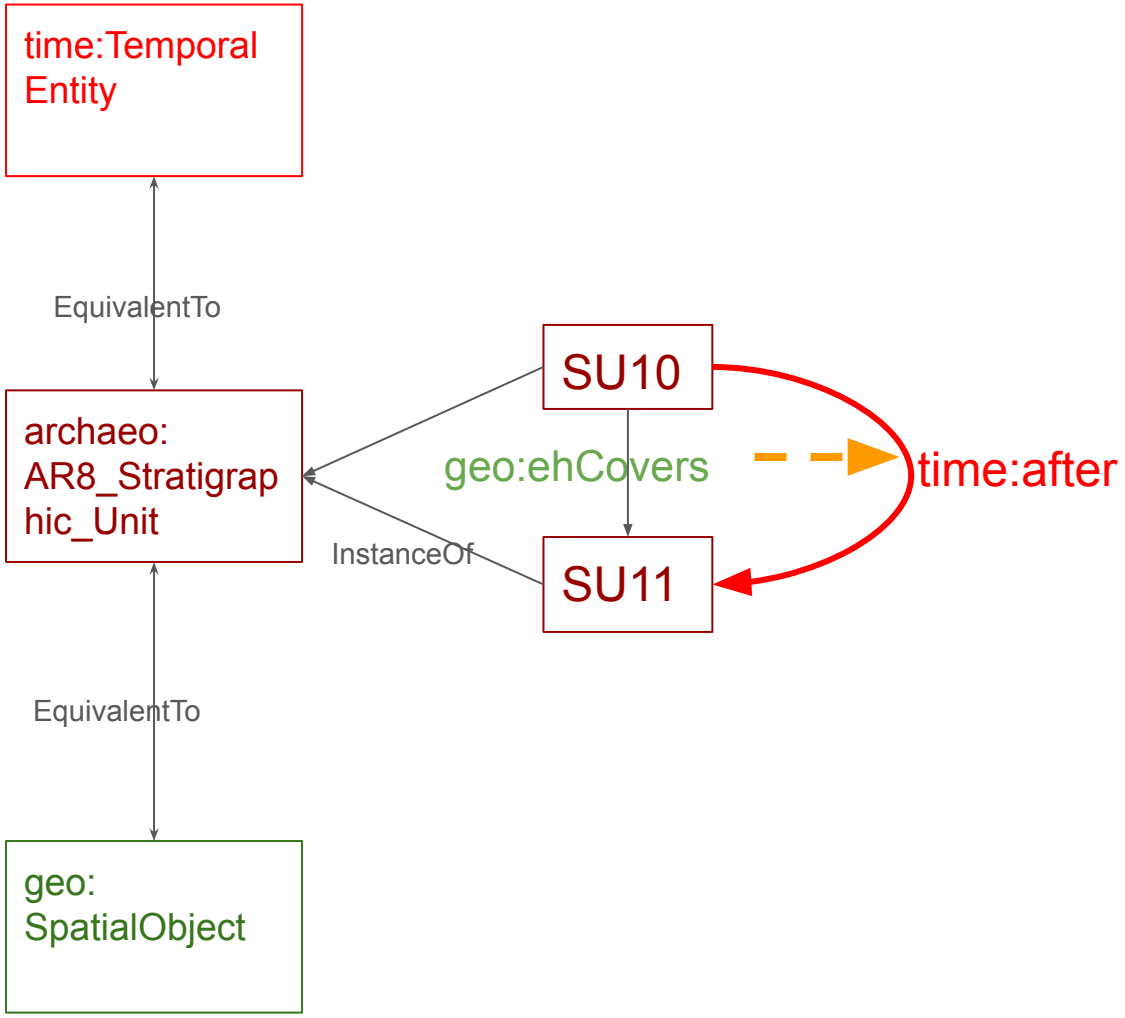
Harris matrix -
1-Law of superposition - most common example modeled with CRM archaeo, geosparql, and owl-time:



CQ#1.4: If SUx covers SUy, then according to the law of superposition, one can postulate that SUx should be after SUy unless proven otherwise.



Harris matrix -
1-Law of superposition - most common example modeled with an inference (SWRL rule):

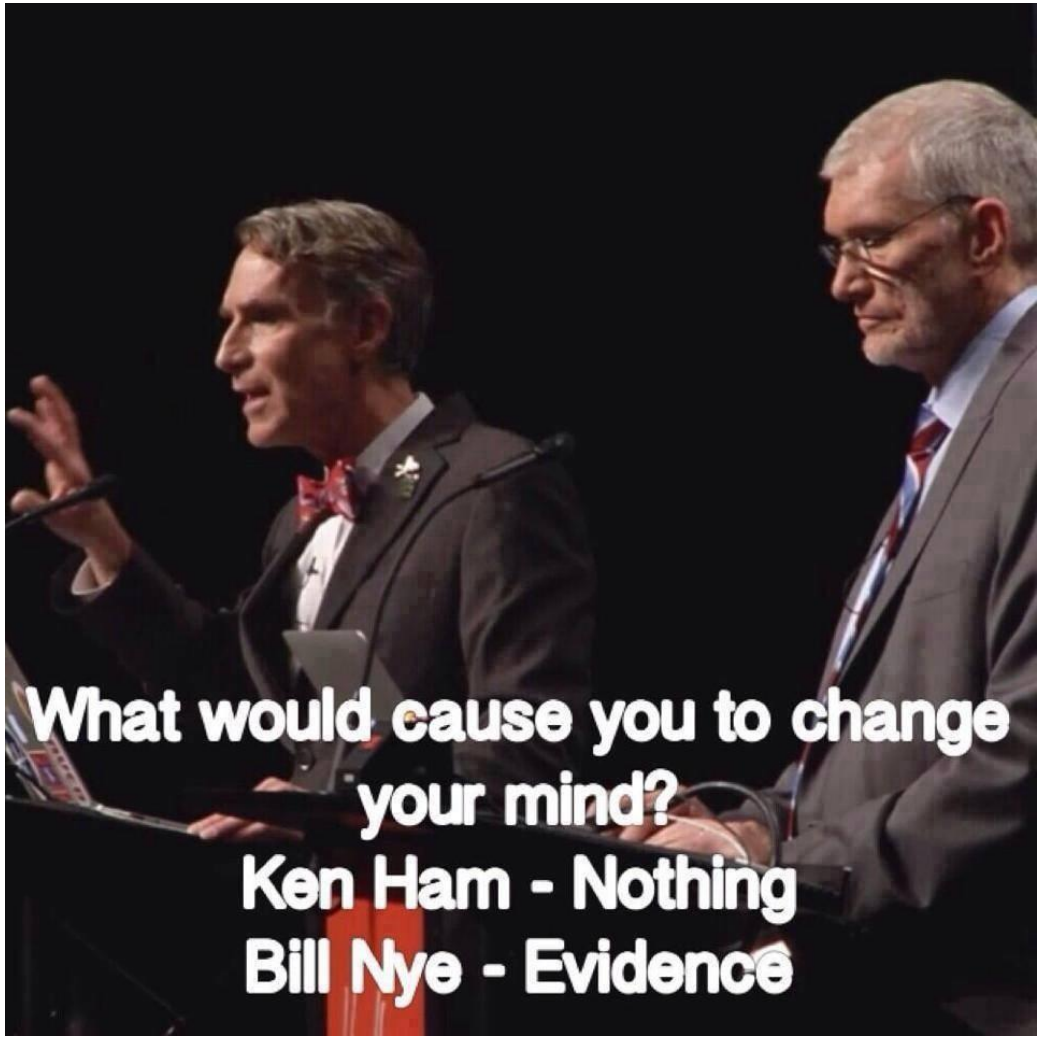


inference space->time

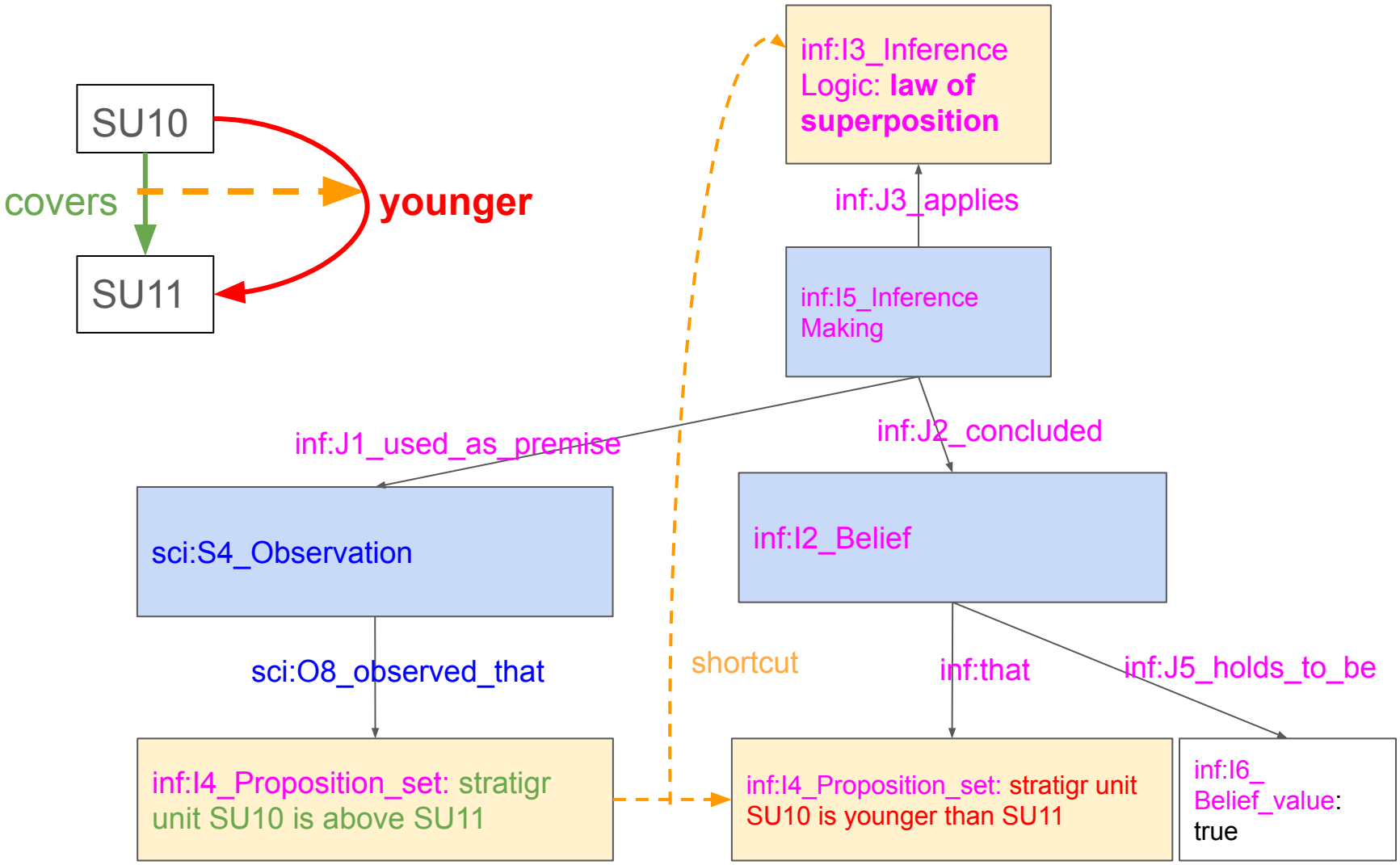
PREFIX:
archaeo:CRMarchaeo
geo:geosparql
time:owl-time

SWRL rule:
archaeo:
AR8_Stratigraphic_Unit(?i),
archaeo:
AR8_Stratigraphic_Unit(?j),
geo:ehCovers(?i, ?j) ->
time:after(?i, ?j)

Need for argumentation and hypotheses modelling for stratigraphic data



1-Law of superposition modeled using CRMinf



1-Law of superposition modeled as an inference using CRM archaeo

PREFIX:
crm:CIDOC CRM
archaeo:CRMarchaeo

swrl rule:
archaeo:AR8_Stratigraphic_Unit(?i),
archaeo:AR8_Stratigraphic_Unit(?j),

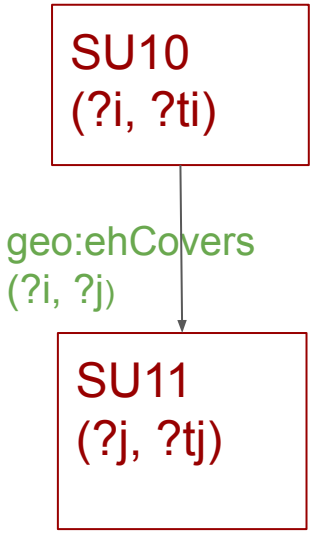
SU10
(?i, ?ti)

SU11
(?j, ?tj)

1-Law of superposition modeled as an inference using CRM archaeo, geosparql

PREFIX:
crm:CIDOC CRM
archaeo:CRMarchaeo
geo:geosparql

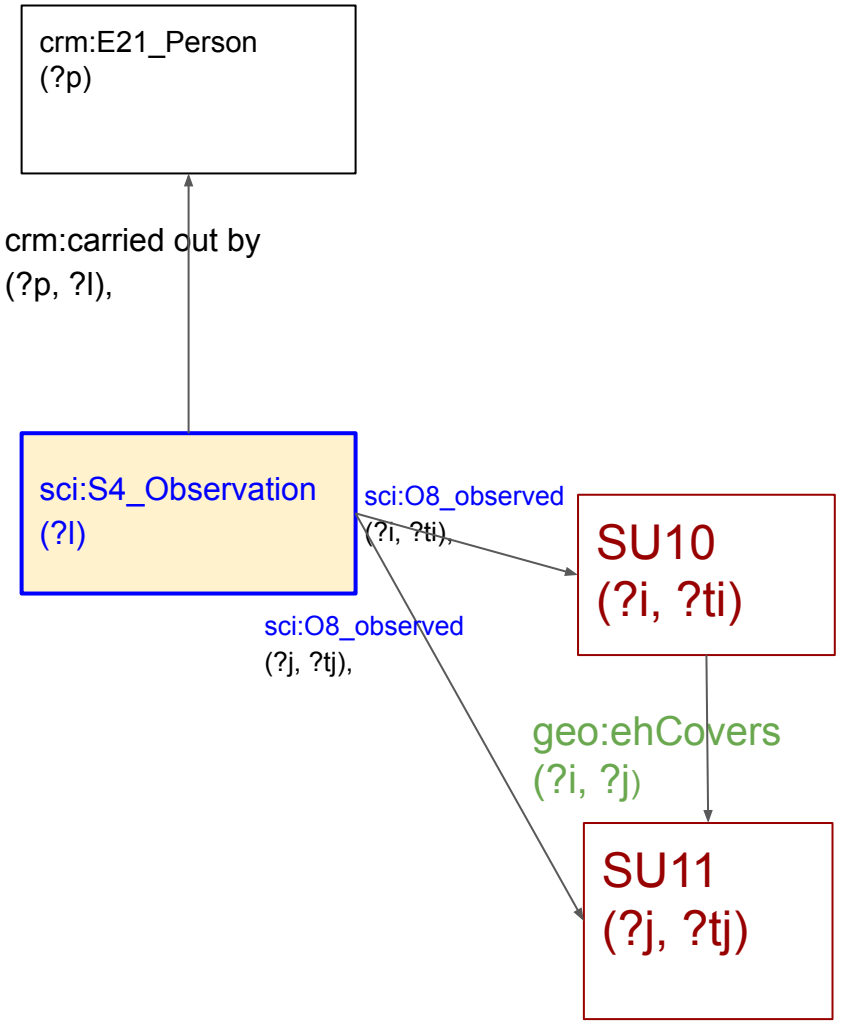
swrl rule:
archaeo:AR8_Stratigraphic_Unit(?i),
archaeo:AR8_Stratigraphic_Unit(?j),
geo:ehCovers(?i, ?j),



1-Law of superposition modeled as an inference using CRM archaeo, geosparql, CRMsci

PREFIX:
crm:CIDOC CRM
archaeo:CRMarchaeo
geo:geosparql
sci:CRMsci

swrl rule:
archaeo:AR8_Stratigraphic_Unit(?i),
archaeo:AR8_Stratigraphic_Unit(?j),
geo:ehCovers(?i, ?j),
sci:S4_Observation(?l),
sci:O8_observed(?i, ?ti),
sci:O8_observed(?j, ?tj),

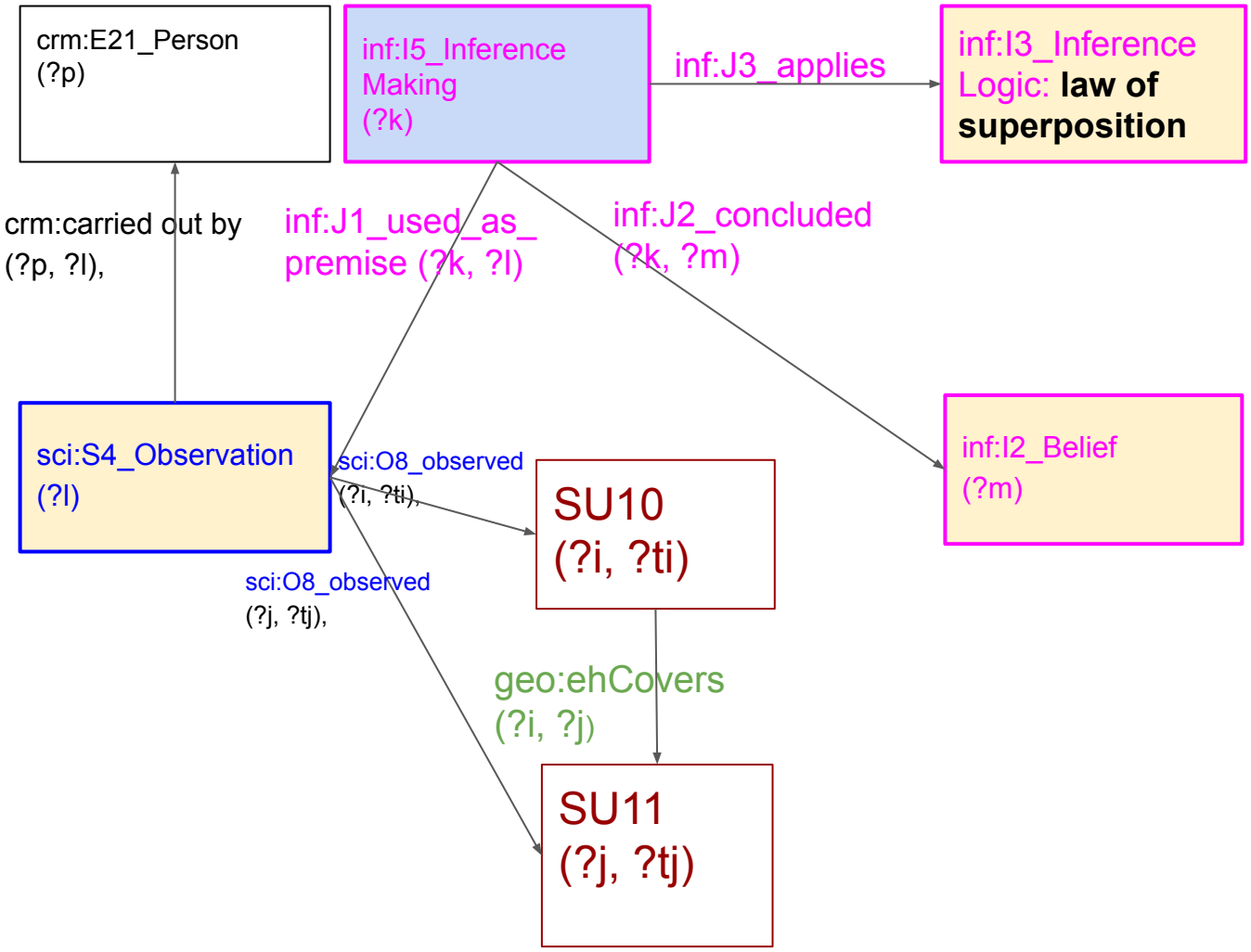


1-Law of superposition modeled as an inference using CRM archaeo, geosparql, CRMsci, CRMinf

PREFIX:
crm:CIDOC CRM
archaeo:CRMarchaeo
geo:geosparql
sci:CRMsci
inf:CRMinf

swrl rule:
archaeo:AR8_Stratigraphic_Unit(?i),
archaeo:AR8_Stratigraphic_Unit(?j),
geo:ehCovers(?i, ?j),
sci:S4_Observation(?l),
sci:O8_observed(?i, ?ti),
sci:O8_observed(?j, ?tj),

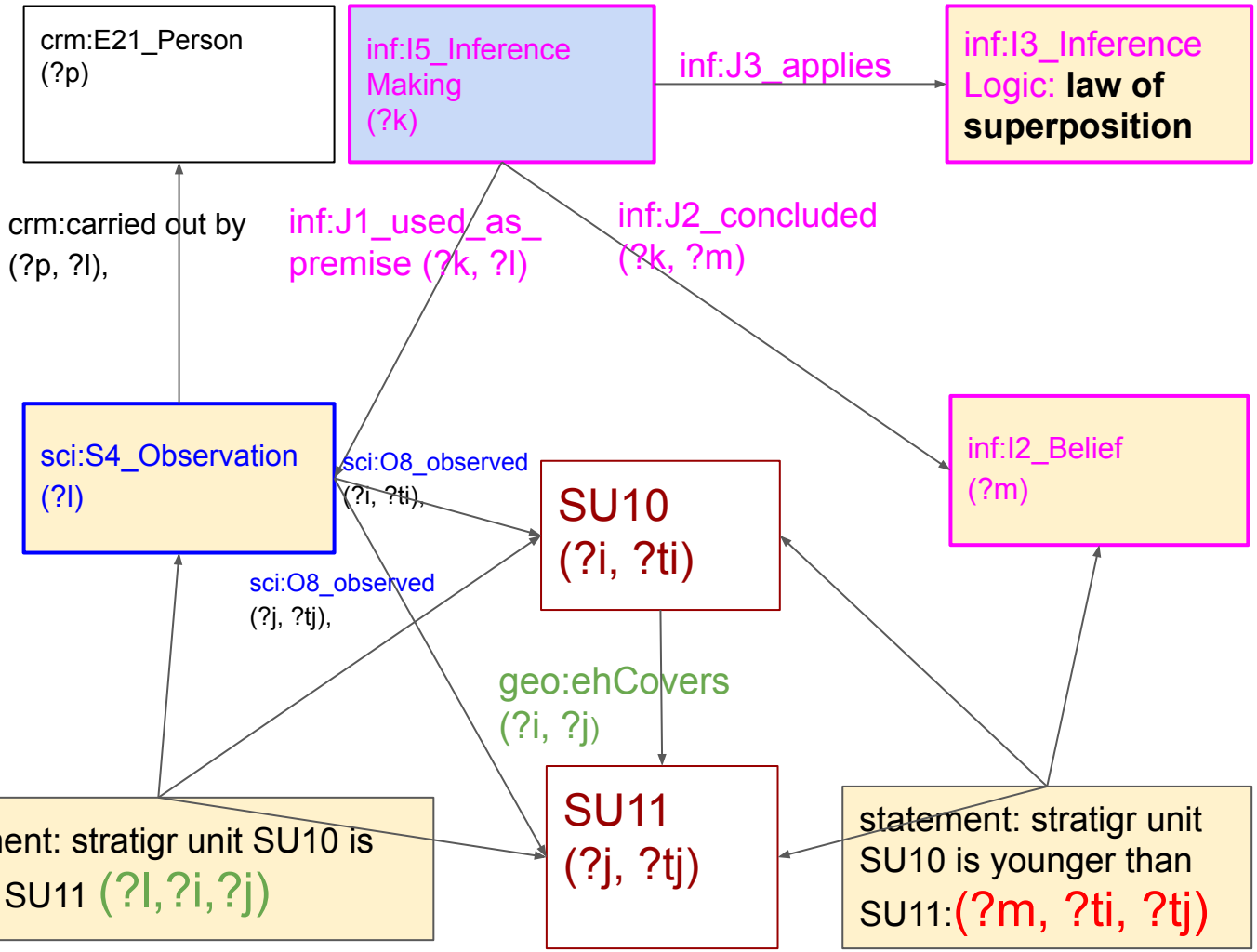
crm:P14_carried_out_by(?p, ?l),
inf:I5_Inference_making(?k),
inf_I3_Inference_logic (law of superposition),
inf:J3_applies(?k, law of superposition),
inf:J1_used_as_premise(?k, ?l),
crm:E21_Person(?p),
inf:J2_concluded(?k, ?m),
inf:I2_Belief(?m),



1-Law of superposition modeled as an inference using CRM archaeo, geosparql, CRMsci, CRMinf

PREFIX:
crm:CIDOC CRM
archaeo:CRMarchaeo
geo:geosparql
sci:CRMsci
inf:CRMinf

swrl rule:
archaeo:AR8_Stratigraphic_Unit(?i),
archaeo:AR8_Stratigraphic_Unit(?j),
geo:ehCovers(?i, ?j),
sci:S4_Observation(?l),
sci:O8_observed(?i, ?ti),
sci:O8_observed(?j, ?tj),
statement(?l,?i,?j),
crm:P14_carried_out_by(?p, ?l),
inf:I5_Inference_making(?k),
inf_I3_Inference_logic (law of superposition),
inf:J3_applies(?k, law of superposition),
inf:J1_used_as_premise(?k, ?l),
crm:E21_Person(?p),
inf:J2_concluded(?k, ?m),
inf:I2_Belief(?m),
statement(?m, ?ti, ?tj)

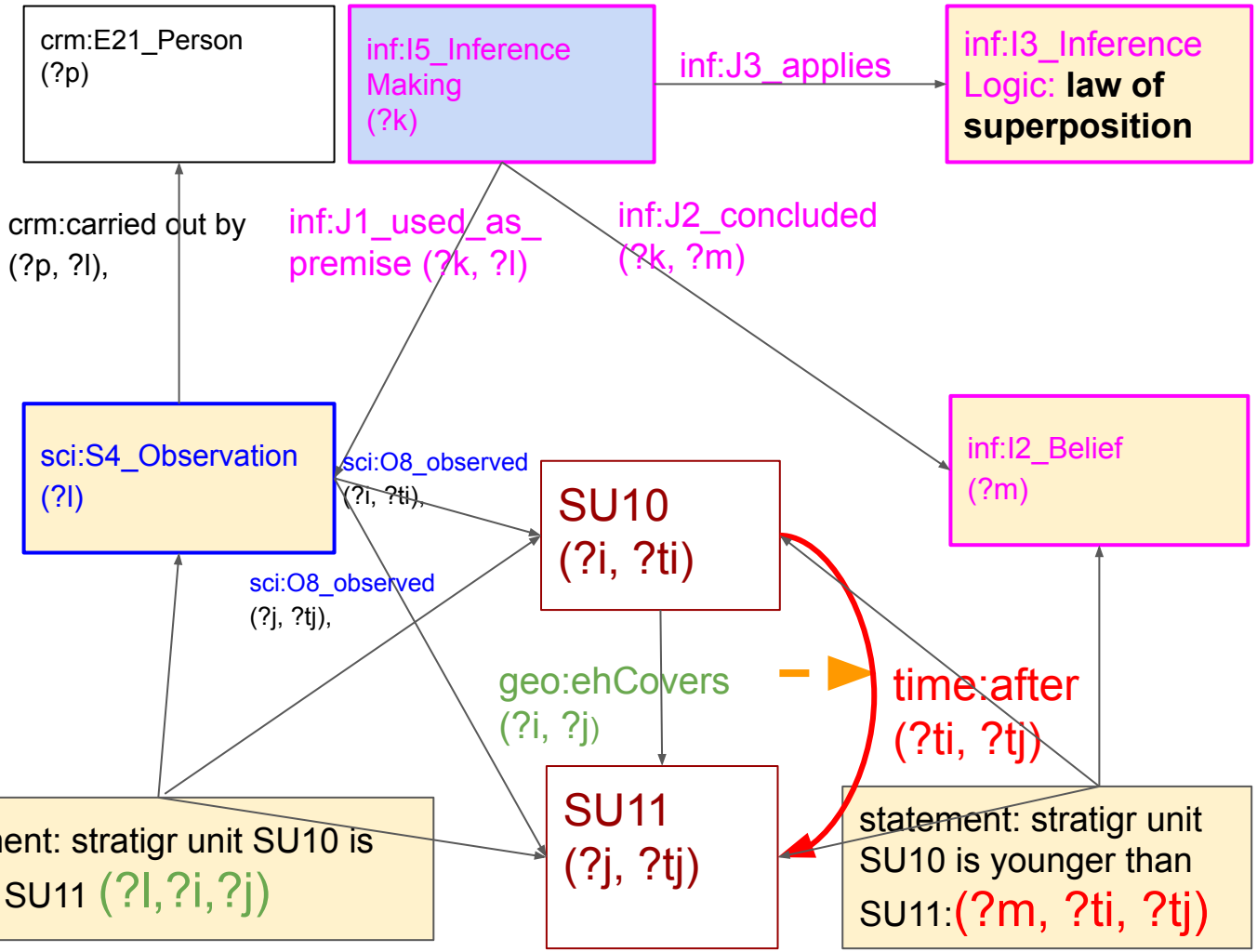


1-Law of superposition modeled as an inference using CRM archaeo, geosparql, CRMsci, CRMinf, and owl-time

PREFIX:
crm:CIDOC CRM
archaeo:CRMarchaeo
geo:geosparql
sci:CRMsci
inf:CRMinf
time:owl-time

swrl rule:
archaeo:AR8_Stratigraphic_Unit(?i),
archaeo:AR8_Stratigraphic_Unit(?j),
geo:ehCovers(?i, ?j),
sci:S4_Observation(?l),
sci:O8_observed(?i, ?ti),
sci:O8_observed(?j, ?tj),
statement(?l,?i,?j),
crm:P14_carried_out_by(?p, ?l),
inf:I5_Inference_making(?k),
inf_I3_Inference_logic (law of superposition),
inf:J3_applies(?k, law of superposition),
inf:J1_used_as_premise(?k, ?l),
crm:E21_Person(?p),
inf:J2_concluded(?k, ?m),
inf:I2_Belief(?m),
statement(?m, ?ti, ?tj)

⟶ time:after(?ti, ?tj)



Conclusion:

- Harris matrix and the stratigraphy methodology are about reasoning about spatio-temporal relationship and archaeological data:

  The semantic modeling need to mirror both spatio-temporal reasoning, argumentation, and hypotheses making

- Modeling with CRMinf of Harris matrix principles shows the potential of archaeological reasoning using inf and its applicability
- Neat demonstration of semantic and inference modeling with CIDOC CRM family of models (CRMinf+CRMarchaeo…) for the community of archaeologists

Next steps:

- Demonstration about the main law (#1 law of superposition), but
  - 2-Law of original horizontality
  - 3-Law of original continuity
  - 4-Law of stratigraphic succession
  - 5-Law of original consolidation
- Some fine tuning of modeling, consistency checking
- Test data transformation and query
- Test inference making from real-word stratigraphic datasets

Modelling Applicability: Stratigraphy in excavation archaeology

[1]
https://www.images-archeologie.fr/Accueil/Recherche/p-3-lg0-notice-IMAGE-Releve-d-une-coupe-stratigraphique-sur-le-site-de-l-ancienne-abbaye-medievale-de-Saint-Faron-a-Meaux-Seine-et-Marne-2016.htm?&notice_id=10745

Modelling Applicability: Stratigraphy in building archaeology

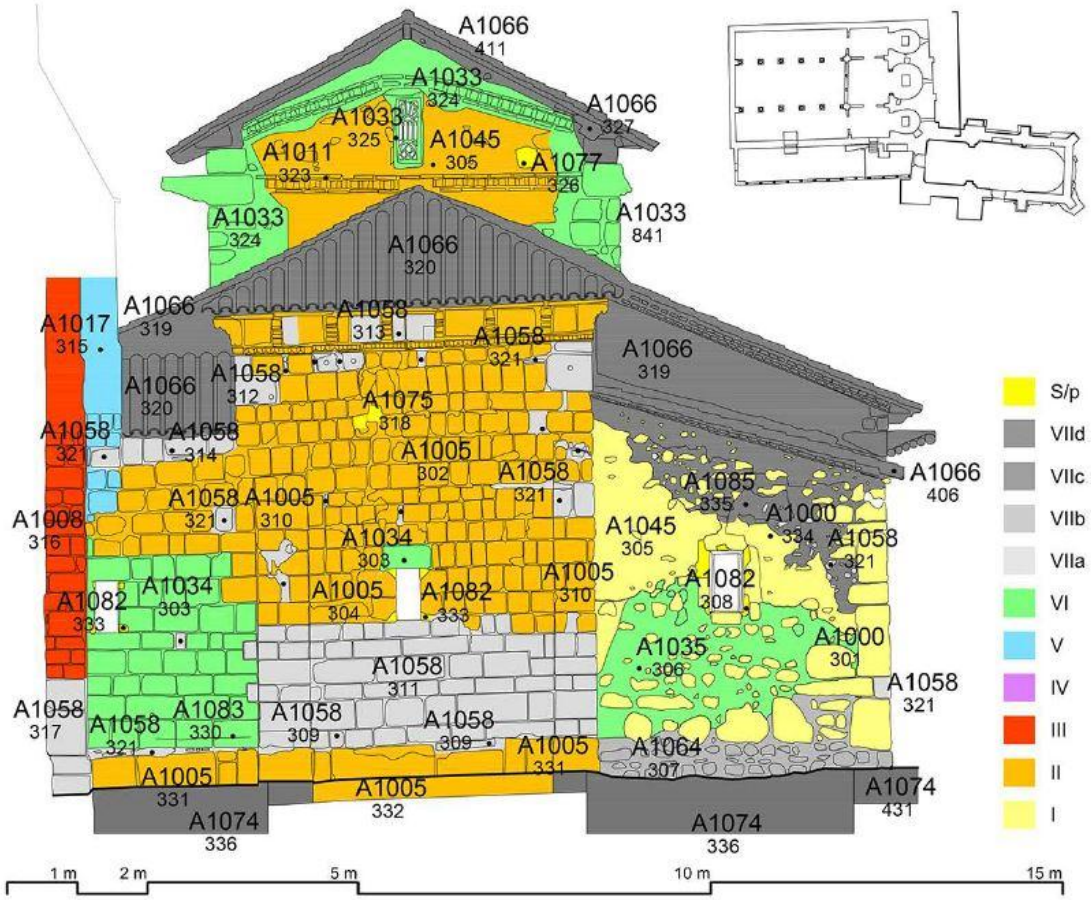


Fig. 9. San Miguel de Escalada (León), east wall, archaeological record. Phase I: rough masonry. Phase II: regular ashlar stone (UTRERO, MURILLO, 2022, in press).

[1] Utrero Agudo, María de los Ángeles, and José Ignacio Murillo Fragero. 2022. "Análisis Arqueológico Del Conjunto de San Miguel de Escalada: De Monasterio Altomedieval a Monumento Histórico-Artístico." https://digital.csic.es/handle/10261/287323.

[2] Utrero Agudo, María de los Ángeles. 2022. "Early Medieval Hispanic Constructions as Material Culture: Archaeology of Architecture and Technology." https://digital.csic.es/handle/10261/275241.

Modelling Applicability:
Stratigraphy in heritage science and material analysis - micro-stratigraphy in polychromy analysis (LRMH)

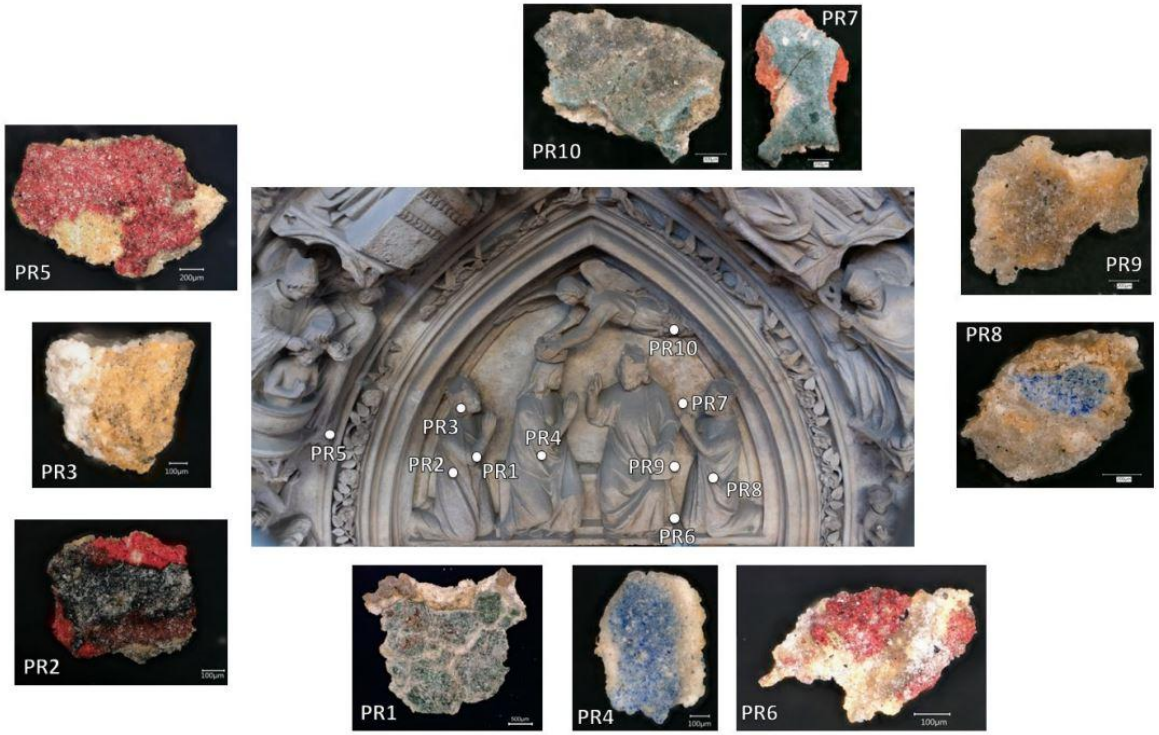


Figure 4 : Porte rouge de la cathédrale Notre-Dame de Paris, tympan et voussures du portail. Emplacement des prélèvements et leurs images microscopiques. © LRMH, A. Dequier.

[1] RAPPORT n° R403J - PARIS 4e (Paris, 75). Cathédrale Notre-Dame de Paris. Façade extérieure nord, porte rouge. Caractérisation des vestiges de polychromies du tympan sculpté et de la voussure.

Modelling Applicability:
Stratigraphy in heritage science and material analysis - micro-stratigraphy in paintings and artworks (C2RMF)

Fig. 1 a) Photograph of the painting *Virgin and Child surrounded by saints and a donor* (RFML.PE.2018.51.1). © C2RMF, T. Clot and **b)** detail showing the locations where the three cross-sections were taken in white (A, B and C), and in red the 22 locations where CXRF depth profiles were applied

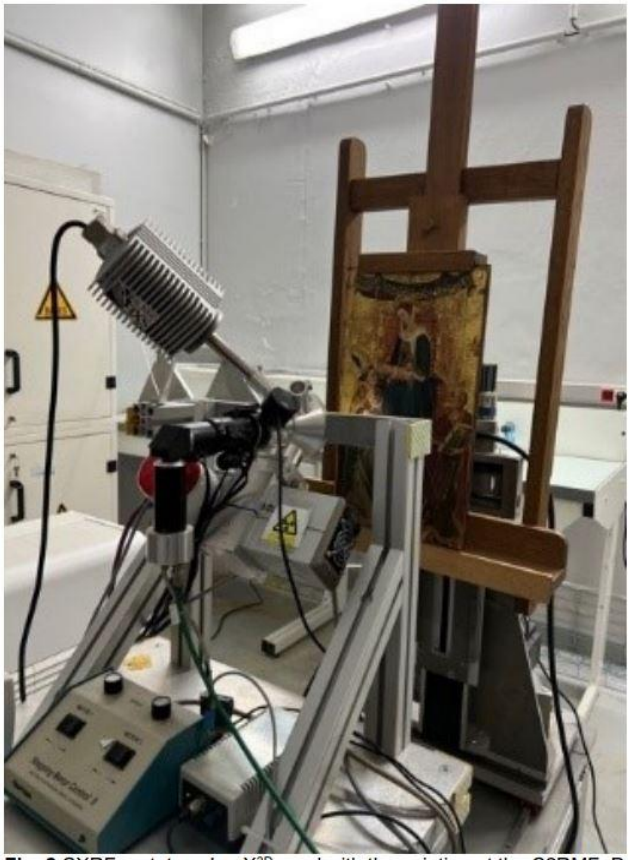


Fig. 2 CXRF prototype LouX^{3D} used with the painting at the C2RMF, Paris

Tapia, José, Myriam Eveno, Thomas Calligaro, Laurent Pichon, Éric Laval, Elisabeth Ravaud, and Ina Reiche. 2023. “Efficiency of Combined MA-XRF and CXRF to Give Nondestructive Insights about Changes of a Historical Painting.” The European Physical Journal Plus 138 (1): 46. https://doi.org/10.1140/epjp/s13360-022-03596-5.

Modelling Applicability:
Stratigraphy in heritage science and material analysis - micro-stratigraphy in paintings and artworks (C2RMF)

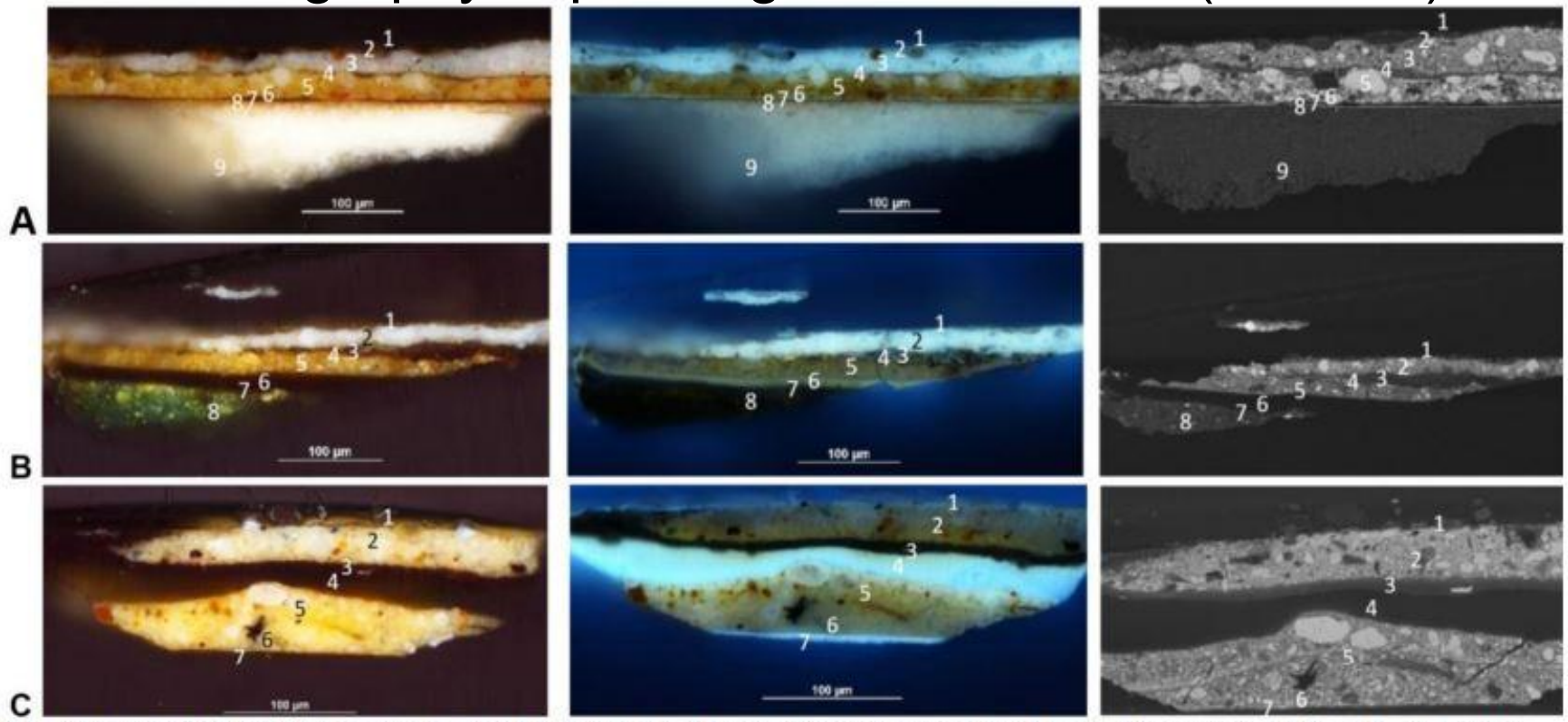


Fig. 3 Optical (left), UV (center) and back scattered electron micrographs (right) of cross-sections A, B, and C.

Tapia, José, Myriam Eveno, Thomas Calligaro, Laurent Pichon, Éric Laval, Elisabeth Ravaud, and Ina Reiche. 2023. “Efficiency of Combined MA-XRF and CXRF to Give Nondestructive Insights about Changes of a Historical Painting.” The European Physical Journal Plus 138 (1): 46. https://doi.org/10.1140/epjp/s13360-022-03596-5.

Modelling Applicability:
Stratigraphy in heritage science and material analysis - micro-stratigraphy in paintings and artworks (C2RMF)

Table 1 OM and SEM-EDX descriptions of the paint layers compared with CXRF lateral scans (y) of the cross-sections and CXRF depth scans (z) of adjacent points. Layer one represents the outer layer closest to the surface of the painting. The element underlined (e.g., Cu) means it is the main identifiable element, without underline (e.g., Cu) that it is present, and between parenthesis, e.g., "(Cu)", that it is a minor element. Coat of arms 3 removed by the restorers between the cross-section sampling and the CXRF depth scan.

Cross-section	Layer and composition determined by OM/ SEM-EDX observations	Elements identified by CXRF lateral scan (y)	Elements identified by CXRF depth scans (z) of adjacent locations	Identification
A			**Location 11**	
	1. Thin fluorescent under UV layer (several µm)			
	2. Thin organic layer with big orange grains (red ochre; Al, Si, Fe) (several µm)	(Fe) right next to Cu		Coat of arms 3
	3. Light beige layer (lead white; Pb, Ca) with small red, black and blue grains (Cu) as well as grains of green earth (10-30 µm)	Cu		
	4. Organic layer, possible varnish (several µm)			Coat of arms 2
	5. Beige-orange layer of lead white (Pb, Fe, Ca) with red, white and black grains (earth pigments, vermillion; Ca, Fe, Hg, S, Mg) (15-25 µm)	Fe, Hg, Pb	Fe, Hg, Pb	
	6. Organic layer, possible varnish (several µm)			Coat of arms 1
	7. Gold leaf (Au)	Au	Au	
	8. Bole (earth pigments; Al, Si, Mg, Fe) (several µm)	Not clear. Fe, Hg		
	9. White ground layer (calcium carbonate with several alumina silicates; Ca, Al, Si) (66 µm)			
B			**Location 1**	
	1. Organic layer with orange and yellow grains (Pb, Ca). Possibly tinted varnish (several µm)		(Fe), Pb	Monk's tunic
	2. Lead white and earth pigments (Mg, Al, Si, Fe) with a P, Cl, Pb and Ca layer on the surface (13-16 µm)	Fe, Pb	Fe, Pb	Monk's tunic
	3. Brown organic non fluorescent under UV layer with some earth elements (Al, Si) (13 µm)			Golden detail
	4. Gold leaf (Au)	Au	Au	Golden detail
	5. Beige mordant layer (lead white, earth pigments, lead tin yellow ; Pb, Sn, Al, Si, Fe) (13-17 µm)	Not clear	Not identified	Golden detail
	6. Organic layer, possibly varnish (~7 µm)			Bishop's green tunic
	7. Copper green glaze non-UV-fluorescent layer (Cu, Pb, Sn) (5-6 µm)	Cu	Cu, Pb	Bishop's green tunic
	8. Green copper layer with some grains of lead tin yellow (Cl, Sn and Pb) (30 µm)	Cu	Cu, Pb	Bishop's green tunic
	No ground layer present in this cross section			
C			**Location 4**	
	1. Slightly fluorescent under UV organic layer, perhaps a tinted varnish (several µm)	Fe, Pb	Fe, Hg	Cross
	2. Light beige layer with lead white, earth pigments, blue copper pigment, orange iron oxide and carbon black (20-25 µm)	(Fe), Cu, Pb	Pb	Cross
	3. Thick non-fluorescent under UV organic layer with some Cu and Pb (5-6 µm)	Not clear	Not clear	Triangle
	4. Thick organic varnish layer fluorescent under UV (8-20 µm)			Floor
	5. Beige layer (lead white, orange iron oxide, vermilion) (13-16 µm)	Fe, Hg, Pb	Cu, Hg, Pb	Floor
	6. Beige layer (lead white, earth pigments; Al, Si, Fe) (15-25 µm)	Pb	Not identified	Floor
	7. Thin organic layer of impregnation (several µm)			
	No ground layer present in this cross section			

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Guillem Anaïs, Van Ruymbeke Muriel, Eide Øyvind, De Luca Livio, Spatio-Temporal Reasoning on Stratigraphic Data in Archaeology: Formalization of the Harris Laws as Inferences Using CIDOC CRM.

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- n-Dame_Heritage (ERC-2021-ADG, Grant agreement ID: 101055423)
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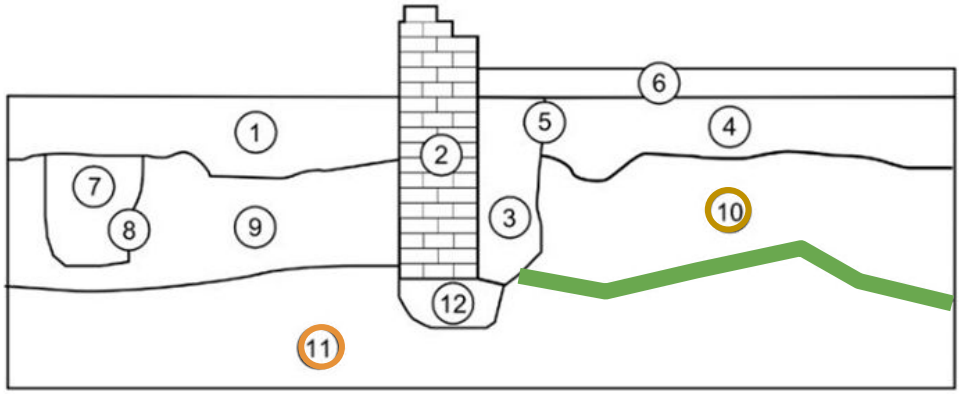

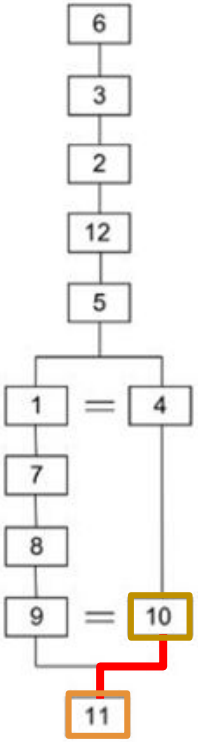

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