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Archaeological classification and ontoterminology: the case of Islamic archaeology of the al-Andalus

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Abstract. This paper describes the continuities and discontinuities between classification as a practice in archaeology and the development of an ontoterminology in the domain of Islamic archaeology of the al-Andalus. Developing an ontoterminology requires an interdisciplinary approach, which effectively places terminology as a subject matter between linguistics and knowledge representation and reasoning. The example of lighting artefacts shown in this paper demonstrates that the archaeological typologies have information that is implied or conflated in their proposed ordering of artefacts. While the purpose of the typologies is to express the names of artefact types in Islamic archaeology, the development of an ontoterminology requires a formalism in which the essential characteristics of each artefact type are made explicit. This allows for a better understanding of the typologies of artefacts through logical reasoning.

1. Introduction

Within archaeology, classification plays a key role in the organization of knowledge regarding the physical remains of past cultures. In this context, classification is the ordering of archaeological data into classes or groups. Typologies of archaeological data, such as artefacts, are the most relevant classification systems. According to Darvill, a typology consists of a theoretical system of types and subtypes of objects, based on “their qualitative, quantitative, morphological, formal, technological, and functional attributes” (Darvill, 2009). Classification is also used in the seriation of objects within a culture. A series, as a broad unit of classification, groups together objects according to incremental changes. According to Kipfer, a series has “a duration in time, when one culture or style develops into another, and an extent in space (the area occupied by the various cultures or styles making up the series” (Kipfer, 2000, pp. 506).

This paper describes the continuities and discontinuities between classification as a practice in archaeology and the development of an ontoterminology in the domain of Islamic archaeology of the al-Andalus. This work is carried out in the context of an ongoing PhD thesis in linguistics at the Universidade NOVA de Lisboa, Portugal, and in information and communication science at the Université de Savoie Mont-Blanc, France. An ontoterminology has been defined as “a terminology whose conceptual system is a formal ontology” (Roche, 2012, p. 2626). On the other hand, an ontology consists of an “explicit specification of a conceptualization” (Gruber, 1993, p. 199), i.e. a formal and computational concept system representing shared knowledge in a domain.

The development of an ontoterminology requires an interdisciplinary approach effectively placing terminology as a subject matter between linguistics and knowledge representation and reasoning, a domain within artificial intelligence. Among other things, this justifies the theoretical distinction between terms and concepts. Terms are used and recognized by domain experts within specialized communication, i.e. in the production and reception of texts in specialized domains of activity. They are units of meaning within a given linguistic system (for instance, Portuguese or Spanish). From a linguistic point of view, terms are therefore placed within lexis and are analysed as such. Concepts, on the other hand, are analysed as units of knowledge in a given domain. They are placed in relation to one another in a concept system and represented through a formalism, following an approach in line with knowledge representation.

2. Classification in archaeology: from practice to theory

Archaeological classification can be thought of as an activity and as a result deriving from the practical requirements of field work. Classification schemes can be valuable resources, for example, in the relative dating of pottery sherds. In theoretical terms, Adams & Adams consider that types within typologies of artefacts have multiple dimensions, namely material, mental and representational (Adams & Adams, 1991). The material dimension pertains to the real-world objects whose fragments are excavated, classified, restored and later preserved in museum collections. The mental dimension refers to the mental images that archaeologists have of these objects, their attributes and the relationships established between them. Finally, the representational dimension consists of all kinds of descriptions (verbal or non-verbal), categorizations and nomenclatures proposed by archaeologists.

This approach to classification enables the distinction between real-world objects, their mental images and the representations that are made of them. According to Adams & Adams, the basic elements of a typology are concepts, descriptions, definitions, labels, categories and members (Adams & Adams, 1991). Concepts are the mental aspects of typologies, which make possible for archaeologists to have an understanding of types, their defining characteristics, and to communicate about them in a meaningful way.

Within the representational dimension, descriptions are the verbal or non-verbal representations of types and their characteristics. They enable communication between two or more individuals in the domain. Definitions are statements or depictions that identify the attributes that are able to distinguish one type from the remaining artefact types. Adams & Adams (1991) consider that most types are never explicitly defined in archaeology, although it is theoretically possible to produce definitions for any type of artefact. Labels are identifiers of types within a typology. They consist of arbitrary words, numbers or alphanumeric codes that allow to refer to types in place of their descriptions or definitions. Names, on the other hand, are not arbitrary, since they invoke certain features of types in a given language, while also having a denotative function. According to Adams & Adams (1991), most typologies employ either labels or names, but not both.

With regard to categories, Adams & Adams (1991) consider that they are not purely within concepts, descriptions or definitions. Instead, categories range over the mental and representational dimensions in sorting objects for the purposes of a given typology. Lastly, members refer to the real-world objects, whose characteristics are analysed and identified as exemplars of a given type concept, i.e. they are placed within a type category.

2.1 Relationship with terminology and ontology development

This approach to classification raises the question of how the different elements of a typology can be represented in an ontoterminology, i.e. a terminology whose conceptual dimension is represented in an ontology. There is no question that a type category is represented as a class in an OWL ontology, since it consists of a set of individual objects. Conversely, type members are represented in OWL as individuals within classes.

With regard to the mental dimension of typologies described by Adams & Adams, we saw that types are defined or described in typologies through depictions or verbal statements. These can be interpreted by the terminologist or ontology developer in order to gain an understanding of the relationships between types and their defining characteristics. Characteristics of types can be represented in OWL through object properties. Type concepts, therefore, are represented by the formal description of OWL classes in an ontology through sets of axioms.

Regarding the other so-called ‘representational’ elements of typologies, type names consist of terms in a given language within specialized communication in archaeology. Type labels, on the other hand, are not necessarily linguistic items. Furthermore, their arbitrary nature may limit them to the purposes of a particular typology. In an ontoterminology, type names will denote OWL classes that represent type categories.

3. Islamic archaeology of the al-Andalus

In Portugal and Spain, Islamic archaeology is focused on the recovery and study of the material culture left behind during the eight centuries of Islamic presence in the Iberian Peninsula (from 711 to 1492). Pottery artefacts are the most studied type of material from this period due to its durability and cultural significance. The study of Islamic pottery of the al-Andalus has allowed for a deeper understanding of its culture and society, including its everyday life, eating habits, trade relations, technical development, symbolism and ideology (Gómez Martínez, 2004).

3.1 Terminology and classification in Islamic archaeology

The terminology of Islamic pottery artefacts, as used by Portuguese and Spanish archaeologists, is placed in close association with the typological analysis of these objects. This approach was pioneered in Spain by Rosselló-Bordoy (1978). His research was initially focused on the analysis of artefacts recovered in Mallorca, having identified 17 different series of pottery artefacts in the region, for which he proposed a terminology in Spanish and Catalan. In his later work, Rosselló-Bordoy included information from historical sources and documented finds from other terri-

ories of the al-Andalus, expanding his classification to 41 different series within 10 functional classes (Rosselló-Bordoy, 1991).

A similar approach was followed in Portugal by the CIGA (*Cerâmica Islâmica do Gharb al-Ándalus*) group of archaeologists. The activity of this group is focused on the study of pottery artefacts recovered in the western part of the al-Andalus, known in the Islamic period as Gharb al-Andalus. A typology and terminology of artefacts in Portuguese was proposed by the CIGA group (Bugalhão et al., 2010). The typology consists of 8 classes, which are based on the function of the artefact types. These classes are further specialized into a total of 48 types according to formal and functional distinctions.

The information presented for each artefact type in both typologies includes names, verbal descriptions and archaeological illustrations of typical examples, focusing on attributes such as geometrical shape and component parts.

4. Developing an ontology of artefact types

The knowledge shared by Portuguese and Spanish archaeologists, as expressed in the specialized texts of the domain, is currently being represented through an OWL ontology. OWL was chosen not only for its importance as a recommendation by the W3C for the semantic web, but also due to its foundations in description logics. This enables the use of reasoners within ontology editors such as Protégé (Musen, 2015). Reasoners facilitate ontology development by checking for inconsistencies and drawing inferences, which allows for the automatic classification of concepts.

Within such formalism, the above-mentioned typologies of pottery artefacts can be represented and distinguished from a comprehensive conceptualization of artefact types. The categories employed in archaeological classifications may have different scopes. For example, the class of artefacts for ‘other uses, not exclusively domestic’ (Rosselló-Bordoy, 1991, p. 172) is used to group together artefacts that do not seem to fit within other classes (in this case, alembics). Other categories have a more precise scope, such as ‘tableware’ or ‘lighting objects’ (Bugalhão et al., 2010, pp. 460-461). Archaeological classes, therefore, may include widely different types of objects. For instance, a class such as ‘ritual and recreational objects’ includes drums, playing stones and basins for ablutions (Bugalhão et al., 2010, p. 462).

The example of lighting artefacts will be discussed in this section to further illustrate the similarities and differences between a classification in archaeology and an ontology in knowledge representation. The typologies are based on hierarchies in which the class of lighting objects has several subclasses. This expresses the fact that there can be several types of lighting objects made of pottery. On the other hand, the conceptualization of the domain proposed in this paper is based on the epistemological principle of genus-differentia, also referred to as ‘specific difference’ (Roche, 2003).

Our approach allows for a fine-grained distinction between artefact types based on their essential characteristics, either formal or functional. Furthermore, the proposed conceptualization may hold across other material types beside pottery. The use of a reasoner in Protégé allows for the automatic classification of the above-mentioned typologies of lighting objects within our ontology. This makes explicit information that was conflated within the typologies of pottery artefacts.

4.1 From typologies to an ontology of artefact types: the case of lighting objects

In the typology proposed by the CIGA group, based on findings from the Gharb al-Andalus, the class of pottery lighting objects subsumes four classes denoted by the Portuguese terms *candil*, *candeia*, *candeia de pé* and *lanterna* (Bugalhão et al., 2010). Fig. 1 shows instances of these types of lighting objects.

On the other hand, the typology of lighting objects proposed by Rosselló-Bordoy consists of three series, denoted by the Spanish terms *candil*, *almenara* and *fanal* (Rosselló-Bordoy, 1991). These are illustrated in Fig. 2.

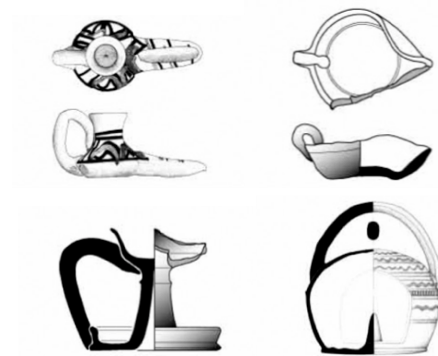


Fig. 1: Illustration of the class of pottery lighting objects according to the CIGA group. From left to right and top to bottom: *candil*, *candeia*, *candeia de pé* and *lanterna* (Bugalhão et al., 2010, p. 471)

The available information shows that *candil* [pt] denotes a lighting object with a closed chamber, while *candeia* has an open chamber.¹ *Candeia de pé* also has an open chamber, which is supported by a tall foot. Finally, *lanterna* denotes a lighting object that was designed to be used in open spaces, and is characterized by a closed orifice and globular body.

¹ In pottery analysis, a vessel is considered to be open if the orifice has a diameter equal to or greater than the maximum diameter of the body. On the other hand, a vessel is considered to be closed if the orifice has a diameter less than the maximum diameter of the body (Rice, 2015).

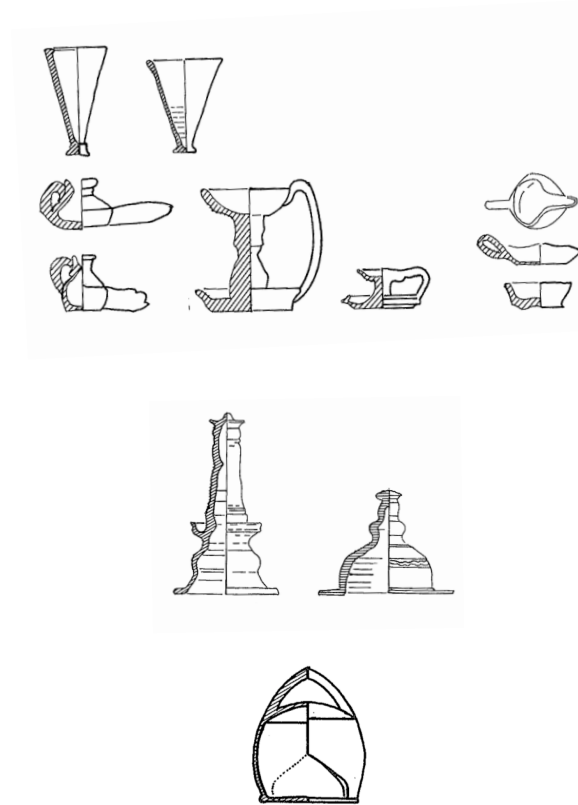


Fig. 2: Illustration of the series of lighting objects according to Rosselló-Bordoy. From top to bottom: *candil*, *almenara*, *fanal* (Rosselló-Bordoy, 1991, p. 174)

Regarding the Spanish terms, *candil* [es] denotes any artefact kind for domestic illumination, open or closed, unlike in the case of the Portuguese term *candil* [pt], which tends to be used for denoting the closed shape (Bugalhão et al., 2010). On the other hand, *fanal* denotes a lighting object designed for open spaces. There are several variants of lighting objects for domestic use, some of which have well established terms in Spanish. The closed and open variants are denoted by the terms *candil de piqueta* and *candil de pellizco*, respectively, or *candil de cazoleta cerrada* and *candil de cazoleta abierta*. The open variant with a tall foot is denoted by the term *candil de pie alto* (Navarro Palazón & Jiménez Castillo, 2007; Rosselló-Bordoy, 1991).

An ontology of these artefact types was proposed in a previous paper following the genus-differentia principle. The differences found between the Portuguese and Spanish terminology were explained by the relationship between each lexical network and the ontology (Almeida, Roche, & Costa, 2016). However, this ontology of lighting objects was not complete, since it excluded objects such as the one referred

to by the Spanish terms *almenara* and *policandela*, whose existence in pottery is doubtful. Also absent from the ontology is a kind of portable lamp that has a disk instead of a neck, referred to in Spanish as *candil de disco impreso* (Gómez Martínez, 2000).

Rosselló-Bordoy's seriation motivate a further problem with regard to our ontology. The *candil* [es] series, shown in Fig. 2, includes objects that constitute a different series of artefacts according to other authors. This series is denoted by the Spanish term *lamparilla*, and is characterized by its conical profile (Vallejo Triano & Escudero Aranda, 1999). A variant with a bistrum-shaped body is thought to exist, and is denoted by the Spanish term *lamparilla bitronconónica*. A differentiating factor of these artefacts is that they lack a beak in which to hold the wick. Contrary to other domestic lighting objects, the wick would be floating in a cork within the fuel chamber (Gómez Martínez, 2000).

The consideration of the artefact types mentioned above leads us to propose the concept system represented in Fig. 3 and Fig. 4.

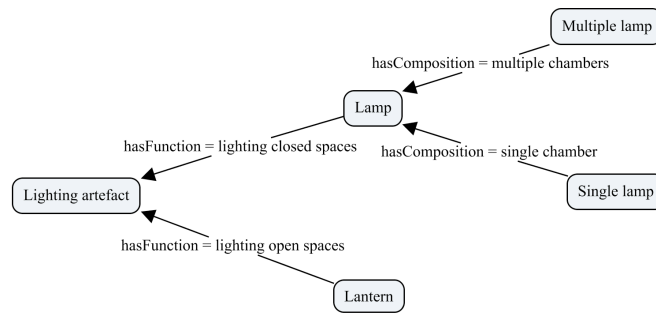


Fig. 3: Concept system of lighting artefacts

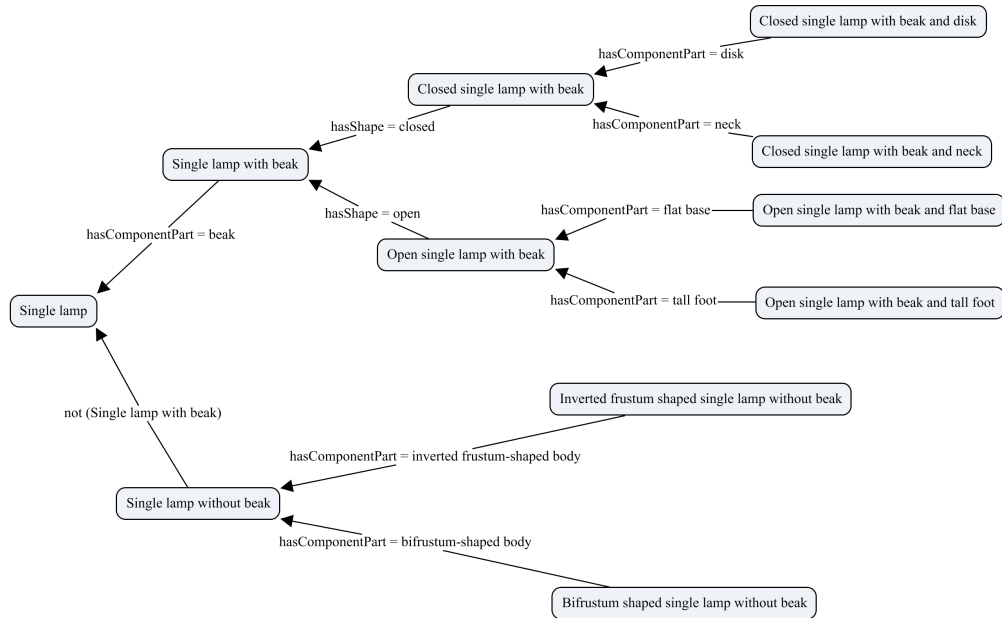


Fig. 4: Concept system of lighting artefacts (cont.)

This hierarchy was formalized in OWL through the Protégé ontology editor (Fig. 5). Concepts are represented by classes in OWL. Essential characteristics are represented by object properties, such as *hasFunction* or *hasComponentPart*, and by classes or individuals in the range of these properties, such as *lighting closed spaces* or *tall foot*. In the cases where we need to represent the absence of a characteristic, as in ‘without a beak’, the resulting class is defined through the negation of its sibling class. In this example, ‘single lamp without beak’ can be defined in Protégé as *SingleLamp and (not SingleLampWithBeak)*, since all single lamps are defined as either having a beak or not (i.e. *SingleLamp* \equiv *SingleLampWithBeak* or *SingleLampWithoutBeak*).

Archaeological classification and ontoterminology

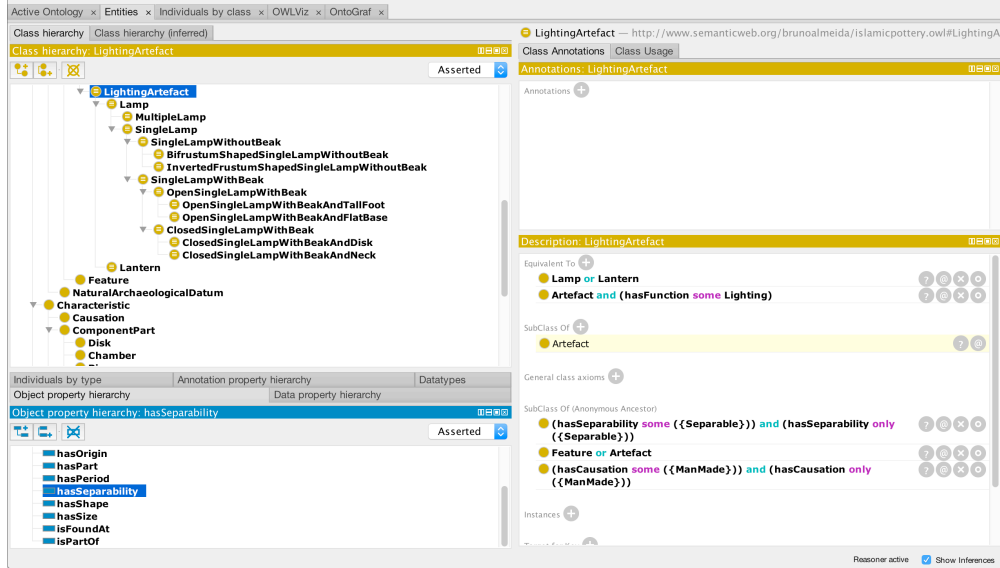


Fig. 5: Ontology in Protégé

This conceptualization allows to distinguish between lamps with a single chamber and lamps with multiple chambers, which includes the *almenara* artefact type. The specialization of single lamps, as seen in Fig. 4, allows to distinguish between lamps with a beak, such as *candil* [pt] or *candeia*, and lamps without a beak, such as *lamparilla* or *lamparilla bitronconónica*. Finally, the specialization of single lamps allows to distinguish between closed shapes, including *candil de disco impreso*, and open shapes, namely *candeia* and *candeia de pé*.

4.2 The archaeological typologies of artefacts within the ontology

The typologies of pottery artefacts mentioned above can be better understood by representing them within our ontology. In order to achieve this, a class hierarchy was created for each of these typologies, namely *CIGALightingObject* and *Rossello-BordoyLightingObject* (Fig. 6 and Fig. 7, respectively). This allows for a reasoner to classify each one of these classes within the conceptualization of artefacts described in the last section.

In these hierarchies, each class was described through relevant attributes gathered from the available textual and visual sources. For example, the *candeia* class of the CIGA group was described as having an open shape, single chamber, beak, flat base and the function of providing a light source in domestic environments. Based on this information, HermiT, a reasoner within Protégé, correctly classified *candeia* as a subclass of *OpenSingleLampWithBeakAndFlatBase* (as highlighted in the class description shown in Fig. 8).

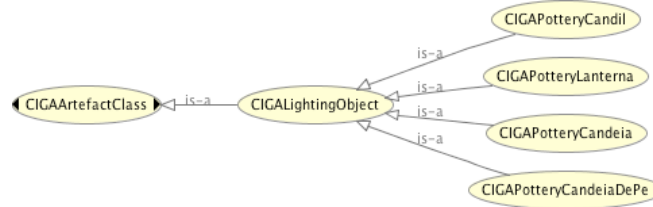


Fig. 6: The class of pottery lighting objects according to the CIGA group

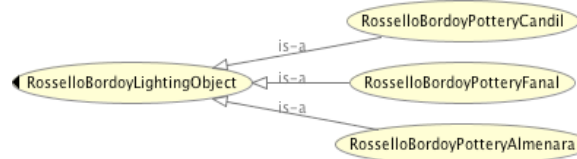


Fig. 7: The class of pottery lighting objects according to Rosselló-Bordoy

The screenshot shows the Semantic Web browser interface for the ontology `islamicarchaeology`. The left pane displays the class hierarchy, with `CIGAPotteryCandeia` selected. The right pane shows the description of `CIGAPotteryCandeia`, including its annotations and sub-classes.

Annotations: `CIGAPotteryCandeia`

- `rdfs:comment` [language: pt]: "Candeia: Objecto de iluminação ostentando depósito aberto" (Bugalhão et al., 2010, p. 461)

Description: CIGAPotteryCandeia

Equivalent To: `(hasShape some ((Open))) and (hasShape only ((Open)))`

SubClass Of:

- `CIGALightingObject`
- `hasComponentPart some {FlatBase}`
- `hasComponentPart some {SingleChamber}`
- `hasFunction some ((LightingClosedSpaces))`
- `OpenSingleLampWithBeakAndFlatBase`

General class axioms:

- `SubClass Of (Anonymous Ancestor):`
 - `(hasSeparability some ((Separable))) and (hasSeparability only ((Separable)))`
 - `hasFunction some Lighting`
 - `hasOrigin some ((Islamic))`

Fig. 8: Description of the candeia class within the ontology

Fig. 9 shows that HermiT was able to infer the relationship between the defined classes of our conceptualization based on genus-differentia and the artefact types identified by the CIGA group and Rosselló-Bordoy. This makes explicit information that was conflated in both classification schemes. While the types of lighting objects are placed at the same level in the typologies, the defined classes we propose express more fine-grained relationships. For example, *almenara* and *candil* [es] are both

domestic lighting artefacts (i.e. ‘lamps’), contrary to *fanal*. Both *candeia* and *candeia de pé* have open chambers, contrary to *candil* [pt], and so on.

This approach also allows us to study the differences between each classification scheme. For example, the *RosselloBordoyPotteryCandil* class is subsumed by *SingleLamp*, which means that in Rosselló-Bordoy’s scheme, the *candil* [es] class is any kind of domestic lighting object with a single chamber. On the other hand, the *CIGAPotteryCandil* class is subsumed by *ClosedSingleLampWithBeak*, showing that the *candil* [pt] class in the CIGA group’s proposal excludes the objects referred to in Spanish as *lamparillas*.

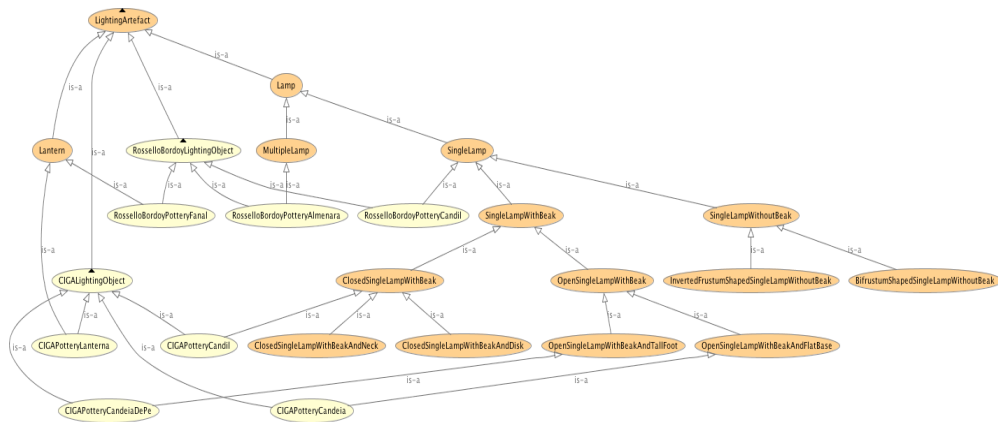


Fig. 9: Inferred relationship between the archaeological classifications and the conceptualization of artefacts

5. Concluding remarks

This article has shown how archaeological classification relates to the development of an ontoterminology. Typologies of artefacts provide insights into the material culture of the al-Andalus. Furthermore, these typologies are directly related to the terminology of the domain in Portugal and Spain. This relationship is attested to by the proposals put forward by Portuguese and Spanish archaeologists, which are important sources for the development of an ontoterminology.

The example of lighting artefacts shows, however, that the typologies have information that is implied or conflated in their proposed ordering of artefacts. This is to be expected, since the purpose of these typologies is to express the names of artefact types in Islamic archaeology. On the other hand, the development of an ontoterminology requires a formalism in which the essential characteristics of each artefact type are made explicit.

The approach presented in this paper allows to gain a better understanding of the typologies through logical reasoning, since we can determine how each typology

relates to a formal conceptualization of artefacts based on the genus-differentia principle. Furthermore, this approach enables the contrastive study of the Portuguese and Spanish terminology of the domain in reference to our ontology, which is valuable from the point of view of terminology research.

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Résumé

Cet article décrit les continuités et les discontinuités entre la classification en archéologie et le développement d'une ontoterminologie dans le domaine de l'archéologie islamique de l'al-Andalus. Le développement d'une ontoterminologie exige une approche interdisciplinaire qui place la terminologie comme un domaine entre la linguistique et la représentation des connaissances. L'exemple des artefacts d'éclairage présenté dans cet article démontre que les typologies archéologiques ont des informations implicites ou confondues dans leur organisation proposée d'artefacts. Alors que le but de ces typologies est d'exprimer le nom des types d'artefacts dans l'archéologie islamique, le développement d'une ontoterminologie nécessite d'un formalisme explicitant les caractéristiques essentielles de chaque type d'artefact. Cette approche permet une meilleure compréhension des typologies des artefacts par le raisonnement logique.